NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 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. NASA's activities are designed to maintain United States leadership in aeronautical and space research, technology, and utilization and to:

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

-- Expand the practical applications of space technology;

-- Develop, operate, and improve manned and unmanned space vehicles;

-- Improve the civil and military usefulness of aeronautical vehicles, while minimizing their environmental effects and energy consumption;

-- Disseminate pertinent findings to potential users; and

-- Promote international cooperation in peaceful activities in space.

The FY 1978 budget provides for continued progress in the expansion of human knowledge; in the practical applications of space; in the development of versatile, reusable space transportation; and in the development of technology for more efficient flight in the atmosphere. One major new initiative to expand our knowledge of the universe is the Space Telescope. Placed in orbit and serviced by the Space Shuttle, the Space Telescope will capitalize on the unique environment of space, above the obscuring effects of the earth's atmosphere, to increase by a hundredfold the volume of space accessible for observation. A major initiative in continued exploration of the solar system is the Jupiter Orbiter/Probe mission, which will conduct a comprehensive exploration of the planet Jupiter, its atmosphere, physical environment and satellites. The FY 1978 budget also provides for initiation of development of Landsat-D, a significant next step in the practical application of space technology in the area of earth resources. Landsat-D will carry a powerful new instrument, the Thematic Mapper, with greater resolution and spectral coverage than is available in the current Landsat series. These improvements promise to open up new uses of Landsat data and to enhance current uses in such areas as mineral and petroleum exploration, world-wide crop inventories and land use inventory.

The FY 1978 budget provides for progress on, and in many cases, fruition of, Science and Applications projects approved in prior years. Development work will be in progress on the Solar Maximum Mission initiated in FY 1977 to study the sun during the period of peak solar activity late in this decade. Flight Activity during FY 1978 will include two High Energy Astronomy Observatories, the Pioneer Venus missions, the Mariner missions en route to Jupiter and Saturn, Landsat-C, Seasat-A, the Nimbus-G environmental monitoring satellite, the Heat Capacity Mapping Mission, and the Tiros-N next generation weather satellite. Continuing the trend of recent years, the launch activity for non-NASA users of space who reimburse NASA for launch services will exceed NASA funded activity. Participation in space programs has become widespread, involving U.S. Government agencies and private organizations as well as other nations.

FY 1978 will be a year of major progress toward the era of versatile and reusable space systems. The Solar Maximum Mission and Landsat-D project will be developing and using a new type of spacecraft called the Multi-Mission Modular Spacecraft. The basic spacecraft structure and system modules are designed to be the building blocks for a number of future missions and to take advantage of the capabilities of the Space Transportation System for satellite servicing, retrieval and reuse. For the Space Shuttle, the key element of the Space Transportation System (STS), FY 1978 will be a critical year of development, ground testing and atmospheric flight testing. Main propulsion system testing will be in progress at the National Space Technology Laboratories in Mississippi. Approach and landing tests of the first Space Shuttle Orbiter will be in progress at Dryden Flight Research Center in California. Following these tests, this Orbiter will be shipped to the Marshall Space Flight Center in Alabama to be mated with the external tank and solid rocket boosters for full scale ground vibration tests. The second orbiter will be in final assembly leading to delivery to the Kennedy Space Center in Florida in late 1978 and first orbital flight in 1979. Production activities will be undertaken in FY 1978 to provide a total national fleet of five orbiters. Long lead procurement will begin on external tanks and boosters to be used in the early Space Shuttle operational period. Development of the multi-purpose Spacelab will continue by the European Space Agency, with an engineering model scheduled for delivery to the U.S. in late 1978. STS Upper Stage development will also be continuing, with the DOD developing the Interim Upper Stage (IUS) and NASA providing for development of a spinning solid upper stage to deliver smaller payloads to geosynchronous orbits which do not require the IUS capability.

In Aeronautics, the FY 1978 budget provides for continued advances in research and technology activity to provide the basis for improved aircraft performance, reduced environmental effects and reduced energy requirements. A major thrust in the program is on development of technology to permit the U.S. to produce in the 1980's transport aircraft capable of approximately twice the energy efficiency of current aircraft. The budget also provides for continuation of work on major aeronautical facilities with construction of the National Transonic Facility at the Langley Research Center in Virginia and modification of the 40X80 foot subsonic wind tunnel at the Ames Research Center in California, as approved by the Congress last year.

The capability to achieve the objectives of the programs assigned to NASA both in the near term and in the future depends on continuing broad-based progress in research and technology work at NASA centers, in industry and at universities. The FY 1978 budget provides for continuation of these activities at approximately the same level of effort as in FY 1977.

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 totalling $4,019,789,000 are requested for FY 1978 to support the programs described in these justifications.

BUDGET SUMMARY

	FY 1976	Transition Quarter	FY 1977	FY 1978
		(Thousands of Dollars)		
BUDGET PLAN				
Research and development	2,677,380	700,600	2,788,425	3,011,000
Construction of facilities	82,130	10,750	118,090	161,800
Research and program management	792,312	220,169	844,777	846,989
TOTAL BUDGET PLAN	3,551,822	931,519	3,751,292	4,019,789
OUTLAYS	3,669,022	951,428	3,705,750	3,902,789

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

Research and Development	Budget Plan FY 1976	Transition Quarter	FY 1977	FY 1978
SPACE FLIGHT	1,560,574	406,500	1,668,700	1,753,500
Space shuttle	1,206,000	321,000	1,318,100	1,349,200
Space flight operations	188,674	48,400	199,200	267,800
Expendable launch vehicles	165,900	37,100	151,400	136,500
SPACE SCIENCE	434,126	116,400	380,325	405,700
Physics and astronomy	159,300	43,500	166,300	224,200
Lunar and planetary exploration	254,250	67,464	191,900	148,200
Life sciences	20,576	5,436	22,125	33,300
APPLICATIONS	178,230	47,700	198,200	228,800
AERONAUTICS AND SPACE TECHNOLOGY	250,250	63,100	272,100	328,700
Aeronautical research and technology	175,350	43,800	190,100	231,000
Space research and technology	74,900	19,300	82,000	97,700
ENERGY TECHNOLOGY APPLICATIONS	5,900	1,500	6,000	4,500
TRACKING AND DATA ACQUISITION	240,800	63,400	255,000	281,700
TECHNOLOGY UTILIZATION	7,500	2,000	8,100	8,100
TOTAL RESEARCH AND DEVELOPMENT	2,677,380	700,600	2,788,425	3,011,000
Construction of Facilities	82,130	10,750	118,090	161,800
Research and Program Management	792,312	220,169	844,777	846,989
TOTAL	3,551,822	931,519	3,751,292	4,019,789
OUTLAYS	3,669,022	951,428	3,705,750	3,902,789

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT

- Develop Space Transportation System to provide for:

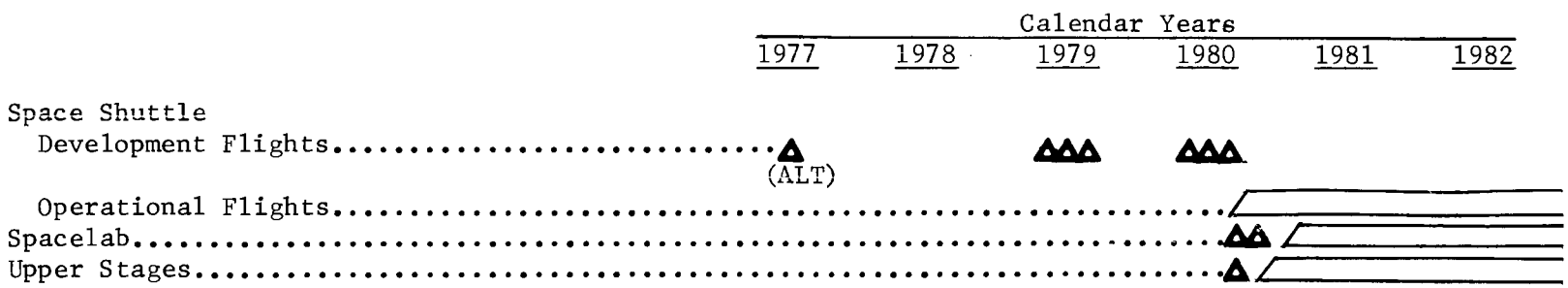
  -- Versatile and reusable Space Shuttle system
  -- Manned orbital experiments using Shuttle and Spacelab
  -- Deep space and geosynchronous mission capability with upper stages
  -- Orbital placement, servicing and retrieval of automated satellites
  -- Economy in transportation, space operations, and payload costs

- Initiate production to provide national fleet of five Shuttle orbiters

- Establish capability for Space Transportation System operations

- Provide expendable launch vehicle services as required by NASA and other users during transition to Space Transportation System

MAJOR FLIGHT ACTIVITY

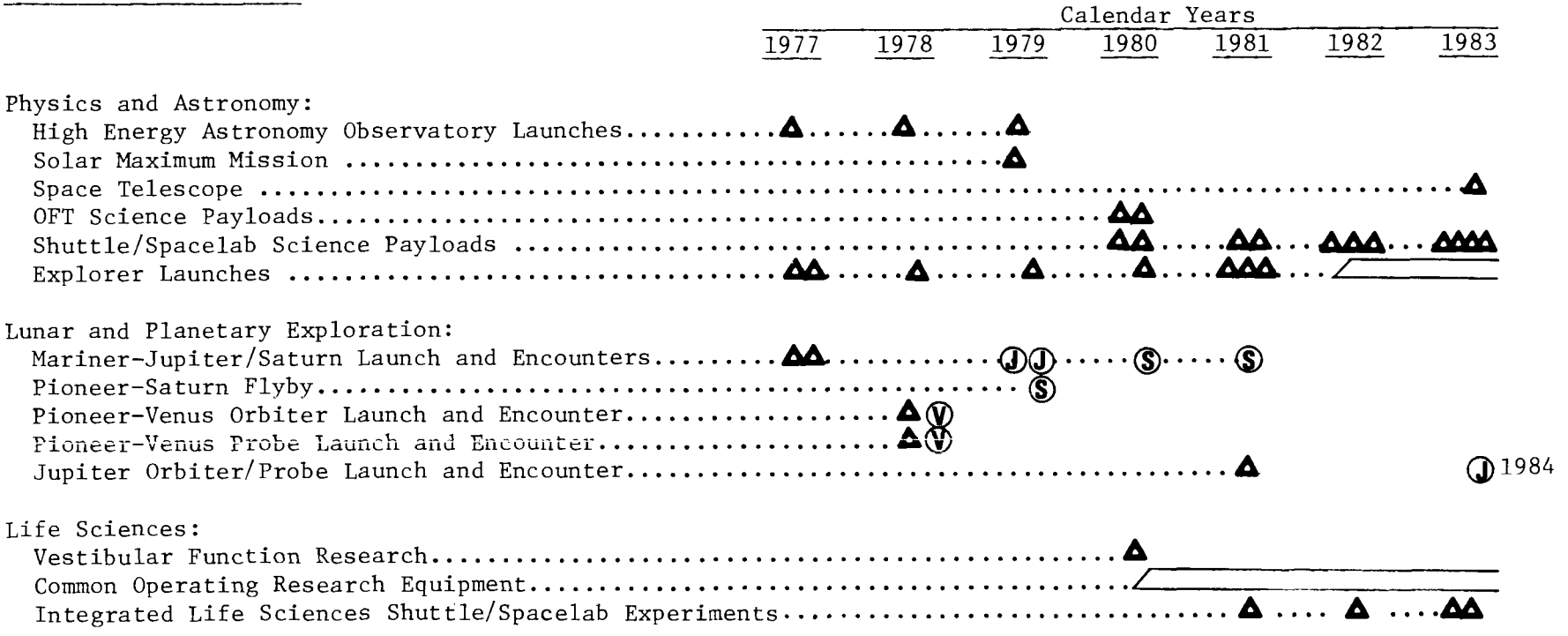


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE

- Increase our understanding of the evolution and nature of the universe through a balanced program of 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 bioinstrumentation fields

MAJOR FLIGHT ACTIVITY

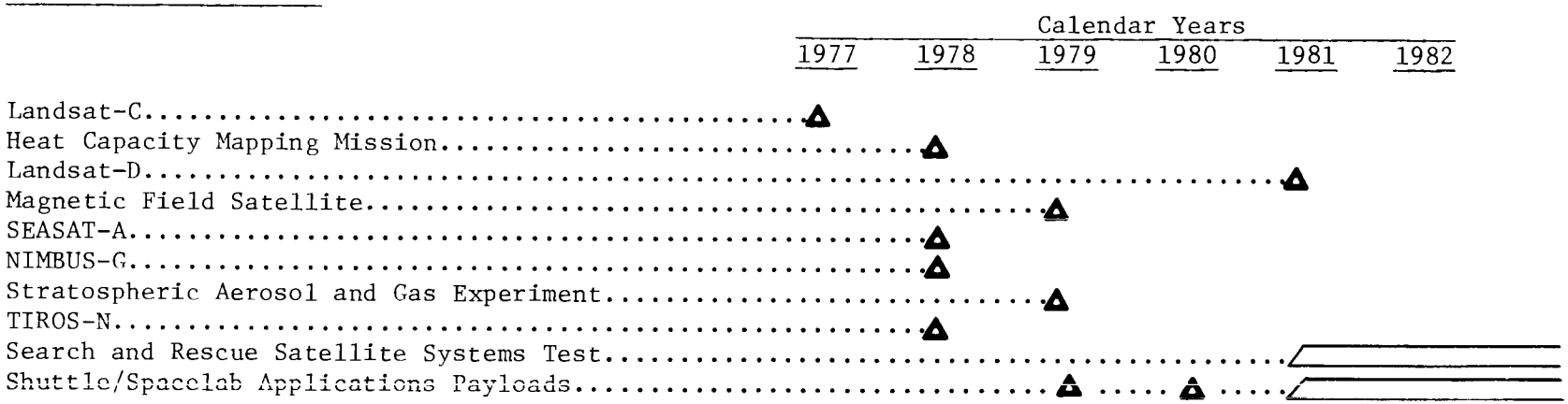


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE APPLICATIONS

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

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AERONAUTICAL RESEARCH AND TECHNOLOGY

- For civil and military aircraft:
  - -- Improved performance
  - -- Reduced energy requirements
  - -- Reduced environmental effects

Representative Technology Efforts

- -- Highly Maneuverable Aircraft Technology
- -- Energy Efficient Engine
- -- Composite Primary Structures
- -- Energy Efficient Transport
- -- Variable Cycle Engine

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
  - -- Technology flight experiments using Shuttle and Spacelab
  - -- Low cost standardized components

MAJOR FLIGHT ACTIVITY

	Calendar Years					
	1977	1978	1979	1980	1981	1982
Shuttle/Spacelab Technology Payloads						

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENERGY TECHNOLOGY APPLICATIONS

- Energy technology identification and verification to facilitate use of NASA-developed aerospace technologies, experience and facilities to meet the program needs of the Energy Research and Development Administration and other agencies responsible for energy programs

- Technical definition of a feasible satellite system for generation of energy in space

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 an average of approximately 50 active spacecraft including NIMBUS-F, Geodynamic Experimental Ocean Satellite (GEOS) C, Landsat 1 and 2, Atmosphere Explorers (AE) 3 and 5, Orbiting Solar Observatory (OSO) I, the upcoming International Ultraviolet Explorer (IUE), High Energy Astronomy Observatory (HEAO), Landsat C, Heat Capacity Mapping Mission (HCMM), and the International Sun Earth Explorer (ISEE) missions.

  -- Planetary Missions - In addition to continuing support for several Pioneer spacecraft, Helios 1 and 2, and Viking 1 and 2, the Mariner Jupiter/Saturn '77, and the Pioneer Venus '78 missions will also be covered.

  -- Sounding Rockets

  -- Research Aircraft

TECHNOLOGY UTILIZATION

- Accelerate the transfer of NASA-developed research and technology advances to public and private sectors.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	FY 1976 PL 94-116	Transition Quarter PL 94-116	FY 1977 PL 94-378	FY 1978 Request
Research and Development	2,677,380	700,600	2,761,425	3,011,000
Construction of Facilities	82,130	10,750	118,090	161,800
Research and Program Management	792,312	220,795	844,777	846,989
Basic Appropriation	(775,512)	(213,678)	(813,000)	(846,989)
Supplemental Appropriation for civilian pay raises (PL 94-303)	(16,800)	(7,117)	---	---
Proposed supplemental for civilian pay raises	---	---	(31,777)	---
Total	3,551,822	932,145	3,724,292	4,019,789

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

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

	Total	Research and Development	Construction of Facilities	Research and Program Management
Fiscal Year 1976				
Appropriation, PL 94-116	3,535,022	2,677,380	82,130	775,512
Supplemental Appropriation, PL 94-303	16,800	---	---	16,800
Total Appropriation (Budget Plan)	3,551,822	2,677,380	82,130	792,312
Transition Quarter				
Appropriation, PL 94-116	925,028	700,600	10,750	213,678
Supplemental Appropriation, PL 94-303	7,117	---	---	7,117
Unobligated balance lapsing	-626	---	---	-626
Total Budget Plan	932,519	700,600	10,750	220,169
Fiscal Year 1977				
Appropriation, PL 94-378	3,692,515	2,761,425	118,090	813,000
Proposed Supplemental for civilian pay raises	31,777	---	---	31,777
FY 1975 funds applied to 1977 budget plan	27,000	27,000	---	---
Total Budget Plan	3,751,292	2,788,425	118,090	844,777
Fiscal Year 1978				
Appropriation request/Budget plan	4,019,789	3,011,000	161,800	846,989

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION
(Millions of Dollars)

Installation	Research and Development				Construction of Facilities				Research and Program Management				TOTAL			
	1976	TQ	1977	1978	1976	TQ	1977	1978	1976	TQ	1977	1978	1976	TQ	1977	1978
Johnson Space Center	997.2	244.7	995.1	973.9	5.1	.8	4.2	5.6	128.8	37.5	139.7	139.6	1,131.1	283.0	1,139.0	1,119.1
Kennedy Space Center	104.1	31.8	148.4	206.4	40.1	.5	34.6	54.9	99.8	28.6	107.0	110.2	244.0	60.9	290.0	371.5
Marshall Space Flight Center	420.0	122.1	486.0	587.5	2.4	1.0	4.3	21.1	132.8	35.7	138.6	134.7	555.2	158.8	628.9	743.3
National Space Technology Laboratories	10.8	3.4	12.9	10.3	.2	.2	.9	.9	1.7	.5	1.9	2.0	12.7	4.1	15.7	13.2
Goddard Space Flight Center	366.6	97.0	391.5	473.5	2.4	1.3	2.1	5.2	108.6	28.6	115.9	116.1	477.6	126.9	509.5	594.8
Jet Propulsion Laboratory	194.2	54.1	192.1	175.3	3.8	1.5	2.0	5.1	---	---	---	---	198.0	55.6	194.1	180.4
Wallops Flight Center	14.3	4.2	17.1	18.6	1.2	.6	1.5	1.8	13.1	4.0	13.9	14.2	28.6	8.8	32.5	34.6
Ames Research Center	139.6	32.7	114.7	110.5	5.6	1.2	12.2	15.0	50.9	13.3	53.7	53.7	196.1	47.2	180.6	179.2
Dryden Flight Research Center	20.6	6.4	22.2	19.1	6.0	.3	1.6	.8	14.5	5.3	17.3	17.0	41.1	12.0	41.1	36.9
Langley Research Center	151.3	44.8	149.0	173.4	6.5	1.3	33.4	27.6	93.2	24.2	95.4	95.4	251.0	70.3	277.8	296.4
Lewis Research Center	167.0	38.2	156.3	151.1	2.0	.7	3.6	3.9	80.7	22.2	87.5	88.7	249.7	61.1	247.4	243.7
NASA Headquarters	91.7	21.2	103.1	111.4	.8	1.3	---	---	68.2	20.3	73.9	75.4	160.7	42.8	177.0	186.8
Construction of Facilties Programs																
Various Locations					---	---	---	1.8					---	---	---	1.8
Facility Planning and Design					.3	---	12.7	11.8					.3	---	12.7	11.8
Balance of the following programs undistributed by installation																
Space Shuttle Facilities					3.0	---	.2	---					3.0	---	.2	---
Rehabilitation and Modification					.1	.1	3.5	3.3					.1	.1	3.5	3.3
Minor Construction					2.6	---	1.3	3.0					2.6	---	1.3	3.0
Total Budget Plan	2,677.4	700.6	2,788.4	3,011.0	82.1	10.8	118.1	161.8	792.3	220.2	844.8	847.0	3,551.8	931.6	3,751.3	4,019.8

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

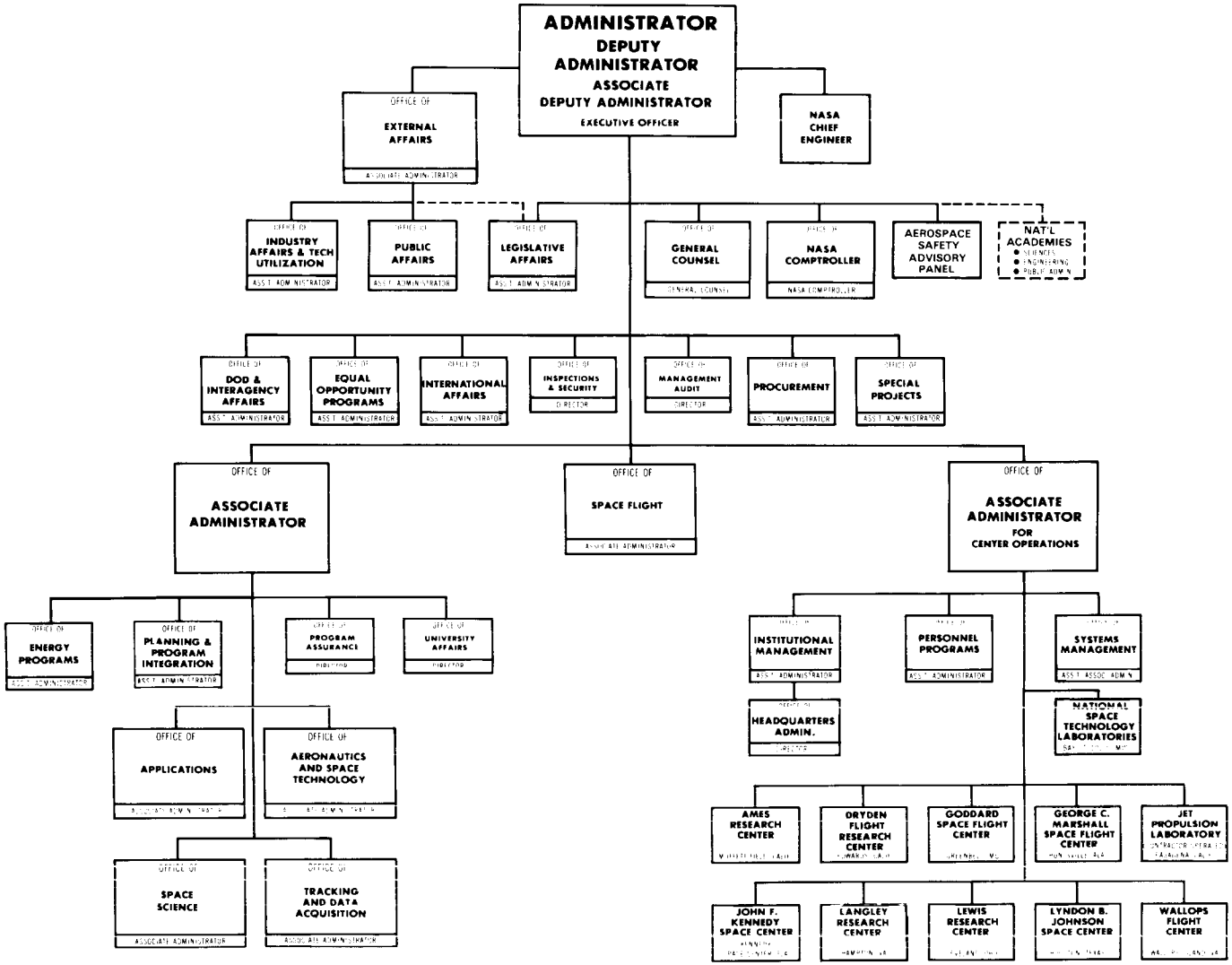
RESEARCH AND PROGRAM MANAGEMENT

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

	FY 1976	Transition Quarter	FY 1977	FY 1978
Johnson Space Center	3,613	3,613	3,613	3,613
Kennedy Space Center	2,259	2,259	2,259	2,259
Marshall Space Flight Center	4,115	4,115	3,910	3,910
National Space Technology Laboratories	70	70	70	70
Goddard Space Flight Center	3,752	3,752	3,675	3,625
Wallops Flight Center	415	415	414	413
Ames Research Center	1,676	1,676	1,613	1,601
Dryden Flight Research Center	498	498	520	520
Langley Research Center	3,321	3,321	3,172	3,165
Lewis Research Center	3,025	3,025	3,025	3,025
Headquarters	1,572	1,572	1,545	1,536
Total, Permanent Positions	24,316	24,316	23,816	23,737

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to advance our knowledge of the Earth, its space environment, and the universe; to expand the practical applications of space technology; to develop, operate and improve manned and unmanned space vehicles; to provide technology for improvement of the performance of aeronautical vehicles while minimizing their environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE FLIGHT: A program to provide all the transportation and related support and capabilities required to conduct space operations. The major development objective is the reusable Space Shuttle, the key element of a versatile, economical transportation system to provide a wide variety of users with round trip access to space during the 1980's and beyond.

SPACE SCIENCE: A program utilizing space systems, supported by 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 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, and space communications.

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.

ENERGY TECHNOLOGY APPLICATIONS: A program to assure that national energy technology programs receive the maximum benefit from NASA-developed aeronautics and space technology.

TRACKING AND DATA ACQUISITION: A worldwide program to support deep space, earth orbital, suborbital, and aeronautical programs.

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 a versatile, economical Space Transportation System to provide domestic and international users with round trip access to space for the 1980's and beyond.

The Space Shuttle is the most important element of the Space Transportation System. Its versatility and reusability will open up a new era in expanding the uses of space for a wide variety of earth applications, scientific, defense, and technological activities. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to earth orbit of payloads and propulsive stages for high energy and escape missions. The advent of readily available, economical transportation to and from low earth orbit, for automated payloads as well as for scientists and other personnel without special flight training, will revolutionize our concepts of using space and will significantly expand the returns from space operations. In addition to reduced transportation costs, significant savings are anticipated in payload costs resulting from repair and reuse of payloads and from relaxation of weight, size, and reliability constraints. These advantages will enhance both the flexibility and the productivity of space missions compared to existing expendable launch vehicles.

During FY 1978 the Space Shuttle will be in a critical phase of development, ground testing and atmospheric flight testing, leading to accomplishment of the first manned orbital flight in 1979 and initial operational capability in 1980. Main propulsion system testing will be in progress at the National Space Technology Laboratories in Mississippi. Approach and landing tests will be completed at the Dryden Flight Research Center in California. The orbiter used in those tests will then be transported to the Marshall Space Flight Center in Alabama to be mated with the external tank and solid rocket boosters for total system ground vibration tests. The second orbiter will be in final assembly leading to delivery to the Kennedy Space Center in Florida in preparation for the first manned orbital flight in 1979. Production activities will be initiated on three additional orbiters to provide a total national fleet of five orbiters.

Other activities related to the establishment of the Space Transportation System operational capability will also intensify in FY 1978. The Spacelab, which will be a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built for NASA by the European Space Agency, with ten European nations participating in the Spacelab development. The Interim Upper Stage (IUS) being developed by the U.S. Air Force will be used to deploy Shuttle launched payloads to high energy and escape orbits. NASA is providing for development of the spinning upper stage to deliver smaller payloads to geosynchronous orbits which do not require the IUS capability. Other space flight activities related to the Space Transportation System include ground support and control equipment, multi-use mission support equipment, training equipment, and long-lead time item procurement to provide external tanks and solid rocket boosters for early operational missions.

FY 1978 Space Flight activities also include expendable launch vehicles for automated projects. Launch vehicle hardware and services, as well as 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 experiments flown on Skylab provide the foundation for the Solar Maximum Mission (SMM) currently under development. 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 1978-80.

Development of the Space Telescope is planned for initiation in FY 1978. This multiple-purpose telescope will be launched by the Shuttle in 1983, and will serve as an astronomy observatory in space for over a decade. The Space Telescope will capitalize on the unique environment of space, above the obscuring effects of the Earth's atmosphere, to increase by a hundredfold the volume of space accessible for observation. These observations will significantly advance our understanding of the origin and evolution of the universe and the energy-generating mechanisms of stellar systems and objects.

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 and infrared astronomy and the sun-earth relationships, and on definition of payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab.

A continuing goal of the Upper Atmospheric Research program is to understand and evaluate potential threats to the upper atmosphere. This is being accomplished through a coordinated program of short-term assessment activities and the establishment of a long-term basic science program.

A major highlight of the 1976 activities was the successful landings of Vikings I and II. Both landers and the two Viking orbiters are continuing to provide valuable data concerning the planet Mars. The FY 1978 budget provides for study and definition efforts on a potential next step mission to Mars, building on the Viking results.

Investigations 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 carry multiple probes to give us our first detailed measurements of the dense Venusian atmosphere.

The Helios A and B cooperative missions with West Germany, which were launched in December 1974 and January 1976, are continuing to study the Sun, from a closer range than ever before.

Exploration of the outer planets is proceeding, with the Pioneer 11 spacecraft enroute to a rendezvous with Saturn in 1979, and Pioneer 10 on its way to being the first spacecraft to escape our solar system. Two Mariner Jupiter/Saturn missions are under development for launches in 1977. Initiation of development for the Jupiter Orbiter/Probe mission is planned for FY 1978. This mission will conduct extensive exploration of Jupiter by sampling its atmosphere with an instrument-bearing probe, obtaining data on the planet's magnetosphere and atmosphere, and observing the Jovian satellites.

New data on the physical characteristics of the Moon continue to be gathered by the Apollo Lunar Surface Experiment Packages. 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.

The Life Sciences research and development program is designed to provide a basis for enhancing people's ability to work efficiently in space; to develop experiments and related equipment to be flown on Spacelab missions; and to support NASA's effort 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 medical 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 applied in the non-space related sector for practical benefits here on Earth. 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, 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, an experiment using Landsat data to determine wheat production over the North American continent with extension to the entire world. Landsat-C, currently under development, and scheduled for launch readiness in late 1977, 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, initiated in FY 1977, will provide a powerful instrument with significantly greater spectral coverage and resolution than are currently available. The FY 1978 budget provides for initiation of the Landsat-D project, which will carry the Thematic Mapper and will test a total data acquisition, processing, dissemination and analysis system. The Landsat-D project promises to open up new uses of Landsat data and to enhance current uses in such areas as mineral and petroleum exploration, worldwide crop inventories, and land and water inventory applications.

Earth Dynamics Monitoring and Forecasting efforts are directed towards observing the physical characteristics and dynamic motions of the earth, to contribute to improvements in our knowledge of the earth's gravity and magnetic field, of geodetic surveying and control techniques, and our knowledge of earthquake mechanisms. Validation of techniques for measuring tectonic plate motions, using the Laser Geodynamics Satellite and accurate ground instruments, is in progress. The motions of these large solid plates are one of the causes of severe earthquakes. Data to be provided by Magnetic Field Satellite, an Applications Explorer, is expected to advance our knowledge of the earth's magnetic field and geologic structure with potential benefits in location of mineral resources.

Ocean Condition Monitoring and Forecasting involves sea state conditions, current systems and ocean circulation patterns which have important implications for ship routing, offshore activities, fishing, and weather forecasting. Data on the sea surface topography are currently being acquired with the Geo-

dynamic Experimental Ocean Satellite (GEOS-3), launched in 1975. Seasat-A, which will offer extensive capability for observing and monitoring ocean conditions, is under development for launch in 1978.

The Environmental Quality Monitoring program has as its objective the development and demonstration of systems for identifying and measuring pollutants in the air and water on global and regional scales. A major step forward in this area will occur in 1978 with the launch of the NIMBUS-G satellite currently under development. Significant data will also be obtained by the Stratospheric Aerosol and Gas Experiment, an Applications Explorer, which will fly a single instrument to detect and map stratospheric aerosols and gas concentrations to complement the data to be acquired by NIMBUS-G.

The Weather and Climate Observation and Forecasting program focuses on the application of satellite data to the detection, prediction, and early warning of severe storms and to the improvement of our capability for mid-range and long-range weather prediction. The atmospheric processes associated with severe storms and daily weather and climate require a variety of approaches, including ground based research and satellite systems, to develop data and techniques for better forecasts. Development of a prototype third generation weather satellite, TIROS-N, is in progress with launch planned for 1978. Preparations for NASA participation in the first Global Atmospheric Research Program experiment, to be conducted in 1978-1979, are also underway.

The objective of the Materials Processing in Space program is to exploit the special characteristics of the space environment 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 directly applicable to industrial and biomedical processes on the ground, as well as to the production of unique new products in space. In FY 1978 studies will continue on the ground and using sounding rocket missions. Development will be initiated on experiments to take advantage of the unique capabilities of the Shuttle and Spacelab.

The NASA effort in Space Communications is directed toward developing and demonstrating advanced technology, and providing expert advice and consultation on communications satellites to various Government departments and agencies. The highly successful series of Applications Technology Satellites and the cooperative U.S./Canadian Satellite (CAS-C) will continue to be used by various domestic and international experimenters to demonstrate innovative application of communications satellites. A significant effort will be undertaken to provide technical consultation and support in preparation for the 1979 World Administrative Radio Conference.

An important new initiative in FY 1978 is a cooperative program with Canada that will lead to demonstration of a satellite-aided Search and Rescue System. The Search and Rescue System will employ

sensitive receivers and high gain antennas to be carried on operational polar-orbiting meteorological spacecraft to demonstrate the feasibility of obtaining a significant increase in the capability to detect and locate distress signals from general aviation aircraft and marine vessels.

The Applications Explorer Missions program consists of relatively low cost Scout-launched spacecraft tailored to specific requirements. Missions under development include the Heat Capacity Mapping Mission, which will obtain temperature and heat retention data for applications to mineral-potential assessments, studies of soil moisture, mapping of thermal effluents, measurement of plant canopy temperature, and mapping of snow coverage; the Stratospheric Aerosol and Gas Experiment, which will help develop measurement techniques for the detection and mapping of aerosols and ozone; and the Magnetic Field Satellite, which will map the magnitude and direction of the earth's global magnetic field with improved accuracy.

AERONAUTICS AND SPACE TECHNOLOGY

The objective of the Aeronautics program is the advancement of aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs. This technology is necessary to help maintain the 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 a variety of aircraft types. These efforts are integrated with additional focused technology efforts to develop advanced long haul and short haul air transportation system concepts.

In FY 1978, the program places major emphasis on the aircraft energy efficiency technology efforts with initiation of the second phase of activities on an energy efficient engine and energy efficient transport and initiation of a systems technology effort on an advanced turboprop.

The objectives of the Space Research and Technology program are to provide a technology base which will adequately support current and future space activities, and to implement approaches for further reducing the costs of future space activities through standardization of components.

Research and technology efforts 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; providing a "no-moving-part" data storage system for aerospace vehicles; developing multipurpose user-oriented software technology to reduce future software development costs; and demonstrating the technology readiness of an advanced planetary orbiter spacecraft propulsion system. In the Space Technology Payloads area, the FY 1978 budget provides for continuing and expanding efforts on the definition and development of space technology experiments and equipment designed to capitalize on the capabilities of the Shuttle and Spacelab. In the Low Cost Systems area, the primary emphasis will continue to be on the development and improvement of various standard spacecraft components to further reduce the overall cost of space systems.

ENERGY TECHNOLOGY APPLICATIONS

Energy technology identification and verification efforts in NASA are primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on earth 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. NASA is also conducting technical studies to define a feasible solar satellite power system. NASA will continue to make its capabilities and facilities available to ERDA and other agencies, as requested, to accomplish energy technology activities on a reimbursable basis.

TRACKING AND DATA ACQUISITION

This program provides for continuation of tracking and data acquisition support for earth 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 are also provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

The FY 1978 support workload will remain high, with the Spaceflight Tracking and Data Network supporting an average of approximately 50 earth orbital scientific and applications spacecraft and the Deep Space Network supporting a full complement of planetary missions. Upcoming missions to be supported by the Spaceflight Tracking and Data Network include the High Energy Astronomical Observatories, the International Ultraviolet Explorer, Seasat-A, the Heat Capacity Mapping Mission, Landsat-C, Nimbus-G, and many other international missions and missions of other U.S. agencies. The Spaceflight Tracking and Data Network will also be supporting the Shuttle approach and landing tests. Additions to the support workload of the Deep Space Network include the Viking extended mission and the Mariner Jupiter/Saturn missions in 1977, as well as the Pioneer Venus missions in 1978.

A major aspect of the Tracking and Data Acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA will acquire this capability through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in FY 1980.

TECHNOLOGY UTILIZATION

The objective of this program 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, [$2,761,425,000] *$3,011,000,000,* to remain available until expended. *(42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1977; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Development

Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed)				Costs and obligations			
	1976 actual	TQ actual	1977 estimate	1978 estimate	1976 actual	TQ actual	1977 estimate	1978 estimate
Program by activities:								
Direct program:								
1. Space flight:								
(a) Space shuttle	1,206,000	321,000	1,288,100	1,349,200	1,165,905	331,253	1,288,000	1,354,300
(b) Space flight operations	188,674	48,400	202,200	267,800	226,644	51,472	216,000	260,100
(c) Expendable launch vehicle development and support	95,900	24,900	91,800	81,600	87,671	26,031	92,300	91,600
2. Scientific investigations in space:								
(a) Physics and astronomy	184,300	48,800	187,100	251,100	182,662	44,432	171,800	241,400
(b) Lunar and planetary exploration	292,150	73,564	217,100	162,000	304,907	68,507	242,200	163,800
(c) Life sciences	20,576	5,436	22,125	33,300	18,040	5,734	21,000	30,600
3. Space applications	185,330	48,500	211,800	243,000	203,175	60,087	223,600	233,300
4. Space research and technology	74,900	19,300	82,000	97,700	78,724	20,503	80,500	91,100
5. Aeronautical research and technology	175,350	43,800	190,100	231,000	175,339	44,224	192,000	215,000
6. Energy technology applications	5,900	1,500	6,000	4,500	4,902	1,090	6,000	5,200
7. Supporting activities:								
(a) Tracking and data acquisition	240,800	63,400	255,000	281,700	263,766	66,621	265,000	280,000
(b) Technology utilization	7,500	2,000	8,100	8,100	7,211	2,004	7,600	7,800
Total direct program costs, funded	2,677,380	700,600	2,761,425	3,011,000	2,718,946	721,958	2,806,000	2,974,200
Reimbursable program:								
1. Space flight:								
(a) Space shuttle	10	250	250	250	10	----------	410	260
(b) Space flight operations	5,294	1,420	4,620	4,700	4,782	1,618	6,750	4,720
2. Scientific investigations in space:								
(a) Physics and astronomy	11,859	18	9,310	1,200	7,329	1,349	5,900	4,830
(c) Life sciences	88	----------	20	----------	113	65	30	10
3. Space applications	156,759	34,124	213,350	186,140	193,729	56,395	214,570	197,200
4. Space research and technology	1,408	−1,241	60	60	1,102	281	620	60
5. Aeronautical research and technology	20,503	2,857	16,120	15,950	21,607	3,871	22,950	16,180
6. Energy technology applications	35,401	10,016	98,700	143,000	16,356	9,351	89,930	128,420
7. Supporting activities:								
(a) Tracking and data acquisition	871	127	3,520	3,300	728	27	3,720	3,260
(b) Technology utilization	4,962	1,059	5,500	6,600	3,659	1,197	6,620	6,260
Total reimbursable program costs	239,155	48,630	351,500	361,200	249,415	74,154	351,500	361,200
Total program costs, funded	2,916,535	749,230	3,112,925	3,372,200	2,968,361	796,112	3,157,500	3,335,400
Change in selected resources (undelivered orders and stores)	----------	----------	----------	----------	−21,308	−45,977	268,417	36,800
10.00 Total	2,916,535	749,230	3,112,925	3,372,200	2,947,053	750,135	3,425,917	3,372,200
Financing:								
Offsetting collections from:								
11.00 Federal funds	−113,116	−25,872	−197,431	−247,582	−113,116	−25,872	−197,431	−247,582
14.00 Non-Federal sources	−126,039	−22,758	−154,069	−113,618	−126,039	−22,758	−154,069	−113,618
21.00 Unobligated balance available, start of period: For completion of prior period budget plans:								
Direct	----------	----------	----------	----------	−235,322	−191,938	−216,709	----------
Reimbursable	----------	----------	----------	----------	−110,033	−122,900	−96,283	----------
24.00 Unobligated balance available, end of period: For completion of prior period budget plans:								
Direct	----------	----------	----------	----------	191,938	216,709	----------	----------
Reimbursable	----------	----------	----------	----------	122,900	96,283	----------	----------
25.00 Unobligated balance lapsing	----------	----------	----------	----------	----------	941	----------	----------
40.00 Budget authority (appropriation)	2,677,380	700,600	2,761,425	3,011,000	2,677,380	700,600	2,761,425	3,011,000
Relation of obligations to outlays:								
71.00 Obligations incurred, net					2,707,898	701,504	3,074,417	3,011,000
72.00 Obligated balance, start of period					731,653	690,742	661,556	999,073
74.00 Obligated balance, end of period					−690,742	−661,556	−999,073	−1,086,773
90.00 Outlays					2,748,809	730,690	2,736,900	2,923,300

Note.—Reconciliation of budget plan to obligations:

	1976 actual	TQ actual	1977 estimate	1978 estimate
Total budget plan	2,916,535	749,230	3,112,925	3,372,200
Deduct portion of budget plan to be obligated in subsequent periods	152,724	107,932	----------	--------
Add obligations of prior period budget plans	183,242	108,837	312,992	--------
Total obligations	2,947,053	750,135	3,425,917	3,372,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

BUDGET PLAN SUMMARY

Code		FY 1976	Transition Quarter	FY 1977	FY 1978
			(Thousands of Dollars)		
	SPACE FLIGHT	1,560,574	406,500	1,668,700	1,753,500
253	Space shuttle	1,206,000	321,000	1,318,100	1,349,200
253	Space flight operations	188,674	48,400	199,200	267,800
253	Expendable launch vehicles	165,900	37,100	151,400	136,500
	SPACE SCIENCE	434,126	116,400	380,325	405,700
254	Physics and astronomy	159,300	43,500	166,300	224,200
254	Lunar and planetary exploration	254,250	67,464	191,900	148,200
254	Life science	20,576	5,436	22,125	33,300
	APPLICATIONS	178,230	47,700	198,200	228,800
254	Space applications	178,230	47,700	198,200	228,800
	AERONAUTICS AND SPACE TECHNOLOGY	250,250	63,100	272,100	328,700
405	Aeronautical research and technology	175,350	43,800	190,100	231,000
254	Space research and technology	74,900	19,300	82,000	97,700
254	ENERGY TECHNOLOGY APPLICATIONS	5,900	1,500	6,000	4,500
255	TRACKING AND DATA ACQUISITION	240,800	63,400	255,000	281,700
255	TECHNOLOGY UTILIZATION	7,500	2,000	8,100	8,100
	TOTAL	2,677,380	700,600	2,788,425	3,011,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code		FY 1976	Transition Quarter	FY 1977	FY 1978
			(Thousands of Dollars)		
253	Space Flight	1,560,574	406,500	1,668,700	1,753,500
254	Space Science, Applications and Technology	693,156	184,900	666,525	736,700
255	Supporting Space Activities	248,300	65,400	263,100	289,800
(250)	Subtotal, General Science, Space and Technology	2,502,030	656,800	2,598,325	2,780,000
405	Air Transportation	175,350	43,800	190,100	231,000
	Total	2,677,380	700,600	2,788,425	3,011,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL PERIOD
(Thousands of Dollars)

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
OFFICE OF SPACE FLIGHT, TOTAL	1976	1,560,574	945,237	103,291	335,483	10,097	38,495	821	10	1,474	242	10,913	97,732	16,779
	TQ	406,500	233,768	31,740	98,920	3,300	8,807	245	3	170	200	3,452	22,185	3,710
	1977	1,668,700	940,803	147,650	417,050	12,204	38,500	475	100	275	1,239	11,415	78,724	20,265
	1978	1,753,500	912,980	205,480	481,980	9,950	49,950	630	100	380	1,200	16,070	49,200	25,580
Space shuttle	1976	1,206,000	849,990	49,925	292,015	2,800	189	---	---	760	242	150	---	9,929
	TQ	321,000	208,245	20,400	88,700	700	---	---	---	---	200	27	---	2,728
	1977	1,318,100	837,803	88,800	374,300	5,700	---	---	---	150	1,239	115	---	9,993
	1978	1,349,200	780,600	133,500	418,400	3,800	---	---	---	---	1,200	100	---	11,600
Space flight operations	1976	188,674	95,247	37,301	43,468	7,297	850	821	---	714	---	307	255	2,414
	TQ	48,400	25,523	8,300	10,220	2,600	360	245	---	170	---	28	285	669
	1977	199,200	103,000	41,650	42,750	6,504	900	475	---	125	---	700	200	2,896
	1978	267,800	132,380	60,180	63,580	6,150	550	630	---	380	---	270	200	3,480
Expendable launch vehicles	1976	165,900	---	16,065	---	---	37,456	---	10	---	---	10,456	97,477	4,436
	TQ	37,100	---	3,040	---	---	8,447	---	3	---	---	3,397	21,900	313
	1977	151,400	---	17,200	---	---	37,600	---	100	---	---	10,600	78,524	7,376
	1978	136,500	---	11,800	---	---	49,400	---	100	---	---	15,700	49,000	10,500
OFFICE OF SPACE SCIENCE, TOTAL	1976	434,126	18,127	55	73,438	---	65,184	100,463	3,945	76,792	100	50,326	100	45,596
	TQ	116,400	3,670	---	20,458	---	18,300	26,746	1,075	19,936	---	15,789	---	10,426
	1977	380,325	18,324	60	50,289	---	80,685	82,945	5,468	64,082	100	25,926	1,510	50,936
	1978	405,700	22,808	200	79,030	---	96,299	70,368	7,350	57,642	100	20,468	1,200	50,235
Physics and astronomy	1976	159,300	1,387	---	73,050	---	55,620	1,659	3,890	6,115	---	1,324	100	16,155
	TQ	43,500	229	---	20,458	---	15,029	660	1,064	1,436	---	60	---	4,564
	1977	166,300	1,278	---	50,289	---	73,819	5,109	5,457	8,597	---	461	1,510	19,780
	1978	224,200	420	---	79,030	---	92,437	6,625	7,350	12,570	---	400	1,200	24,168
Lunar and planetary exploration	1976	254,250	10,815	---	22	---	9,564	97,306	55	62,103	---	49,002	---	25,383
	TQ	67,464	1,364	---	---	---	3,271	25,693	11	16,628	---	15,729	---	4,768
	1977	191,900	9,516	---	---	---	6,866	75,925	11	46,628	---	25,465	---	27,489
	1978	148,200	7,942	---	---	---	3,862	61,843	---	32,347	---	20,368	---	22,138
Life Sciences	1976	20,576	5,925	55	366	---	---	1,498	---	8,574	100	---	---	4,058
	TQ	5,436	2,077	---	---	---	---	393	---	1,872	---	---	---	1,094
	1977	22,125	7,530	60	---	---	---	1,911	---	8,857	100	---	---	3,667
	1978	33,300	14,446	200	---	---	---	1,900	---	12,725	100	---	---	3,929
OFFICE OF APPLICATIONS, (Space applications)	1976	178,250	31,585	610	6,926	611	88,514	18,109	5,168	8,078	---	9,327	3,647	5,655
	TQ	47,700	6,650	95	1,924	137	24,451	6,186	1,888	2,065	---	2,967	518	819
	1977	198,200	32,515	605	12,010	600	88,514	30,220	5,950	7,506	---	9,941	2,269	8,070
	1978	228,800	34,320	650	19,480	300	120,030	25,100	5,450	4,650	---	7,840	2,210	8,770
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1976	250,250	1,381	---	2,824	---	5,393	18,975	470	52,353	17,951	79,898	64,087	6,918
	TQ	63,100	261	---	665	---	1,376	5,493	250	10,077	5,347	22,439	15,208	1,984
	1977	272,100	1,747	---	4,615	---	6,047	21,341	545	41,935	17,863	101,039	71,550	5,418
	1978	328,700	2,850	---	5,820	---	7,000	20,500	500	46,900	14,450	128,850	95,750	6,580
Aeronautical research and technology	1976	175,350	627	---	780	---	100	1,295	415	44,132	17,181	62,053	45,302	3,465
	TQ	43,800	85	---	186	---	---	347	235	8,201	5,347	17,836	10,334	1,229
	1977	190,100	810	---	750	---	100	915	490	34,026	17,863	80,355	52,764	2,027
	1978	231,000	810	---	950	---	---	1,000	500	37,700	14,250	99,950	72,350	3,490
Space research and technology	1976	74,900	754	---	2,044	---	5,293	17,680	55	8,221	770	17,845	18,785	3,453
	TQ	19,300	176	---	479	---	1,376	5,146	15	1,876	---	4,603	4,874	755
	1977	82,000	937	---	3,865	---	5,947	20,426	55	7,909	---	20,684	18,786	3,391
	1978	97,700	2,040	---	4,870	---	7,000	19,500	---	9,200	200	28,400	23,400	3,090
ENERGY TECHNOLOGY APPLICATIONS	1976	5,900	404	---	902	---	340	2,732	---	75	20	---	1,383	44
	TQ	1,500	225	---	122	---	---	619	---	239	---	---	269	26
	1977	6,000	1,300	---	1,400	---	---	1,155	---	100	---	---	2,000	45
	1978	4,500	500	---	600	---	---	800	---	100	---	---	2,500	---
OFFICE OF TRACKING AND DATA ACQUISITION	1976	240,800	---	---	---	---	168,279	52,489	4,700	---	2,267	---	---	13,065
	TQ	63,400	---	---	9	---	43,909	14,641	1,023	---	831	---	---	2,987
	1977	255,000	---	---	---	---	177,300	55,300	5,000	---	3,000	---	---	14,400
	1978	281,700	---	---	---	---	199,700	57,200	5,200	---	3,300	---	---	16,300
OFFICE OF TECHNOLOGY UTILIZATION	1976	7,500	435	110	422	53	391	630	15	800	---	900	55	3,689
	TQ	2,000	100	---	10	10	128	134	---	206	---	151	5	1,256
	1977	8,100	450	100	600	50	500	650	15	800	35	700	250	3,950
	1978	8,100	450	100	600	50	500	650	15	800	35	700	250	3,950
TOTAL BUDGET PLAN	1976	2,677,380	997,169	104,066	419,995	10,761	366,596	194,219	14,308	139,572	20,580	151,364	167,004	91,746
	TQ	700,600	244,674	31,835	122,108	3,447	96,971	54,064	4,239	32,693	6,378	44,798	38,185	21,208
	1977	2,788,425	995,139	148,415	485,964	12,854	391,546	192,086	17,078	114,698	22,237	149,021	156,303	103,084
	1978	3,011,000	973,908	206,430	587,510	10,300	473,479	175,248	18,615	110,472	19,085	173,428	151,110	111,415

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE FLIGHT PROGRAMS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Space Shuttle	1,206,000	321,000	1,288,100	1,318,100	1,349,200
Space Flight Operations	188,674	48,400	205,200	199,200	267,800
Expendable Launch Vehicles	165,900	37,100	151,400	151,400	136,500
Total	1,560,574	406,500	1,644,700	1,668,700	1,753,500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Design, Development, Test and Evaluation....	1,206,000	321,000	1,288,100	1,318,100	1,207,500
Orbiter.....	867,335	216,300	842,500	874,100	690,500
Main engine.....	140,800	37,900	193,800	178,400	219,900
External tank.....	82,240	26,000	64,000	81,000	80,000
Solid rocket booster.....	65,700	20,400	82,600	95,800	83,600
Launch and landing.....	49,925	20,400	105,200	88,800	133,500
Production.....	---	---	---	---	141,700
Total.....	1,206,000	321,000	1,288,100	1,318,100	1,349,200
Distribution of Program Amount by Installation:					
Johnson Space Center.....	849,990	208,245	814,500	837,803	780,600
Kennedy Space Center.....	49,925	20,400	105,200	88,800	133,500
Marshall Space Flight Center.....	292,015	88,700	353,200	374,300	418,400
National Space Technology Laboratories....	2,800	700	4,200	5,700	3,800
Goddard Space Flight Center.....	189	---	---	---	---
Ames Research Center.....	760	---	---	150	---
Dryden Flight Research Center.....	242	200	---	1,239	1,200
Langley Research Center.....	150	27	---	115	100
Headquarters.....	9,929	2,728	11,000	9,993	11,600
Total.....	1,206,000	321,000	1,288,100	1,318,100	1,349,200

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. The Shuttle will be the first reusable space vehicle and will be configured to carry many different types of payloads to and from low earth orbit. Its development will provide multipurpose, economical space operations for earth applications, scientific, defense and technological payloads. The Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable launch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions. These capabilities will greatly enhance the flexibility and produtivity of the missions and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements--the orbiter, the main engines, an external propellant tank and twin solid rocket boosters--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 propelled by three liquid fueled reusable main engines. 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) (24 nautical miles), the solid rocket boosters burn out, are separated and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) down range. They will then be recovered for refurbishment and reuse. The orbiter will continue on into space, powered by its three main engines, for another six and one-half minutes. Just before orbital insertion, the engines will be shut down and the external tank will be jettisoned. Following a ballistic trajectory, the empty tank will tumble out of

space and break up over 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 reenter the atmosphere for its approach and landing.

The Space Shuttle will have a flight crew of three: the commander, the pilot, and a mission specialist. On some missions one or more payload specialists will be added to check out and operate payloads. The Shuttle can provide a habitable environment for the crew including scientists and engineers, for missions up to thirty days in duration. 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 a shirt-sleeve environment.

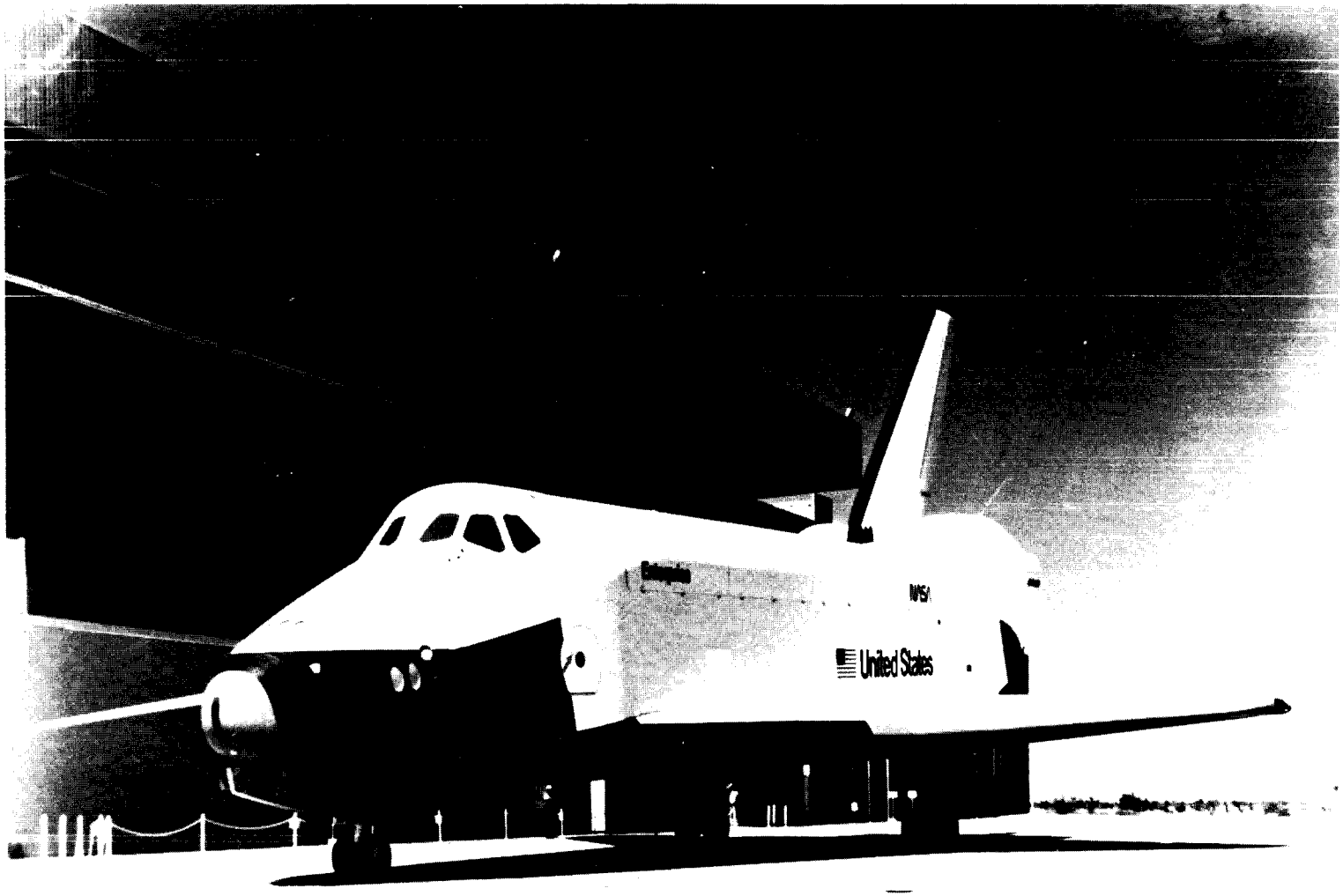
STATUS:

Space Shuttle development is well underway and in the period of peak effort 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. Assembly of Orbiter No. 1 has been completed and rollout occurred on September 17, 1976. Final subsystem installation and integrated testing are proceeding in preparation for the planned captive flight tests of the orbiter mated with the carrier aircraft to begin in the first half of 1977. Modification of the 747 carrier aircraft to be used for these tests has been completed and flight testing is underway. The approach and landing tests will verify the performance of the orbiter for the low altitude subsonic portion of the return from an orbital mission.

Work has also progressed on fabrication of the major structures for Orbiter No. 2, which will be used for the manned orbital test flights to start in 1979. During FY 1977, the mid fuselage and payload bay doors will be shipped to Palmdale, California for orbiter assembly. In addition, a number of major test articles will be completed this year and testing will be initiated.

During FY 1977, main engine tests are being conducted on components at Santa Susana, California, and on test engines at the National Space Technology Laboratories (NSTL) in Mississippi. Assembly and welding of the liquid oxygen tank, the liquid hydrogen tank, and the intertank will be completed on the external tank main propulsion test article during FY 1977 at the Michoud Assembly Facility in Louisiana, and delivered to NSTL for testing. Early in FY 1977 the first solid rocket motor development case was delivered to the motor contractor, Thiokol Corporation. The first development motor will be static fired toward the end of the fiscal year.

Design and procurement were initiated for the computerized launch processing system and for models of ground support equipment to be used at the Kennedy Space Center (KSC) in Florida and at the Dryden Flight Research


NASA
United States

Center (DFRC) in California. Operational software has been developed by a KSC/IBM team, minicomputer deliveries are continuing, and simulation support is being provided for checkout procedures development.

The FY 1978 activities will support preparations for the first manned orbital flight in 1979. Following the approach and landing tests, Orbiter No. 1 will be transported to the Marshall Space Flight Center in Alabama for the mated ground vibration tests. The second orbiter, which is to be used for the first manned orbital flight, will be assembled and checked out at Palmdale, California, and delivered in the latter half of 1978 to the Kennedy Space Center in Florida, where it will begin preparations for launch. The first set of flight engines will be tested at the National Space Technology Laboratories in Mississippi and, with associated ground support equipment, will also be delivered to the Kennedy Space Center for installation on Orbiter No. 2 in the latter half of 1978. The main propulsion test article test firing series will be continued in 1978.

In support of the mated ground vibration tests, the Marshall Space Flight Center in Alabama will receive the external tank and the solid rocket booster, which together with Orbiter No. 1 complete the Shuttle test vehicle assembly. Solid rocket motor development and qualification firings are planned in FY 1978. In addition, solid rocket booster components for the first orbital flight will be delivered to the Kennedy Space Center in Florida during FY 1978.

Components of the launch processing system (LPS) at KSC will be delivered and the software validated. Integration with the other ground support equipment will continue throughout FY 1978 at KSC.

Shuttle production activities will provide for refurbishment and modification of the two orbiters being used in the development program and production of three additional orbiters to establish a total national fleet of five orbiters. The funding requested in FY 1978 will provide for long lead procurements for Orbiters 3, 4, and 5; initial hardware fabrication for modifying Orbiter No. 1 to an orbital capability; the start of primary structures fabrication for Orbiter No. 3; and long lead procurement for the main engines required for the five orbiter fleet.

In summary the major activities planned in FY 1978 related to the Space Shuttle system are as follows:

- Completion of the approach and landing test program at the Dryden Flight Research Center in California.

- Initiation of main propulsion system testing at the National Space Technology Laboratories in Mississippi.

- Performance of mated vertical ground vibration testing at the Marshall Space Flight Center in Alabama.
- Verification of the software for the first manned orbital flight in the software development laboratory.
- Completion of Orbiter No. 2 in preparation for delivery to the Kennedy Space Center in Florida for the first manned orbital flight.
- Initiation of production leading to a national fleet of five orbiters.
- Initiation of main engine production of flight engines.

CHANGE FROM FY 1977 BUDGET ESTIMATE:

The current estimate for the FY 1977 Space Shuttle activities has increased by $30.0 million. This additional FY 1977 funding will be made available from the reprogramming of $27.0 million in savings from the Apollo Soyuz Test Project plus $3.0 million from FY 1977 Space Flight Operations funds. This FY 1977 increase represents a rephasing of the program funding requirements and not an increase in the Shuttle development cost estimate of $5.220 billion in 1971 dollars. The Congress has been notified of this planned reprogramming action, consistent with the Section 4 provisions of the NASA Authorization Act, 1975 and 1977.

The additional $30.0 million in FY 1977 is required during this critical development phase to provide increased assurance of timely availability of test article hardware for the major ground test programs, which is paced by the main propulsion system test at NSTL, and of meeting the current development schedule for orbiter captive and free flight testing at the Dryden Flight Research Center.

Orbiter

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Orbiter	867,335	216,300	842,500	874,100	690,500

OBJECTIVES AND STATUS:

The orbiter will be a reusable vehicle with the capability for a variety of 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.

FY 1977 is a year of intensive activity on the Space Shuttle Program in manufacturing and ground and flight testing as well as the certification of components and subsystems. Orbiter No. 1 manufacturing and assembly has been completed at the Rockwell International/Space Division plant in Palmdale, California and an integrated checkout will be completed prior to transporting the orbiter overland to the Dryden Flight Research Center (DFRC) in California in early 1977. The design certification review was held in December 1976, at which time the design of the orbiter and the modified Boeing 747 carrier aircraft were certified for the approach and landing test program.

Modification of the 747 carrier aircraft has been completed at the Boeing plant located at Renton, Washington, and the aircraft is now undergoing ground and flight testing. It will be delivered to DFRC in January 1977 to support the approach and landing test program. Unmanned and manned orbiter/747 captive flights, leading to the approach and landing flights, will begin in the first half of 1977.

Major structural assemblies for Orbiter No. 2 will be delivered to Palmdale, California, and individual systems installation and checkout will continue during 1977 and early 1978.

The main propulsion test article (MPTA), consisting of a steel truss structure and a flight type orbiter aft fuselage will be delivered to the National Space Technology Laboratories (NSTL) in Mississippi in late FY 1977. The Space Shuttle main engines will be installed into the orbiter aft fuselage at NSTL, where propulsion and acoustic testing will be performed in FY 1978.

The flight type structural test articles, consisting of an orbiter airframe and a separate crew module, are now being fabricated. The flight type orbiter airframe with a mass simulating the crew module will complete manufacturing during FY 1977 and will be transferred to the Lockheed facility at Palmdale, California where structural testing will start in early 1978. This testing will subject the test article to limit, fatigue, and ultimate loads. The reaction frame for testing at Lockheed is in fabrication. Crew module structural test article testing will also be initiated in FY 1978.

The one-quarter scale model of the Space Shuttle system, consisting of the orbiter, external tank, and solid rocket boosters, will be completed and will be delivered in FY 1977 to the test location at Downey, California. Ground vibration testing of the individual quarter scale elements and of the quarter-scale mated Space Shuttle configuration will be completed in early 1978 and the results will be used to verify the analytically developed mathematical model. The data will be used to correlate with vibration data to be obtained during the full-scale ground vibration testing.

Certification testing is in progress on components and subsystems of Orbiter No. 1 and will be completed prior to the first free flights of the orbiter during the approach and landing test program.

The critical design review of the thermal protection system will be held in early 1977. The 95% complete drawing release for details, assemblies and installations for the Orbiter No. 2 thermal protection system will be made during 1977. Environmental testing will also be conducted and verification testing will continue.

Testing of the orbiter avionics subsystems is of major importance during FY 1977. Emphasis is being placed on hardware and software certification, installation and checkout for the approach and landing tests (ALT). Hardware and software testing and qualification for orbiter flight testing is proceeding. The avionics hardware/software required in Orbiter No. 1 for ALT certification have been delivered and testing has started in the Shuttle Avionics Integration Laboratory (SAIL) at the Johnson Space Center (JSC) in Texas, and in the avionics development laboratory operating with the flight control hydraulics laboratory at the Rockwell Space Division in Downey, California. Detailed design of Orbiter No. 2 avionics subsystems will continue through 1977. Modifications will be initiated during 1977 to the SAIL to convert to the orbital flight test configuration and incorporate the launch processing system controls. Design of the mated element simulator by the Marshall Space Flight Center (MSFC) in Alabama is now underway to support delivery to the SAIL during FY 1978.

Design reviews of the S-Band communications equipment for Orbiter No. 2 will be completed in FY 1977. The Ku-Band communications and radar systems contractor started work in November 1976 and a design review of these subsystems will be held early in 1977.

In addition, support activities managed by the Johnson Space Center include developing and acquiring simulators and crew trainers, completion of the 747 carrier aircraft modifications, supplying Government furnished equipment such as space suits, and performing many tests and studies required to support the orbiter project.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The Orbiter project funding requirements for FY 1977 have increased by $31.6 million. This increase stems from technical difficulties in development and qualification testing of subsystems, such as the high temperature reusable surface insultation, auxiliary power unit and the propellant feed lines. In addition, the increase reflects the impact of technical changes, such as the Ku-Band rendezvous radar and double density memory capability for the on-board computer; the orbiter avionics software development problems; increased requirements in the integration of flight software and hardware for the approach and landing and orbital test programs; and higher Rockwell burden rates for development effort resulting from the FY 1977 Budget decision to defer the start of Orbiter production to FY 1978.

BASIS OF FY 1978 ESTIMATE:

FY 1978 activities will include the completion of the approach and landing test (ALT) program, continuation of development qualification and verification test activity to support the first manned orbital flight, and the delivery of Orbiter No. 2 to the Kennedy Space Center in Florida in late 1978. The purpose of the approach and landing test program is to test the orbiter's capability to accomplish approach and landing maneuvers in various control modes and center of gravity locations. The orbiter will be separated from the 747 carrier aircraft at an altitude of 20 to 24 thousand feet and will land at the Dryden Flight Research Center in California. The ALT tests will be completed in early 1978.

Subsequent to successful completion of the ALT program, Orbiter No. 1 will be refurbished and delivered to the Marshall Space Flight Center (MSFC) for mated ground vibration testing with other elements of the Space Shuttle system. Delivery of Orbiter No. 1 to MSFC is scheduled for mid-1978.

A major activity in FY 1978 will be the final assembly and checkout of Orbiter No. 2 at the Palmdale, California plant of Rockwell International/Space Division, the orbiter prime contractor. All of the major structural subassemblies will be delivered to Palmdale, California and assembled during 1978. During the first half of 1978, major subsystems of this orbiter will be installed and checked out. In the latter half of 1978, Orbiter No. 2 will be mated to the 747 carrier aircraft and ferried to the Kennedy Space Center to prepare for the first manned orbital flight in 1979.

Development and verification testing of major test articles will continue during FY 1978. The main propulsion test article (MPTA), consisting of the truss structure with flight type aft fuselage, external tank, and the main engines, will undergo static firing at the National Space Technology Laboratories in Mississippi; the structural test article airframe will undergo load tests at the Lockheed Palmdale, California facility; and the crew module structural test article will be assembled to support the start of structural tests in mid-1978.

Test facility activation at the Marshall Space Flight Center in Alabama will be completed in early FY 1978. Orbiter No. 1, an external tank and solid rocket boosters will be delivered and the full scale mated ground vibration tests will begin.

Characterization and materials testing of the thermal protection system (TPS) will continue during FY 1978. Manufacture of reusable surface insulation tiles and the reinforced carbon-carbon surfaces for Orbiter No. 2 will proceed through the fiscal year. Also during FY 1978, qualification testing of the major parts of the life support system will be completed such as the active thermal control system; food, water, and waste management; and the atmospheric revitalization system.

The emphasis during FY 1978 on avionics subsystems will shift from support of the ALT flights to providing support to the orbital flight test (OFT) program. Qualification of the S-Band communication equipment in Orbiter No. 2 will be completed and a design review for the S-Band payload communication interface equipment will be completed. The design review for the Ku-Band communication/radar equipment will be completed in the second quarter of 1978 and certification tests for this equipment will start late in 1979. End-to-end S-Band space-to-ground compatibility and performance tests for the space tracking data network, Air Force Space Control Facility and the tracking and data relay satellite links will be conducted at the electronic system test laboratory at the Johnson Space Center in Texas.

Software development, integration and performance analyses, and detailed design of the OFT software packages represent major avionics activities during FY 1978. Coding and checkout of early releases of the entry, ascent, on-orbit and abort packages will be accomplished in early 1978.

Simulations will be conducted in the avionics development laboratory at the Rockwell Space Division plant in Downey, California to develop and confirm the design of the flight control system with refined data on structural forces (loads), aerodynamic effects and flight trajectories. The mated element simulator from the Marshall Space Flight Center in Alabama will be delivered and integrated with other orbiter systems for testing at the Shuttle Avionics Integration Laboratory (SAIL) at the Johnson Space Center in Texas.

Certification of the orbital flight test hardware and software configuration will begin during FY 1978. The SAIL will be used to develop and demonstrate the launch processing system avionics software and system interfaces. A simulated flight checkout test will be demonstrated on the SAIL and conducted on Orbiter No. 2 to verify the overall systems operation in the flight configuration using the actual orbital flight hardware.

Orbiter support tasks will continue during FY 1978. Reaction control subsystems testing, and the integration testing of the reaction control system and the orbital maneuvering subsystem will be conducted at the White Sands Test Facility in New Mexico. The Shuttle mission simulator will be used to start crew

training in mid-1978 for the orbital flight tests. A motion base crew station and a fixed base crew station will be utilized both with cabin and console instrumentation similar to the actual orbiter forward cabin. The Shuttle procedures simulator will also continue to support simulations and studies during this period. Analyses will be made of Space Shuttle trajectories, orbit determination, and guidance and navigation systems. Design and development will continue on the extravehicular mobility units (EMU) in FY 1978 and certification of the development units will proceed. Flight and training EMU's for the development phase of the Shuttle program will be manufactured during this period.

Modification of the Johnson Space Center mission control center (MCC) to support the orbital flight tests will continue during FY 1978 in the areas of communications and computer systems and software development. NASA will also continue logistics support, perform wind tunnel tests and evaluations, and perform systems integration tasks as required for the approach and landing tests and the orbital flight tests.

In summary, the following major activities are included in the plan for the orbiter project in FY 1978:

- Completion of approach and landing tests to verify the aerodynamic and landing characteristics of the orbiter.
- Delivery of Orbiter No. 1 to the Marshall Space Flight Center in Alabama for mated vertical ground vibration testing.
- Completion of assembly and checkout of the orbiter crew module structural test article.
- Continuation of structural testing on the orbiter airframe test article at Palmdale, California.
- Completion of assembly and checkout of Orbiter No. 2 in preparation for delivery to Kennedy Space Center for the first manned orbital flight.
- Supporting efforts, including software development, training activities, and preparation for orbital flight mission control and operations.
- Continuation of main propulsion system testing at the National Space Technology Laboratories in Mississippi.

Main Engine

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Main Engine	140,800	37,900	193,800	178,400	219,900

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 1977, the prime contractor, Rocketdyne Division of Rockwell International, is testing and fabricating 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 for FY 1978. Engine firings conducted at the National Space Technology Laboratories in Mississippi recently attained 100 percent of the required power. Fabrication of the main propulsion test article engines to support the main propulsion test activity scheduled for early 1978 will be completed. During FY 1977, manufacturing of the initial set of flight engines was started and this set will be delivered to KSC in late 1978.

Main engine testing at NSTL has experienced some delays due to the subsynchronous whirl and heating problems experienced on the high pressure fuel turbopump. Recent testing provides evidence that these problems have been solved. The test program for the remainder of FY 1977 and for FY 1978, will allow for the schedule recovery and support of the first manned orbital flight in mid-1979.

In addition to the development work by Rocketdyne and subcontractors, 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.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

Main engine funding for FY 1977 has been decreased by $15.4 million. This decrease represents the rephasing of project requirements based on revised engine deliveries, consistent with current projected need dates, and deferred logistics support requirements based on revised engine test schedules.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding requirements for the main engine development provide for intensive test activity. Engine component certification testing will continue at Santa Susana on components such 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 certify their performance and reliability characteristics for flight operations. Concurrent with component testing at Santa Susana, California, testing of flight configured engines will be conducted at the National Space Technology Laboratories (NSTL) in Mississippi to demonstrate engine flight readiness.

Main propulsion system verification tests of three engines combined with the orbiter and external tank test articles will be conducted at NSTL during FY 1978. These tests will include verification of the engine longitudinal oscillation (POGO) suppression system.

The first three flight engines will be completed, acceptance tested at NSTL, and shipped to the Kennedy Space Center (KSC) in Florida in late 1978. Prior to this time, the engine ground support equipment necessary to support engine installation, checkout, and operational support of the first manned orbital flight will be delivered to KSC.

Project support tasks to be continued at the Marshall Space Flight Center in Alabama include providing the hardware for the engine systems hardware simulation laboratory to conduct control system and dynamic operations testing, engine software integration support activities, and assessments of engine controller components. In addition, project support funding will provide for procurement of main engine propellants required for the test programs at both NSTL and Santa Susana.

In summary, major activities planned in the main engine project in FY 1978 include:

- Continuation of engine component testing at Santa Susana, California
- Continuation of engine system testing at the National Space Technology Laboratories in Mississippi.

- Completion of delivery of the ground support equipment for engine installation at the Kennedy Space Center in Florida.

- Delivery of three engines to the National Space Technology Laboratories in Mississippi to support the main propulsion test program.

- Completion of assembly of the first set of flight engines for the first manned orbital flight.

External Tank

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
External tank.....	82,240	26,000	64,000	81,000	80,000

OBJECTIVES AND STATUS:

The external tank will contain all the propellants for the three orbiter main engines--liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the orbiter's main engines from 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 and break up over 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, Colorado 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.

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, materials, and processes are being employed to the maximum extent

consistent with maintaining safety and reliability. Six large tools are common to the fabrication of domes and barrel sections for both of the propellant tanks. Extremely lightweight one-inch thick foam insulation will be applied to the outer surface of the external tank.

In FY 1977, major assembly and welding operations will be completed on the liquid hydrogen and liquid oxygen tanks, as well as on the intertank for the main propulsion test article at the Michoud Assembly Facility in Louisiana. These three major portions of the tank will be assembled into a complete tank for delivery to the NSTL test site in late 1977.

Assembly of the structural test article intertank and simulators for testing at the Marshall Space Flight Center in Alabama are in the final phase to support a delivery to the test site in mid-FY 1977.

CHANGES FROM FY 1977 ESTIMATE:

The external tank estimate for FY 1977 has increased by $17.0 million. This increase results primarily from the impact of technical changes necessitated by revised structural loads, vibroacoustic, and thermal requirements identified from systems wind tunnel testing, as well as the design and engineering changes necessary to reduce frost formation and prevent ice from the external tank from damaging the orbiter's thermal protection system. In addition, project support increases such as utilities rate growth at the Michoud Assembly Facility and the Slidell Computer Complex, and additional in-house systems test and analysis activities have contributed to the increase in FY 1977.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, a complete load test of the first intertank structural test article will be accomplished at the Marshall Space Flight Center (MSFC) in Alabama to verify the structural integrity. Later a second intertank test article and liquid hydrogen and liquid oxygen structural test articles will each be completely assembled and delivered to MSFC for structural verification testing. The design of the test support equipment will also be completed.

Assembly of the external tank ground vibration test article will be accomplished by mid-FY 1978. This tank will be shipped to MSFC where it will be assembled with two solid rocket boosters and Orbiter No. 1. The mated ground vibration tests will expose the vehicle to vibration environments, which will verify mathematical models of vehicle dynamics, including flutter, flight control, loads, and longitudinal oscillations called POGO.

In the second half of 1978, the first orbital flight external tank will be completely assembled, acceptance tested, and prepared for shipment to the Kennedy Space Center in Florida. Assembly of the second, third, and

fourth flight tanks will continue, and component fabrication and initial assembly operations will begin on the fifth and sixth flight tanks.

The following represents a summary of the major activities planned in the external tank project in FY 1978:

- o Completion of load testing on the intertank structural test article
- o Delivery of the external tank liquid oxygen and liquid hydrogen structural test articles to the Marshall Space Flight Center in Alabama
- o Completion of delivery of the external tank main propulsion test article to the National Space Technology Laboratories in Mississippi
- o Initiation of final assembly of the first flight tank for the first manned orbital flight
- o Completion of assembly and delivery of the external tank ground vibration test article to the Marshall Space Flight Center in Alabama for mated ground vibration tests.

Solid Rocket Booster

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Solid Rocket Booster.....	65,700	20,400	82,600	95,800	83,600

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 SRB's will descend by parachutes and land in the ocean about 260 kilometers (140 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 in 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 in Alabama will perform designated systems integration tasks and has the responsibility for total systems integration of the solid rocket booster effort.

In FY 1977 the first development motor case was delivered to Thiokol. Development motor No. 1 will be loaded with propellant in mid-FY 1977 and static fired late in the fiscal year. Development motor No. 2 is scheduled for test firing in early FY 1978.

In FY 1977 the solid rocket booster critical design review and the deceleration subsystem preliminary design review were completed. The full scale development test firings of four booster separation motors were also completed with preparations underway for conducting a second set of four motor firings. Integrated system testing for the electrical and instrumentation verification test program will be initiated.

In addition to initiation of testing of major components, FY 1977 activities included selection of the booster assembly contractor, United Space Boosters, Inc., a division of United Technologies. This contractor will be responsible for assembly, check-out and refurbishment of the booster at the Kennedy Space Center in Florida.

CHANGES FROM FY 1977 ESTIMATE:

The Solid Rocket Booster estimate for FY 1977 has increased by $13.2 million. This increase is the result of design and development problems on the nozzle and tooling for the solid rocket motor, and technical changes to the SRB structures, thrust vector control, and electrical and instrumentation subsystems based on wind tunnel testing.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 extensive efforts will be devoted to manufacture, propellant loading, and delivery of solid rocket motors. Two development motors will be fired early in this period to complete the development test series of four motors. These will be followed by the first two qualification motor firings near the end of FY 1978. In addition, four dynamic test motors will be manufactured and delivered to MSFC for ground testing. Solid rocket motors for the first orbital flight will also be manufactured and delivered to the Kennedy Space Center in Florida during the latter half of 1978.

A major activity on the solid rocket booster project during FY 1978 will be the continuation of the qualification and verification test program. This will include the completion of the electrical and instrumentation verification testing, the drop test program to verify the recovery system parachutes, completion of booster

separation motor development and qualification static firings, and the verification of the overall thrust vector control system. In addition, the fabrication of flight hardware will continue and the hardware required for the first orbital flight will be delivered to KSC. The booster assembly contractor will check and assemble this hardware and will also continue with planning and activation of a solid rocket booster refurbishment facility.

A summary of the major activities planned in the solid rocket booster project in FY 1978 includes the following:

- Delivery of the first flight set of booster components to the booster assembly contractor at the Kennedy Space Center in Florida.
- Completion of development firings of the solid rocket motor at Thiokol.
- Delivery of two sets of solid rocket booster test articles to the Marshall Space Flight Center in Alabama for mated vertical ground vibration tests.
- Initiation of assembly and checkout of the first flight set (2) of solid rocket boosters by the booster assembly contractor at the Kennedy Space Center in Florida for the first manned orbital flight.

Launch and Landing

	FY 76 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)			
Launch and Landing	49,925	20,400	105,200	88,800	133,500

OBJECTIVES AND STATUS:

The Shuttle launch and landing project includes the preparation of a series of Shuttle landing, ground processing and launch station sets at the Kennedy Space Center (KSC) in Florida, and the Dryden Flight Research Center (DFRC) in California and their operation through the approach and landing test (ALT) and orbital flight test (OFT) phases. These station sets include handling, testing and servicing systems and ground support equipment and are identified by the function they perform or the facility into which they are incorporated. At KSC, the launch control center contains the heart of the computerized automated launch processing system (LPS)

which connects to many of the above stations for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing.

Approximately 845 design models of ground support equipment (GSE) for the above station sets have been defined, including some 245 to be provided by the vehicle development contractors with the remaining 600 to be provided by separate GSE procurements. Design requirements have been established for essentially all of the GSE. Half of the procurement packages have completed design reviews and over 10% of them are on contract. Design and procurement of the remainder are planned within the next two fiscal years.

The launch processing system milestones are on schedule. The LPS hardware designed by KSC engineers for checkout of the solid rocket booster (SRB) electronics at Marshall Space Flight Center (MSFC) in Alabama was assembled, checked out and accepted by MSFC. The required operating software was successfully developed by the KSC/IBM team and the hardware and software have been installed at MSFC to meet the SRB checkout need date. Minicomputers have been delivered and will be used as part of the checkout, control, and monitoring subsystem (CCMS) being developed by the Martin Marietta Corporation. The CCMS design is complete and the initial system has been delivered to KSC for software development. Honeywell Information Systems, the central data subsystem (CDS) contractor, delivered and installed the primary and secondary computer systems with peripherals in the launch control center at KSC in 1976. Software simulation support is now being provided for checkout procedure development.

The development contractor on-site launch support efforts at KSC have been initiated with Rockwell International and Martin Marietta. The contractor is preparing test documentation for vehicle assembly, test servicing, checkout and launch requirements, process specifications and procedures. The booster assembly contractor's effort is scheduled to be initiated January 1, 1977.

CHANGE FROM FY 1977 BUDGET ESTIMATE:

Launch and landing funding for FY 1977 was decreased by $16.4 million. This decrease results primarily from the delay of ground support equipment procurements because of problems in structuring procurement packages to achieve a competitive environment and from the current projection of less technical change activity to the Launch Processing System hardware and software than previously anticipated. The procurement delays are not expected to impact major program schedule dates.

BASIS OF FY 1978 ESTIMATES:

The largest portion of the FY 1978 launch and landing funding is required for procuring the ground support equipment (GSE) units and incorporating them into the launch processing station sets. During FY 1978 procurement of the remaining GSE will be initiated.

Some of the major launch support systems to be completed in FY 1978 include the orbiter forward umbilical, tail service mast/umbilical, and external tank vent umbilical/access systems for providing fluid services and ground monitor and control up to the moment of launch; the SRB support holddown mechanisms to release the vehicle for lift-off; and the crew compartment access/egress arm for boarding the crew.

The launch processing system (LPS) hardware deliveries required to initiate processing of the first orbiter at KSC will be completed early in FY 1978. The final increment of hardware and system software for the central data subsystem will be delivered to KSC by mid-1978. Installation of the LPS checkout, control and monitoring subsystem and integration with other ground support equipment will continue through mid-1978. Operating systems software development, verification and validation will reach its highest level of activity during FY 1978.

The design engineering effort for the launch and landing project also will reach the peak activity level in FY 1978. This effort will provide for continuation of the design and procurement documentation (drawings, specifications, standards and criteria) for the launch support systems, LPS and GSE. In addition, engineering services will be devoted to equipment acceptance, installation, and training.

The development contractors' support activities at KSC and contractor manpower buildup will continue during FY 1978. Before the end of 1978 processing of the vehicle for the first orbital flight will begin. The launch team is also the operator of the launch processing station sets, launch support equipment, and the GSE. Detailed procedures for assembly, test, servicing, checkout, and launch of the total Shuttle flight vehicle will be developed.

In summary, major activities planned in the launch and landing project in FY 1978 include:

- o Completion of installation and checkout of the launch processing system hardware for the first manned orbital flight.
  - -- Checkout, control and monitoring subsystems
  - -- Central data subsystem
- o Continuation of systems installation and checkout in the orbiter processing facility, the hypergolic maintenance facility, and high bays 3 and 4 in the vehicle assembly building at the Kennedy Space Center in Florida to support the first manned orbital flight.

Production

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
			(Thousands of Dollars)		
Production	---	---	---	---	141,700

OBJECTIVES AND STATUS:

Shuttle production activities will provide for refurbishment and modification of the two orbiters being used in the development program and for production of three additional orbiters to establish a total national fleet of five orbiters. Orbiter No. 1, following completion of the approach and landing test flights in early 1978, will be upgraded to full manned orbital flight capability. Later, Orbiter No. 2 will be modified to operational status after the initial orbital flight tests are completed. Production also includes the fabrication of the flight engines. In addition, the ground and launch support equipment for the second series of ground processing stations at the Kennedy Space Center in Florida to permit simultaneous processing of two Shuttle vehicles and the flight equipment spares are part of the production activities.

BASIS OF FY 1978 ESTIMATES:

Procurement of components, materials and subsystems for Orbiters 3, 4, and 5 will be initiated during FY 1978. Purchasing of long lead items for these orbiters will be combined to obtain the most economical procurement.

Procurement of components and subsystems, and hardware fabrication will be initiated for the modification of Orbiter No. 1 during FY 1978. Wire harness and tubing fabrication will be started; subcontract procurement and fabrication will also be initiated for the orbital maneuvering/reaction control system pod, the freon coolant loop, the orbital maneuvering system engine, the reusable surface insulation, the leading edge structural subsystems and the atmospheric revitalization system.

The prime contractor will begin fabrication of primary structures for Orbiter No. 3, including the aft fuselage, the crew module, and the forward fuselage. Procurement of the payload bay doors and the avionics airborne hardware will also be initiated.

Subcontractor effort will be underway with the procurement and fabrication of main structural subsystems including the wings and the vertical stabilizer. Procurements and fabrication will be initiated for other

major subcontractor subsystems, including the orbital maneuvering system engine, the orbital maneuvering/reaction control system pod, the mass memory, the general purpose computer, the inertial measurement unit, the air revitalization system, and the power reactant storage assembly.

In addition to long-lead procurement efforts, activity on Orbiters 4 and 5 will include start of detail parts manufacturing for a number of subsystems such as wings, vertical stabilizer, orbital maneuvering system engine, orbital maneuvering/reaction control system pod, the air revitalization system, and the power reactant storage assembly.

Efforts on the main engines to be installed in the production orbiters will start in FY 1978 with the procurement of critical long-lead components. These include the hot gas manifold forgings, the engine nozzle jacket, the housings for the high pressure fuel and oxidizer turbopumps.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Space transportation system operations capability development	11,300	2,840	18,800	16,800	63,000
Development, test and mission operations	161,100	40,800	169,900	166,900	173,000
Advanced programs	12,074	3,500	13,000	12,000	10,000
Space transportation system operations	---	---	---	---	17,800
Planning and program integration	4,200	1,260	3,500	3,500	4,000
Total	188,674	48,400	205,200	199,200	267,800
Distribution of Program Amount by Installation:					
Johnson Space Center	95,247	25,523	100,988	103,000	132,380
Kennedy Space Center	37,301	8,300	42,940	41,650	60,180
Marshall Space Flight Center	43,468	10,220	51,557	42,750	63,580
National Space Technology Laboratories	7,297	2,600	7,000	6,504	6,150
Goddard Space Flight Center	850	360	400	900	550
Jet Propulsion Laboratory	821	245	550	475	630
Ames Research Center	714	170	365	125	380
Langley Research Center	307	28	200	700	270
Lewis Research Center	255	285	200	200	200
Headquarters	2,414	669	1,000	2,896	3,480
Total	188,674	48,400	205,200	199,200	267,800

OFFICE OF SPACE FLIGHT

SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Space Transportation System Operations Capability Development; the common support activities conducted under Development, Test and Mission Operations; Space Transportation System Operations; Advanced Programs; and Planning and Program Integration.

The Space Transportation Systems (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 STS Upper Stages, Multimission and Payload Support Equipment, Mission Control Center Upgrading (Level II), and Payload and Operations Support.

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.

Space Transportation System Operations will provide the transporation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on earth. The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab, and the upper stages into a versatile and economical system; accomplish mission planning; provide the recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

The Advanced Programs effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions. In support of this effort advanced development activities are conducted to obtain significant performance and reliability improvements and reduce future program risks and development costs through the effective use of new technologies.

The Planning and Program Integration effort focuses on insuring hardware and operational compatibility between payloads and STS elements, and on consolidating NASA's plans for utilizing the unique capabilities of the STS for early NASA missions.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SPACE TRANSPORTATION SYSTEM (STS) OPERATIONS CAPABILITY DEVELOPMENT

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacelab	6,100	1,300	10,500	8,000	24,500
Space transportation system upper stages	2,625	700	3,800	1,800	13,500
Multimission and payload support equipment	---	---	3,000	1,500	7,000
Mission control center (MCC) upgrading (Level II)	---	---	---	---	5,000
Payload and operations support	2,575	840	1,500	5,500	13,000
Total	11,300	2,840	18,800	16,800	63,000

OBJECTIVES AND STATUS:

The Space Transportation System Operations Capability Development activity includes five major areas of effort: Spacelab; Space Transportation System Upper Stages; Multimission and Payload Support Equipment; the Mission Control Center (MCC) Upgrading (Level II); and Payload and Operations Support.

The Spacelab is a major element of the space transportation system. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes developing a crew transfer tunnel and procurement of necessary mock-ups, trainers and ground support equipment not provided by ESA. Other activities include procurement of flight and ground hardware, and system activation activities which assure Spacelab compatibility with the orbiter and which will lead to an operational capability.

The STS Upper Stages, which consist of the Interim Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS), are an integral part of the space transportation system. They are expendable, propulsive stages to be used to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone. The IUS is being developed by the U.S. Air Force and will be operational in 1980. It will be used primarily for high energy lunar and planetary missions and for the delivery of up to 5,000 pound payloads to geosynchronous orbit. The SSUS is a spin-stabilized, solid propellant expendable upper stage sized to be used for Delta (1,250 pounds) and Atlas-Centaur (2,250 pounds) class payloads to be launched into synchronous orbit. It is to be fully operational in 1980.

Multimission and Payload Support Equipment consists of ground and flight hardware used for interfaces between the payloads and the space transportation system. This class of hardware will be developed into a standard, reusable inventory for all payloads.

The Mission Control Center Upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Upgrading the capability to the Level II configuration provides additional hardware, equipment, and software to configure the MCC with the flight capability to support two orbiters, a ground simulation network, and an MCC/launch site interface.

The Payload and Operations Support activity consists of four major areas of effort: Operations Management Support, Orbital Flight Test (OFT) Payload Support, Payload Operations Control Center (POCC), and OFT Payloads. The Operations Management effort focuses on determining the most efficient method of operating the Space Transportation System. The Orbital Flight Test Payload Support provides for integrating payloads on the OFT flights during the FY 1979-80 period. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads. The OFT Payloads effort focuses on developing experiments and operational missions that will demonstrate Shuttle capabilities.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 Spacelab funding will be used for incremental procurement of a flight hardware inventory from ESA and for NASA development and production of the crew transfer tunnel. Procurement will be initiated for two demultiplexers. Design and fabrication of a Spacelab simulator will also be initiated. Funding will support contractor effort in systems engineering, systems software, logistics and analytical integration activities.

FY 1978 funds will be used to continue the design and development of the NASA unique items to support the IUS mission planning and implementation. FY 1978 funds will be used to continue the development of SSUS hardware and airborne support equipment and to initiate test firings.

In addition, FY 1978 funds will provide for development of the following Multimission and Payload Support Equipment: cargo integration and test equipment, trace gas analyzer, intersite transportation equipment, payloads specialist station and a flexible multiplexer/demultiplexer. Initial funding for the Mission Control Center Upgrading (Level II) is required in FY 1978 to meet the operational flight schedule requirements for FY 1980. The upgrading will provide additional control equipment and consoles for multivehicle support. Effort will begin on data processing software for command and control, flight design and crew activities planning.

In FY 1978 funding will be required for operations management studies to determine requirements necessary to accommodate Shuttle utilization planning and to investigate long range operations planning for the STS. In addition, payload to orbiter interfaces will be defined, hardware designed and fabrication of that hardware initiated. Funds will be used to define the Payload Operations Control Center (POCC) requirements, as well as preliminary design, fabrication and testing of prototypes. FY 1978 funding will also be used for design and development of hardware required for the OFT payloads.

Spacelab

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
6,100	1,300	10,500	8,000	24,500

OBJECTIVES AND STATUS:

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from earth orbit in the cargo bay of the Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers to personally conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, of which nine are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA responsibilities include the design, development, production and delivery of the first Spacelab and associated ground support equipment to NASA, and the capability to produce additional Spacelabs. NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development of Spacelab operational capability and procurement of additional hardware needed to support NASA's missions.

FY 1977 funds are being applied to the development of the crew transfer tunnel linking the Spacelab to the Shuttle orbiter cabin. FY 1977 funds are also being used to procure verification flight test instrumentation consisting of sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems in the environment to which payloads will be subjected.

Procurement of equipment for the software development facility is being initiated in FY 1977. The equipment, consisting of terminals, a command data management system computer with interface device and spares will be used for maintenance, integration, verification checkout and distribution of the Spacelab software to be delivered by ESA. The facility must be operational when the Spacelab engineering model is delivered to the U.S. by ESA in late 1978. Contractor efforts are in progress at Johnson Space Center in support of Spacelab-to-Orbiter integration activities. The tasks include: systems analyses to develop data required for interface definition and integrated system performance, identification of integration hardware design, payload installation and removal requirements, technical support planning, preparation of interface control documentation, definition of crew station requirements, and establishment of ground support requirements. Procurement of Shuttle interface verification equipment is being initiated to support the ESA development effort. The equipment includes mechanical interface hardware and data signal equipment needed to ensure Spacelab-to-Orbiter interface compatibility. The Johnson Space Center will also procure utility kits and specialized attachment fittings to mate the various Spacelab configurations to the Orbiter.

Contractor efforts associated with the overall integration of Spacelab operations capability development are in process. Other support contractor activities are also in progress to provide for design engineering technical support and operations planning at the Kennedy Space Center, and to develop and maintain crew procedures data and system handbooks at the Johnson Space Center. In addition, procurement of ESA developed long lead hardware has been initiated to provide the minimum inventory of Spacelab flight elements to support up to twelve missions per year.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The Spacelab Program budget for FY 1977 was reduced from $10.5 million to $8.0 million. Half of that reduction ($1.3 million) resulted from the deletion of the high fidelity mockup/earth gravity trainer. The unit was intended for use at the Kennedy Space Center to verify the interfaces with the facilities (e.g., transportation, handling, payload changeout room, and vertical access); it was later to be shipped to the Johnson Space Center to serve as a crew trainer. Recent studies concluded that relocation of the engineering model from the Marshall Space Flight Center to the Kennedy Space Center will provide the capability for which the high fidelity mockup had been required at the launch center. Studies have also shown that training requirements at the Johnson Space Center can be satisfied by making minor modifications to available equipment and using that equipment intensively.

The bulk of the integration efforts which were planned to be separately procured by the Marshall Space Flight Center and the Kennedy Space Center have been consolidated into a single contract. The increased efficiency of this concept has led to a net reduction of $1.2 million in FY 1977 funding for the manpower associated with early planning and preparation for integration and related hardware and software development activity.

The $2.5 million was transferred to the Payload and Operations Support project to be used for Orbital Flight Test (OFT) Payload Support requirements.

BASIS OF FY 1978 ESTIMATE:

Funds are required in FY 1978 for incremental procurement of flight hardware from ESA, and for continued development and production of the crew transfer tunnel.

Development and procurement of two demultiplexers will be initiated. The units are required to separate the individual data streams from the single digital data transmission from the Spacelab to the ground.

Acquisition of equipment for the integration of the Spacelab prior to flight and for the refurbishment afterwards will commence in FY 1978. Development of the equipment to checkout and verify software received from ESA which is required to integrate the mission dependent software into the Spacelab Data Management System will be initiated. The outfitting of workstands in the Operations and Checkout Building at the Kennedy Space Center and the development of ground support equipment will also begin in FY 1978.

FY 1978 funding is also required for systems engineering, systems software, logistics and analytical integration activities. The efforts will also include preparations at the Kennedy Space Center to support systems preflight and postflight processing, integration, Spacelab disassembly and refurbishment after flight, and design engineering.

The design and fabrication of a Spacelab simulator will be initiated and crew training equipment will be developed. This equipment will be used to prepare the flight crew and payload specialist personnel for Spacelab missions.

Efforts are continuing to assure the Spacelab's compatibility with the Orbiter. Mechanical Shuttle interface verification equipment will be completed in FY 1978 and shipped to ESA for use in their development efforts. Equipment for verification of the Orbiter and Spacelab avionics interface will be in fabrication. NASA will be designing and developing verification flight instruments in FY 1978 which will be flown on the first two Spacelab flights. Funds are also required for the development of interface hardware, such as the cabling and special mounting brackets which will be used to connect the Spacelab to the Orbiter. A series of tasks will be performed in FY 1978 to determine the effect of the Spacelab on the thermal and dynamic characteristics of the Orbiter while in flight.

Space Transportation System Upper Stages

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,625	700	3,800	1,800	13,500

OBJECTIVES AND STATUS:

The Space Transportation System (STS) upper stages are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These upper stages are the Interim Upper Stage (IUS) and the Spinning Solid Upper Stage(SSUS). Both are integral parts of the Space Transportation System (STS) and will be used for delivery of payloads to geosynchronous orbits and high energy missions such as lunar and planetary exploration.

The Interim Upper Stage is being developed by the Department of Defense (DOD). It will be a multistage, solid propellant expendable vehicle and will be operational in 1980. NASA is coordinating the incorporation of the NASA-unique and other non-DOD requirements with the DOD during the design, development, test and evaluation phase to insure IUS operations compatibility with the space transportation system.

The IUS will be used primarily for high energy lunar and planetary missions and for delivery of up to 5,000 pound payloads to geosynchronous orbit. This weight capability is in excess of that needed by many geosynchronous payloads using today's expendable launch vehicles. The Spinning Solid Upper Stage (SSUS) will be developed for these smaller payloads and it is being developed for two weight classes. It will be capable of injecting 1,250 pound Delta class payloads into geosynchronous orbit and 2,250 pound Atlas Centaur class payloads into the same orbit. An additional advantage of the SSUS in terms of launch cost economy to the user community is that two Atlas Centaur class SSUS's or four Delta class SSUS's can be flown, with their spacecraft, on a single shuttle flight and still maintain separate spacecraft interfaces. The main objective of the SSUS is to offer the users a lower cost transportation into orbits beyond the Shuttle's capability. The simple physical and functional interface for payloads will provide an effective transition from current expendable launch vehicles to the operational STS, with emphasis on serving the existing commercial spacecraft user community.

During FY 1977 NASA is continuing to participate in the DOD/IUS validation phase and the planning for the development phase. Activities include the specification of mission and payload requirements for the non-DOD missions; further definition of the IUS/Orbiter and ground system interface processing; definition of the NASA unique hardware and software system elements and operational concepts.

During FY 1977, development of the SSUS will be initiated, and efforts are underway to determine the interface compability between the Shuttle and the SSUS. In addition, ground operations requirements are being defined.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $2.0 million decrease from the budget estimate is due to NASA's decision to introduce the definition and development of the SSUS system which will allow the rephasing of the NASA-unique IUS development efforts. The funds will be made available to support Shuttle's critical requirements in FY 1977.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, NASA's IUS funding will support the design and development of NASA-unique hardware and software equipment items, including flight systems, mission related hardware and software, ground support equipment, operations support, IUS/STS integration, and simulation/training.

The SSUS development will be initiated in FY 1977 and will continue in FY 1978. The funding is required for the development of upper stage hardware, including initial test firings, airborne and ground support equipment development, launch site preparation and STS system integration and training. NASA is discussing with industrial contractors the possibility of commercial development of the SSUS system. Qualification testing is planned for late 1978, leading to full operational capability in 1980.

Multimission and Payload Support Equipment

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)			
---	---	3,000	1,500	7,000

OBJECTIVES AND STATUS:

Multimission and Payload Support Equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between the payloads and elements of the Space Transportation System. These requirements can be furnished more economically from a standardized equipment inventory rather than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads. This equipment will support activities such as: payload checkout; STS/payload integration and ground operations at the launch and recovery site; and in-orbit payload operations.

Examples of this type of standardized equipment are: (1) Intersite Payload Transportation Equipment - This equipment will satisfy the payload developers' requirement for transporting payloads to and from the development site and the launch site. The equipment consists of a large container carried on a standard low-boy trailer for moving equipment up to 14.5 feet wide and 11 feet high and 20 feet long. The system is environmentally controlled and designed to be compatible with air transport. FY 1977 funds are being used to initiate the design of the container and its auxiliary equipment. (2) Payload Specialist Station Equipment - This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command/display requirements. This approach will minimize the need for payload unique equipment and operational changeout time. FY 1977 funds are being used for the design of the equipment needed to support OFT payloads. (3) Flexible Multiplexer/Demultiplexer (MDM) - The function of the flexible multiplexer is to combine the Orbiter data stream and up to five separate payload telemetry or command data streams into a single output signal. The function of the flexible demultiplexer is to separate the combined data signal, either telemetry or command, back into the appropriate Orbiter or payload data streams. FY 1977 funds are being used to define this hardware. (4) Cargo Integration and Test Equipment (CITE) - This equipment is required to integrate and check out payload elements as they are assembled into a complete cargo to be flown on the Space Transportation System. It will verify that the payload elements perform as designed, and that these elements will not interfere with each other while being operated. CITE will also verify the compatibility of the cargo/Shuttle interfaces. (5) Trace Gas Analyzer - The trace gas analyzer system will perform in-flight monitoring of the aggregate "offgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of atmospheric substance and a mass spectrometer to measure the concentration of each of the atmospheric constituents.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $1.5 million decrease from the budget estimate reflects the deferral of the trace gas analyzer from FY 1977 to FY 1978. Funds were transferred to the Payload and Operations Support efforts for OFT payload support and operations requirements.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will provide for the continued design and development of hardware for the Intersite Payload Transportation Equipment, the Payload Specialist Station and the Flexible Multiplexer/Demultiplexer. Funds will also be used for the design initiation of the Cargo Integration and Test Equipment and the Trace Gas Analyzer.

Mission Control Center (MCC) Upgrading (Level II)

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
---	---	---	---	5,000

OBJECTIVES AND STATUS:

MCC Upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level I upgrading, funded under the Shuttle development program, provides hardware, equipment and software to upgrade the MCC to support Shuttle development flights. Level II will provide additional hardware, equipment, and software to configure the MCC with the capability to support two simultaneous orbiter missions, a ground simulation network, and a MCC/launch site interface.

BASIS OF FY 1978 ESTIMATE:

Funding for the MCC Upgrading (Level II) is required in FY 1978 to meet the initial operational flight schedule requirements for 1980. This is the beginning of the implementation of the multivehicle support capability needed for STS Operations. This additional capability will consist of additional mission control equipment and consoles. Work will also begin on mission data processing software for command and control, flight design, and crew activities planning. In addition, equipment will be installed to process telemetry data.

Payload and Operations Support

2,575	840	1,500	5,500	13,000

OBJECTIVES AND STATUS:

The Payload and Operations Support activity consists of four major areas of effort: Operations Management Support, Orbital Flight Test (OFT) Payload Support, Payload Operations Control Center (POCC), and OFT Payloads.

Operations management support studies will focus on determining the most efficient mode of operating the space transportation system (STS) such as establishing guidelines for flight planning, mission control/payload operations, flight crew training and flight operations.

The Orbital Flight Test Payload Support provides for the integration of payloads on the OFT flights during the FY 1979-80 time period. The activities involved are management integration such as planning, scheduling, and coordinating all elements; interface definition in environmental, structural, and thermal areas; safety analysis; hardware integration; flight support; and development of the interface control document. In addition, utility modifications are required on four Spacelab engineering model pallets for use on three of the OFT flights.

The Payload Operations Control Center (POCC), to be located at the Johnson Space Center (JSC), will provide for command and control of payloads that operate in the Shuttle and Spacelab. It will operate in conjunction with the JSC Mission Control Center. Funding is required for the design and development of computers, displays, communication links, and associated software.

The OFT Payloads effort involves the development of experiments and operational missions that will make use of the operational test flights. Some candidates being considered are a Skylab Revisit; a tethered satellite system to permit continuous scientific measurements of the earth to be made at low altitudes of 120 kilometers; and demonstration of techniques to construct and fabricate large structures in space.

FY 1977 funds are providing for the establishment of STS operational requirements and the development of STS operational concepts in the following areas: integrated ground operations (on-line/off-line processing flows); integrated logistics support planning; standardization of Shuttle/payload operations as a basis of minimizing cost of flight planning and crew training; and STS operations user charge policies for Upper Stages and the Spacelab.

FY 1977 funds also support payload integration engineering assessments to investigate and analyze orbiter/payload integration techniques and procedures prior to committing specific payloads to a particular OFT mission. The results will be used to assist in developing STS payload implementation techniques to encompass minimum hardware integration and short delivery schedules.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $4.0 million increase from the budget estimate supports increased activity in the Operations Management Support area, and initiation of the OFT Payload Support effort which provides for the integration of payloads on OFT flights. Funds were made available from Spacelab ($2.5 million) and from Multimission and Payload Support Equipment ($1.5 million).

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding for Operations Management Support will be used to determine the requirements to accommodate Shuttle utilization planning, flight planning, and flight operations simultaneously at the JSC Mission Control Center; alternatives for assembly, integration and checkout of payloads with upper stages at KSC; operational concepts and implementation planning for the Shuttle at Vandenberg Air Force Base; and methods and techniques for the intersite transportation of normal and outsized cargo to and from the launch sites.

Future operation of the STS will be studied, such as the effectiveness of extra vehicular activity (EVA) vs. automated techniques for on-orbit maintenance and refurbishment of low altitude spacecraft; methods and techniques of further reducing overall STS operation costs and identification of potential users of the STS.

Funding in FY 1978 for the Orbital Flight Test Payload Support is required to define the payload to Orbiter interfaces, to design the hardware modifications necessary to adapt the Spacelab engineering model pallets to OFT payloads and to initiate the fabrication of this hardware.

FY 1978 funding for the Payload Operations Control Center (POCC) will be used for defining the POCC hardware requirements for computers, displays, communication links, associated software, preliminary design, fabrication and testing of prototypes. These design and hardware verifications will lead to initiation of hardware procurement and installation as well as software development.

The FY 1978 funding for the OFT Payloads will be used for design and development of hardware required for the candidate payloads. It will support mission definition and planning as well as definition of training and test requirements, integration requirements, and definition and long lead procurement of ground support equipment.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

DEVELOPMENT, TEST AND MISSION OPERATIONS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Research and test operations	46,684	11,700	51,300	49,300	44,100
Data systems and flight operations	44,460	11,800	45,900	44,900	44,000
Operations support	44,816	10,950	41,700	41,700	42,300
Launch systems operations	25,140	6,350	31,000	31,000	42,600
Total	161,100	40,800	169,900	166,900	173,000

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 support early project definition, to provide 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 of design and development.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The decrease in the FY 1977 budget estimate for Development, Test and Mission Operations is the result of Congressional action. Based on the Authorization Act, the FY 1977 DTMO funding level was reduced by $3.0 million.

BASIS OF FY 1978 ESTIMATE:

FY 1978 DTMO funding provides 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 Upper Stages, and Advanced Programs.

Research and Test Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
46,684	11,700	51,300	49,300	44,100

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 located across the country in contractor-owned plants and government facilities.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The research and test operations funding was decreased by $2.0 million as part of the impact of the $3.0 million reduction in the FY 1977 DTMO funding, based on Congressional Authorization action.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, research and test operations will support critical Space Shuttle activities, leading to the Orbital Flight Test program (OFT) beginning in 1979; design and development of Upper Stages, and other research and development efforts in advanced programs. Engineering and test support is provided to assure fulfillment of technical goals as they relate to each program.

Examples of FY 1978 Space Shuttle support to be provided at the Johnson Space Center include: (1) ongoing analysis and performance review of the Ku-band steerable antenna; (2) performing orbiter-payload interface studies, utilizing mockups and manipulator development facilities; and (3) continuing support of the Shuttle avionics integration laboratory for validation and analysis of approach and landing test avionics, and reconfiguring of the laboratory for the Shuttle OFT avionics certification program.

At the Marshall Space Flight Center, FY 1978 funding provides for: (1) support to the Shuttle systems 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; and (3) services necessary to determine the structural integrity of the liquid hydrogen tank and the liquid oxygen tank, and other external tank related work in the ground vehicle test and the main propulsion test program.

In addition, FY 1978 research and test operations funds required at the Johnson Space Center and the Marshall Space Flight Center will support Space Shuttle certification inspections, tests, configuration control panels, and integration efforts.

Data Systems and Flight Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
44,460	11,800	45,900	44,900	44,000

OBJECTIVES AND STATUS:

Data systems and flight operations support the 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, as well as operation and maintenance of those facilities in preparation for mission support.

Flight simulation efforts include modification, 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 development of Shuttle flight control and recovery plans and procedures, flight plans, flight data files, crew procedures, and other elements of the data base required for crew activities, operation and maintenance of the T-38 training aircraft, and flight data management.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The data systems and flight operations funding was decreased by $1.0 million as part of the impact of the $3.0 million reduction in the FY 1977 DTMO funding, based on Congressional Authorization action.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding of ground-based flight data systems will support the update of the Mission Control Center and provide flight support and flight data management functions for the Shuttle data reduction center and orbital flight test programs. This effort will also include the operation of the software development laboratory, comprised primarily of the existing real time computer complex system which is used to develop and validate the Shuttle orbiter flight software, as well as to support equipment and software changes.

FY 1978 efforts in flight simulation and development data systems will increase in support of the installation and operation of the Shuttle simulator hardware and software. Mission and systems design and performance studies for the Shuttle will also be underway.

Spacecraft and aircraft operations activities which will be supported in FY 1978 include maintenance, modification, and engineering support services relating to the T-38 training aircraft and the KC-135 zero-G aircraft.

Support requirements in FY 1978 will increase in this area due to the addition of new astronauts and mission specialists and use of the T-38 chase aircraft to support the Shuttle training aircraft and orbital flight test programs. Also required in FY 1978 is the flight control, crew training and engineering support of flight operations planning control for the Shuttle orbital flight test.

Operations Support

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
44,816	10,950	41,700	41,700	42,300

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 these technical services for the 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.

BASIS OF FY 1978 ESTIMATE:

Fiscal Year 1978 funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication, photographic support and logistics support.

Examples of specific services to be provided in FY 1978 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic services including still and motion picture processing and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of Center operations including receipt, storage, 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 1978 funds will also provide a basic level of maintenance, operation, and support services required at the White Sands Test Facility to support program requirements including material and component testing, and 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 are being fabricated and assembled.

In addition, FY 1978 funds will provide the basic level of support to the National Space Technology Laboratories which are engaged in the static test firing and integrated component testing of the Space Shuttle main engine and the qualification of the main propulsion system.

Launch Systems Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
25,140	6,350	31,000	31,000	42,600

OBJECTIVES AND STATUS:

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

BASIS OF FY 1978 ESTIMATE:

The DTMO requirement at the Kennedy Space Center will increase in FY 1978 to support preparation of the launch facilities to accommodate the first manned orbital flight in 1979. FY 1978 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 1978 funding provides for mechanical ground system activities involving operation and maintenance of launch systems and facilities as they are activated for Shuttle; support for development testing of Kennedy Space Center designed Shuttle equipment in the launch equipment test facility; preservation, maintenance, and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which support maintenance activities.

Fiscal Year 1978 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, computations, measurements, and telemetry. These activities 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 the Kennedy Space Center designed Shuttle equipment in the launch equipment test facility.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ADVANCED PROGRAMS

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
12,074	3,500	13,000	12,000	10,000

OBJECTIVES AND STATUS:

The Advanced Programs objective is to provide technical as well as programmatic data for the definition and evaluation of potential future space programs and systems. These efforts have continuously provided a sound basis for new programs and systems, such as the Apollo, Skylab, and the Space Shuttle. In support of these activities, advanced development and advanced studies are conducted to obtain significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In FY 1977, space station conceptual studies are being continued to establish the requirements and performance specifications for a potential future four to six person space station. Conceptual studies on the assembly of large structures in space are nearing completion. Other efforts continuing in FY 1977 include development engineering and testing of improved environmental support and potential equipment components, and investigations of support equipment and tools required for extended operations in space. Work on advanced electromechanical actuators to provide significantly more reliable long life performance for future flight control applications was accomplished with laboratory breadboard models. Lightning investigations and measurements have led to the development of vastly improved "go-no-go" criteria for launch operations.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $1.0 million decrease from the budget estimate reflects a reduction in expendable launch vehicle improvement study efforts and in advanced technology activities relating to space flight programs. Study activity on potential future programs is not being reduced. The reductions in this program area will make funds available to support critical Shuttle requirements in FY 1977.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 the advanced studies effort will concentrate on potential future early space stations, orbital transfer vehicles, and nuclear waste disposal. Advanced operational concepts related to integrated launch operations, orbital assembly of large structures and orbital operation capability will be investigated in further detail.

The advanced development effort will support the advanced study concepts in all the major technical disciplines. Orbital operations studies will be supported with design and testing of concepts applicable to assembly, maintenance and operation of large structures and complex satellite systems, rendezvous and inspection, and satellite retrieval and repair. Consumables management and advanced instrumentation studies will also be continued.

In addition, FY 1978 funding will provide for testing and evaluation of major regenerative life support subsystems. These efforts will include initiation of unmanned regenerative life support integrated system testing; continuation of work on a flight prototype dextrous space teleoperator unit, and the investigation of advanced extravehicular work systems and manned construction system development. Tools, work site aids, space suits, portable life support and ancillary equipment will be investigated to establish and expand the capability for orbital construction operations.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SPACE TRANSPORTATION SYSTEM OPERATIONS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Space shuttle operations.....	---	---	---	---	17,800

OBJECTIVES AND STATUS:

Space Transportation System Operations will provide the transportation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on earth. Space Transportation System Operations will provide for the delivery of free flying payloads to low earth orbit, conduct of experiments using the Shuttle orbiter as a carrier vehicle, conduct of experiments in the manned working areas of the Spacelab, conduct of experiments using Spacelab pallets, delivery of payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages, retrieval of free flying payloads from low earth orbit, and on orbit servicing of satellites. Operational flight missions will be planned and conducted to accomplish these activities in an effective, efficient and economical manner by appropriate combining of payloads, experiments and mission objectives on specific flights. The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab, and the upper stages into a versatile and economical system; accomplish mission planning; provide the recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

BASIS OF FY 1978 ESTIMATE:

With the initial operational capability of the Space Shuttle scheduled for 1980, funding for hardware fabrication, vehicle spares, crew training, flight simulations, software development, and flight and mission planning must be initiated in FY 1978. The pacing procurements include initial long lead time hardware and spares for the external tank and solid rocket booster. External Tank (ET) funding is required to supply raw materials, castings, and forgings to machining vendors so that finished parts can be available at the start of ET subassembly at the Michoud Assembly Facility in early FY 1979. Solid Rocket Booster (SRB) initial hardware procurements in FY 1978 will include solid rocket motor components, electronic and instrumentation parts, pyrotechnics, thrust vector control components and recovery and separation motor parts.

In addition, FY 1978 funding will provide for initiation of crew training and procedures; flight control systems engineering support; console handbooks; requirement documents; training records and instructors; flight data file checklists; the establishment of management systems for communications program plans and directives; and biomedical equipment. Support efforts will provide for analysis necessary for structural payload integration and engineering support for crew systems (extravehicular mobility unit, headsets, space suits, etc). FY 1978 funding is also required for the initial development of mission profiles and trajectories for the operational flights. Examples are systems performance and compatibility analysis, consumables scheduling and utilization planning, and software development flight planning for standardized mission requirements. The planning activities for operation and maintenance of the Shuttle procedures simulator, the Shuttle mission simulator, and the orbiter aerodynamic simulator for crew training will also begin in FY 1978.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

PLANNING AND PROGRAM INTEGRATION

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
4,200	1,260	3,500	3,500	4,000

OBJECTIVES AND STATUS:

The Planning and Program Integration objective is to consolidate NASA's plans for early STS missions, and to insure hardware and operational compatibility between Payloads and STS elements. In FY 1977, STS utilization planning activities are focusing on updating the early Space Shuttle mission plans to include hardware inventories and logistic requirements, improving the responsiveness of cargo planning, refining the cost estimating on Spacelab integration, and formalizing planning methodology for transitioning from conventional launch vehicles to the STS. Studies of payload operations and handling are being expanded to develop a greater understanding of payload ground and flight operations and of associated critical hardware and software end items. Analysis of payloads and their requirements are continuing in such areas as payload descriptions and requirements, payload centers' operation needs, support of the payload data bank, contamination control modeling, and payload mission planning studies. Studies of payload applications and orbital servicing techniques are also in process.

BASIS OF FY 1978 ESTIMATE:

During FY 1978 tasks will continue to be directed toward determining the most economical means of utilizing the STS and assuring hardware and operational compatibility between payloads and STS elements. Payload requirements will be identified, analyzed, and compared to plans for the design and operation of the STS. Changes in planned accommodations for payloads will be evaluated to determine their impact on the payloads. Studies will also concentrate on the definition of the interfaces between the STS and the payloads from the preproject definition phase through hardware integration to mission operations.

A major focus of activity will be on establishing the schedules of candidate payloads for the early Shuttle missions and acquiring technical descriptions of these payloads. The candidate payloads will be subjected to mission analyses involving priority, schedule, cost and engineering tradeoffs in order to develop recommendations for cargo groupings which optimize the use of STS flight resources and capabilities. Specific studies will be concerned with developing techniques for scheduling missions to minimize costs and complexities, with standardizing mission planning tools, and with defining mechanisms for accommodating carry-on payloads.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Scout	10,600	3,400	10,700	10,700	16,000
Centaur	110,100	24,400	90,700	90,700	55,900
Delta	41,800	9,300	43,800	43,800	55,300
Atlas-F	3,400	---	6,200	6,200	9,300
Total	165,900	37,100	151,400	151,400	136,500
Distribution of Program Amount by Installation:					
Kennedy Space Center	16,065	3,040	18,323	17,200	11,800
Goddard Space Flight Center	37,456	8,447	38,027	37,600	49,400
Wallops Flight Center	10	3	---	100	100
Langley Research Center	10,456	3,397	10,550	10,600	15,700
Lewis Research Center	97,477	21,900	77,100	78,524	49,000
Headquarters	4,436	313	7,400	7,376	10,500
Total	165,900	37,100	151,400	151,400	136,500

OFFICE OF SPACE FLIGHT

EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the expendable launch vehicles program is to provide for the centralized procurement of launch vehicles and launch support services for NASA's automated spacecraft missions. The program includes the procurement of launch vehicle hardware, launch services, engineering and maintenance, and, as required, development of improved vehicle systems, including the necessary ground support equipment. Launch vehicles currently being procured are: Scout, Centaur, Delta, and Atlas-F.

The budget request for each launch vehicle project 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 activites 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.

Launches under this program are conducted from sites located at the Eastern Test Range in Florida, the Western Test Range in California, the Wallops Flight Center in Virginia, and the San Marco platform off the coast of Kenya, Africa.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SCOUT

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Hardware	1,600	900	2,400	2,500	6,400
Supporting Activities	9,000	2,500	8,300	8,200	9,600
Total	10,600	3,400	10,700	10,700	16,000

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and reentry experiments. The first Scout launch occurred in July 1960. In the ensuing 16 years, there have been 96 launches, and 82 of these launches have been successful.

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 FY 1977 BUDGET ESTIMATE:

There is no change in the total FY 1977 estimate for the Scout project. The adjustment between the hardware and support elements of the project reflects a rephasing of procurement actions.

BASIS OF FY 1978 ESTIMATE:

Hardware - Funds will be utilized to continue hardware procurement to support the Stratospheric Aersol and Gas Experiment Mission and to initiate procurement to support the Magnetic Field Satellite mission, two San Marco Cooperative Satellite missions, and the Dynamics Explorer program.

Supporting Activities - Engineering and technical support, vehicle testing and checkout, launch operations, and maintenance of launch facilities and ground equipment will be funded to meet launch requirements. During FY 1978, the Heat Capacity Mapping Mission satellite will be launched. In addition, checkout activities to support the Stratospheric Aerosol and Gas Experiment launch will be initiated.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

CENTAUR

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Hardware	57,400	8,600	42,400	37,300	22,600
Supporting Activities	52,700	15,800	48,300	53,400	33,300
Total	110,100	24,400	90,700	90,700	55,900

OBJECTIVES AND STATUS:

The Centaur project provides for the procurement and launch of two booster stages (the Atlas and Titan) and an upper stage (the Centaur). The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

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 two Helios missions and the two Viking missions. The Titan Centaur is 49 meters (160 feet) high and has a payload shroud diameter of 4.3 meters (14 feet.)

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The total FY 1977 estimate for the Centaur project remains the same. Adjustments between the hardware and support categories reflect increased support requirements for the first High Energy Astronomy Observatory (HEAO-A) launch and the two Mariner Jupiter/Saturn (MJS '77) launches.

BASIS OF FY 1978 ESTIMATE:

Hardware - The FY 1978 funds are required to continue incremental procurement of launch vehicle hardware to support the second and third High Energy Astronomy Observatory missions (HEAO-B and -C) and the two Pioneer Venus missions.

Supporting Activities - FY 1978 funding requirements will be utilized for management and engineering support effort, launch support operations, field services and maintenance of facilities and ground equipment. During FY 1978, three missions will be launched: HEAO-B and the two Pioneer Venus missions.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

DELTA

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousand of Dollars)				
Hardware	7,600	2,700	12,800	13,600	16,600
Supporting Activities	34,200	6,600	31,000	30,200	38,700
Total	41,800	9,300	43,800	43,800	55,300

OBJECTIVES AND STATUS:

The Delta launch vehicle is the most used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 127 launches and has experienced a success record of over 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 FY 1977 BUDGET ESTIMATE:

The total FY 1977 estimate for the Delta project remains the same. Minor adjustments between the hardware and support categories reflect refinement of the estimates.

BASIS OF FY 1978 BUDGET ESTIMATE:

Hardware - The FY 1978 funds will be used to continue the launch vehicle hardware procurement efforts initiated in prior years and to be initiated in FY 1978 in support of Nimbus-G, the International Sun-Earth Explorer C (ISEE), the Solar Maximum Mission, the Infrared Astronomy Explorer and the Dynamics Explorer program.

Supporting Activities - FY 1978 funding is required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment. Delta vehicles will be checked out and readied for launch in support of the International Ultraviolet Explorer, Landsat-C and GOES-C, ISEE A/B and C missions, and the SCATHA-A mission.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ATLAS-F

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Hardware	3,400	---	6,200	6,200	9,300

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 OF FY 1978 BUDGET ESTIMATE:

The FY 1978 funds will be used to complete efforts initiated in prior fiscal years to refurbish and modify the Atlas-F launch vehicle in support of the launch of the Tiros-N meteorological satellite and the Seasat-A ocean dynamics satellite. Both of these satellites are planned for launch during the first half of 1978.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

Programs	Budget Plan				
	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Physics and astronomy	159,300	43,500	165,800	166,300	224,200
Lunar and planetary exploration	254,250	67,464	191,100	191,900	148,200
Life sciences	20,576	5,436	22,125	22,125	33,300
Total	434,126	116,400	379,025	380,325	405,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
High energy astronomy observatories	59,218	14,510	36,600	39,362	22,450
Solar maximum mission	---	---	21,300	21,300	30,600
Space telescope	---	---	---	---	36,000
Shuttle/spacelab science payload development	1,100	2,600	6,000	6,000	28,900
Orbiting explorers	29,922	6,500	33,000	30,238	35,000
Orbiting solar observatories	3,600	625	1,000	1,000	1,270
Orbiting astronomical observatories	2,300	490	2,600	2,600	1,980
Suborbital programs	24,800	7,500	26,000	26,000	26,000
Supporting activities	38,360	11,275	39,300	39,800	42,000
Total	159,300	43,500	165,800	166,300	224,200
Distribution of Program Amount by Installation:					
Johnson Space Center	1,387	229	2,458	1,278	420
Marshall Space Flight Center	73,050	20,458	46,250	50,289	79,030
Goddard Space Flight Center	55,620	15,029	74,843	73,819	92,437
Jet Propulsion Laboratory	1,659	660	1,700	5,109	6,625
Wallops Flight Center	3,890	1,064	3,900	5,457	7,350
Ames Research Center	6,115	1,436	6,500	8,597	12,570
Langley Research Center	1,324	60	1,340	461	400
Lewis Research Center	100	---	1,600	1,510	1,200
Headquarters	16,155	4,564	27,209	19,780	24,168
Total	159,300	43,500	165,800	166,300	224,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
High Energy Astronomy Observatories	HEAO-A	1977
	-B	1978
	-C	1979
Solar Maximum Mission	SMM-A	1979
Space Telescope	ST	1983
Space Shuttle Orbital Flight Tests	OFT-4 Science Experiments	1980
	-6 Science Experiments	1980
Spacelab	Spacelab-1	1980
	-2	1980
	Astrophysics Spacelab	1981
	Solar Terrestrial Spacelab	1981
	Astrophysics Spacelab	1982
	Solar Terrestrial Spacelab	1982
	Joint Solar Terrestrial and Astrophysics Spacelab	1982
	Astrophysics Spacelab (2)	1983
	Solar Terrestrial Spacelab (2)	1983

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Explorers:		
Solar Terrestrial Explorers	International Sun-Earth-A/B	1977
	-C	1978
	Dynamics Explorer Program	1981
	San Marco-D/Multistationary	1979
	San Marco-D/Low Orbit	1980
Astrophysics Explorers	International Ultraviolet Explorer-A	1977
	Infrared Astronomy Satellite-A	1981
Suborbital Programs:		
Sounding Rockets	About 60 launches per year	
Balloon Flights	About 50 launches per year	

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, the interplanetary medium, the coupling linking these different plasma regions and the processes that control them. Space-based investigations of solar 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.

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, and have gone on to survey our near-space environment and study its variation with space and time. Larger observatory missions undertaken to date include the Orbiting Solar Observatory (OSO) series, the most recent of which, OSO-8, is currently in its second year of successful solar and high energy astronomy investigations, and the Orbiting Astronomical Observatory (OAO) series. The highly successful OAO-3, launched in 1972, is in its fifth year 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 joint observing program approach of the ATM instruments, coupled with a worldwide coordinated program of complementary ground-based and interplanetary solar measurements has resulted in considerable advances in a number of important solar studies.

During 1976, the Gravity Probe-A mission was successfully launched to confirm with improved accuracy the gravitational redshift predicted by Einstein's Theory of Relativity. Work is continuing on the High Energy Astronomy Observatory (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. Development efforts are also proceeding on a Solar Maximum Mission, scheduled for launch in 1979, to take advantage of the opportunity to study the Sun during the next period of peak solar activity in 1978-80. Work is underway on physics and astronomy payloads designed to capitalize on the unique capabilities of the Space Shuttle/Spacelab. Definition studies for a variety of payloads to be flown on Spacelab missions are being conducted, including preliminary work on several facility-type payloads to investigate phenomena in the various physics and astronomy disciplines. Work is also continuing on two Explorer projects--the International Ultraviolet Explorer (IUE) to be launched in 1977, and the International Sun-Earth Explorer (ISEE) with launches in 1977 and 1978. A number of Explorer definition studies have been completed and development activities will soon commence for an Infrared Astronomy Satellite (IRAS), a cooperative mission with the Netherlands and the United Kingdom to be launched in 1981, and a dynamics explorer program planned for launch activity beginning in 1981.

The Upper Atmospheric Research program's immediate goal is to understand the earth's atmosphere well enough to assess any changes caused by man, and to determine whether or not there is any associated change in the transmission of solar radiation.

In the major flight program area, the FY 1978 funding will provide for completion of work on HEAO-B, including launch and initial mission operations and data analysis effort; completion of fabrication of HEAO-C experiments and the start of observatory integration; continuation of work on the SMM, planned for launch in 1979; development of experiment hardware and software, definition of integration requirements, and development of mission operations plans for Spacelabs 1 and 2; and support of continued operations and data analysis activity for HEAO-A, OAO-3 and OSO-8. Based on extensive definition studies and advanced technological development, the Space Telescope is planned to be initiated in FY 1978, leading to a Shuttle launch in 1983. This 2.4-meter multiple purpose telescope will be able to observe galaxies at far greater distances than those which can be observed from the best ground-based observatory. In the Explorer program, the FY 1978 funding will provide for final integration, test and launch of ISEE-C; continuation of hardware and subsystems procurement and experiment fabrication for IRAS and the dynamics explorer program; continuation of work on the San Marco D missions; some Phase B definition studies; and continuation of acquisition, processing, and analysis of data from IUE, ISEE-A and B, and other operational satellites.

FY 1978 funds will also provide for continuation of sounding rocket activity, with emphasis on the coordination of near-simultaneous launching of several rocket payloads and on correlation with satellite observations; continued operations of the Airborne Observatory; and continued support for balloon flights with greater use of "superpressure" balloons to meet the higher altitude and longer duration requirements of the science investigators, along with several balloon flights in support of the upper atmospheric research program.

For Supporting Activities, FY 1978 funding will provide for continuation of the SRT program, supporting about 225 research tasks with emphasis on those tasks which are critical to maintaining a firm scientific base for Physics and Astronomy and on development of advanced astronomical instrumentation; continued support for the Data Analysis program including operations of the National Space Science Data Center (NSSDC), the analysis of data acquired from the highly successful Skylab program, and the data analysis activities of more than 100 principal investigators at approximately 45 institutions; support for the Spacelab Science Payload Definition program, including continuation of detailed studies of specific facility-class instruments and further definition of instrument pointing systems applicable to facility-class instruments and telescopes; and support for Upper Atmospheric Research, with emphasis on the continuing development of a long term basic science program and extensive treatment of the physics and chemistry of ozone in the stratosphere.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

HIGH ENERGY ASTRONOMY OBSERVATORIES (HEAO)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
HEAO spacecraft	33,994	7,377	18,800	19,857	12,060
HEAO experiments	24,054	6,468	17,800	15,491	5,270
Mission operations and data analysis	1,170	665	(4,014)	4,014	5,120
Total	59,218	14,510	36,600	39,362	22,450
(Expendable Launch Vehicles Program)					
Atlas/Centaur	(19,500)	(2,500)	(15,200)	(12,100)	(8,800)

OBJECTIVES AND STATUS:

The main scientific objective of the HEAO program is to observe and investigate not only those X-ray sources that are already known, but also a much larger number which, either because of their distance or their intrinsic low intensity, have so far remained undetected. A product of this work is expected to be the discovery of new classes of weaker X-ray sources, as well as the observation of the stronger sources outside our group of galaxies. Similarly important objectives include the observation of rare species of cosmic rays, which are crucial to our understanding of heavy element formation, and the observation of the elusive nuclear gamma ray lines so important in establishing the origin of the celestial gamma ray background. This program promises to advance our understanding of newly discovered energy processes and the creation of matter and to deepen our knowledge 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 mission (HEAO-A), scheduled for launch in 1977, will be an X-ray survey. The second mission (HEAO-B), to be launched in 1978, will carry a grazing incidence X-ray telescope and will make detailed studies of specific sources. The third mission (HEAO-C), to be launched in 1979, will carry a combination of gamma ray and cosmic ray instruments.

The FY 1976 and Transition Quarter funding supported the peak development activity for HEAO. Critical design reviews for the spacecraft and the HEAO-B experiments have occurred. The HEAO-A experiments and the spacecraft were fabricated, and integration was completed on schedule. Verification of HEAO-A, as an observatory, began in July 1976. The HEAO-B mirrors are being polished and the detectors will be completed in early 1977. The test and calibration facility at MSFC has been completed and is ready for testing of the mirrors. The HEAO-C flight instrument contracts have been awarded and the design effort is underway. The Preliminary Design Review for the HEAO-C instruments took place during FY 1976. Mission operations efforts included the preparation of the mission control center at the Goddard Space Flight Center, as well as the preparation of required software.

FY 1977 is the year of the first launch of the program--HEAO-A. Activity leading to this launch includes completion of verification of the observatory, delivery of the observatory to Kennedy Space Center (KSC), checkout of the control center and the STDN network, and launch operations. In-orbit operations and data analysis activity will commence. Other activity includes the completion of the HEAO-B spacecraft and flight experiments and the start of integration. HEAO-C activity includes Critical Design Review on the experiments, and major progress on fabrication and checkout of both the experiments and the spacecraft.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $2.8 million in FY 1977 resulted from technical problems, primarily associated with the complex HEAO-B experiments, and accumulated inflation pressures. The funds required to help resolve these unanticipated technical difficulties were provided from the Physics and Astronomy Explorer program.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, funding will provide for continued analysis of data from HEAO-A and the integration of the HEAO-B experiments with the spacecraft, followed by verification tests and launch. These funds will also provide for initial HEAO-B mission operations and data analysis effort, completion of fabrication of the HEAO-C experiments, and the start of HEAO-C observatory integration, leading to launch in 1979.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SOLAR MAXIMUM MISSION (SMM)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	---	---	7,300	7,300	14,600
Experiments	---	---	14,000	14,000	15,900
Mission operations and data analysis	---	---	---	---	100
Total	---	---	21,300	21,300	30,600
(Expendable Launch Vehicle Program)					
Delta	(---)	(---)	(---)	(400)	(4,100)

OBJECTIVES AND STATUS:

The major objective of the Solar Maximum Mission 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 goal 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 preflare storage of energy, the flare "trigger" (i.e., the instantaneous release of the stored energy), the acceleration of particles to subrelativistic 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 International Sun-Earth Explorer satellites; and the neutral atmospheric density and composition will be probed by means of ultraviolet and extreme ultraviolet atmospheric attenuation studies and airglow observations.

The Solar Maximum Mission project provides for the development of a spacecraft employing the basic structure and subsystem modules to be used in the Multimission Modular Spacecraft (MMS). The MMS approach will provide a common basic spacecraft bus and subsystems modules to be used on a number of future Earth orbital missions. During FY 1977, the hardware development phase is being initiated. This includes award of contracts for the design, fabrication, and testing of the scientific experiments; for the experiment module which supports the experiment complement; and for the MMS subsystem modules.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, funds will support the continued development of the spacecraft subsystems, the experiments and other flight hardware, and the testing of the engineering models of the experiments. The spacecraft and experiments will be integrated to form the observatory. The observatory will be tested as an integral unit in late FY 1978 and into FY 1979.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SPACE TELESCOPE (ST)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
ST spacecraft	---	---	---	---	23,300
ST experiments	---	---	---	---	12,300
Mission operations and data analysis	---	---	---	---	400
Total	---	---	---	---	36,000

OBJECTIVES AND STATUS:

The Space Telescope (ST) will make a major contribution to understanding the origin, evolution and scale of the universe; understanding the stars and galaxies, and the nature and behavior of the materials and fields between them; and developing a physical understanding of the universe. It is considered the single most important next step in space astronomy to expand our capability to observe the universe. Operating in space above the atmospheric veil of earth, the ST will increase by more than a hundredfold the volume of space accessible for observation. With its significant improvements in resolution and precision, in light sensitivity, and in wavelength coverage, the ST will permit scientists to investigate fundamental questions concerning the structure, the origin, the evolution, and the energy balance in the universe which could never be approached from observatories below the obscuring effects of the Earth's atmosphere. The ST will open to the astronomical sciences, and to science in the broadest sense, a road to new knowledge which will help shape our concept of the universe. In a priority study by the Space Science Board of the National Academy of Sciences, the 2.4-meter ST was considered to be the highest priority new program in space astronomy.

The ST will enable astronomers to study radiations in the infrared, the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater details about the objects under study. The ST will make it possible to observe objects so remote that the light will have taken many billions of years to reach us, thus allowing us to look far into the distant past of our universe. The ST will contribute significantly to the study of little known energy processes in heavenly bodies, especially the early stages of stars and solar system formation; to the observation of such highly evolved objects as supernova remnants and white dwarf stars; and to other studies related to the origin and physical extent of the universe. With the ST, it will probably be possible to determine the distance to quasars, and the absolute magnitude of the enormous amount of energy they emit. It will also be possible to study individual stars in nearby galaxies and it may be possible to determine if nearby stars have planetary systems comparable to our own. The knowledge gained from these investigations will contribute to our understanding of our place in the universe.

The Space Telescope will be an automated satellite, delivered to orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite. The Space Telescope will differ from existing automated satellites in that its design will permit in-orbit maintenance and repair, retrieval by the Space Shuttle for return to Earth, and refurbishment and reuse. The Space Telescope will serve as the major astronomical observatory in space for more than a decade.

Intensive definition efforts have provided a sound basis for project initiation. Specific activities--focused on project definition, preliminary design and advanced technological development--have been accomplished under Physics and Astronomy Supporting Activities, with funding of $10 million in FY 1975, FY 1976 and the Transition Quarter. The formal project definition studies, which were completed in 1976, have defined minimum cost options

which will permit the scientific requirements to be met and which both NASA and the astronomical community agree will provide a facility in space that cannot be equaled or even approached by ground-based observatories. During this definition period, candidate scientific instruments consistent with the objectives of the Space Telescope have been defined. Advanced technological development activities have also been initiated to ensure the availability of detectors for use in the instruments. A number of technology tasks have been successfully completed in areas such as fine guidance, stray light suppression, precision optics, and dimensionally-stable structures to minimize technical and cost risks in the development phase.

Through these activities, the Space Telescope has reached an advanced state of definition. NASA plans to release in early 1977 requests for proposals (RFP's) covering the Optical Telescope Assembly and the Support Systems Module. These RFP's will specifically state that award of contracts is contingent upon Congressional approval and funding for the project. On the same basis, NASA plans an early 1977 release of the Announcement of Opportunity to the scientific community to solicit proposals for the initial complement of scientific instruments.

The current planning estimate for the development of the Space Telescope, including one month of in-orbit checkout and verification, is $435 million to $470 million in the dollars of the FY 1978 budget.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, the Space Telescope design and development will be initiated, leading to launch in the last quarter of CY 1983. Contracts will be awarded in early FY 1978 for the Optical Telescope Assembly (OTA) and the Support Systems Module (SSM). The contractors will complete their planning, start preliminary design, and initiate long lead procurements. One of the most significant procurements will be for two primary mirror blanks 2.4 meters in diameter for the OTA. Each contractor will also prepare for a Preliminary Requirements Review which will take place approximately three months following contract award. As a result of this review, the contractors baselines will be established for proceeding with planning and implementation of the preliminary design which will culminate in a Preliminary Design Review approximately one year later.

The SSM contractor will also be actively involved with performing analyses necessary to assure a totally integrated Space Telescope system.

Scientific instrument contractors will complete their planning and definition, conduct Preliminary Requirements Reviews and initiate preliminary designs of instruments. Instrument development teams will participate in the preliminary design of the instrumentation.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB SCIENCE PAYLOAD DEVELOPMENT

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Experiments	206	2,600	5,600	5,600	26,100
Integration	---	---	---	---	600
Mission operations and data analysis	894	---	400	400	2,200
Total	1,100	2,600	6,000	6,000	28,900

OBJECTIVES AND STATUS:

The objective of the Shuttle/Spacelab Science Payload Development program is to advance scientific research in the major disciplines of astrophysics, solar physics, space plasma physics, astronomy, and atmospheric science by capitalizing on the unique capabilities of the Space Shuttle and Spacelab. These science payload development activities will provide for the design, development, and integration of experiments and special supporting subsystems to be flown on Shuttle orbital flight test and Spacelab missions. The efforts will also include provision for payload mission operations and data analysis.

Shuttle Orbital Flight Test (OFT) Science Payload Development

The science payloads to be flown on Shuttle OFT missions will include selected experiments in space astronomy, high energy astrophysics, solar physics, and atmospheric, magnetospheric, and plasma physics. These payloads will provide for early demonstration and evaluation of the Shuttle's research capabilities. The Office of Space Science has over-all management responsibility for payload activities on the fourth and sixth OFT missions.

Shuttle/Spacelab Payloads Development

The Shuttle/Spacelab Payload program will provide the capability for major space-borne research investigations in the 1980-1990 time period. This program covers the design and development of major scientific instruments and orbital facilities and the conduct of Shuttle/Spacelab science missions.

The Office of Space Science has the overall payload management responsibility for Spacelabs 1 and 2 scheduled for flight after the Shuttle becomes operational. Spacelab 1, a joint undertaking by NASA and the European Space Agency (ESA), is scheduled for launch in July 1980, and Spacelab 2 in October 1980. The primary objective of the missions is the verification of Spacelab performance and capabilities. The secondary objective is to obtain valuable scientific, applications, and technology data. Two Announcements of Opportunity were issued by NASA in 1976, soliciting proposals addressing specific experimental objectives in Atmospheric

Sciences, Earth Observations, Life Sciences, Astronomy, Solar Physics, High Energy Astrophysics, Communications and Space Technology. The response to these announcements was significant, in that more than 170 proposals were received for Spacelab 1, and more than 150 were received for Spacelab 2. Evaluation of the proposals is underway, and the experiment selections will be made in 1977.

The long-range Shuttle/Spacelab Payloads Development program will be scientifically more ambitious once Shuttle/Spacelab verification is complete. This program will follow an evolutionary approach, expanding upon the comparatively simple experiments planned for Orbital Flight Tests 4 and 6 and Spacelab 1 and 2 missions, proceeding to the development of more elaborate experiments which will eventually evolve to the dedicated discipline "laboratory in space."

The scientific objectives typical of missions to be flown on the Space Shuttle/Spacelab are: (1) To obtain data from continuing investigations of high energy acceleration processes on the sun and in other celestial bodies; (2) To conduct controlled active experiments in atmospheric, magnetospheric, and space plasma physics; (3) To perform new observations in X-ray and gamma ray astronomy and cosmic ray astrophysics which cannot be conducted from earth; (4) To obtain data for continuing investigations into the nature of active galaxies, the creation of the elements, supernova remnants, globular clusters, collapsed objects, and the interstellar medium; (5) To perform remote sensing observations of atmospheric composition and dynamics.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, efforts will be directed to developing experiment hardware and software, defining integration requirements, and planning and developing mission operations for the Shuttle OFT missions and Spacelab 1 and 2.

The FY 1978 request also supports the design and development of experiments and associated instruments/facilities in the solar physics, high energy astrophysics, atmospheric and magnetospheric physics areas for follow-on missions. This initial effort is directed toward the development of instruments and orbital facilities which can be reused for repeated scientific investigations, with a realization of an overall, long-term cost savings. Facilities such as solar optical observations (1-1/4 meter optical, EUV, XUV, X-ray) and LIDAR (Light Detection and Ranging) instruments, for example, can be modified by changing sensors or filters, or by making changes in the focal planes of the instruments, and then reflown to conduct continuing investigations.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ORBITING EXPLORERS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Solar Terrestrial Explorers					
Atmosphere explorers (AE)	6,810	1,290	2,700	3,518	2,758
International sun-earth explorers (ISEE)	14,248	3,513	7,961	8,161	6,751
Dynamic explorer program	---	---	---	3,500	6,000
Other solar terrestrial explorers	1,898	219	2,747	3,922	3,300
Subtotal	22,956	5,022	13,408	19,101	18,809
Astrophysics Explorers					
Small astronomy satellites (SAS)	1,350	353	1,056	1,165	1,392
International ultraviolet explorer (IUE)	4,536	695	3,500	3,174	2,586
Infrared astronomy satellite (IRAS)	---	---	6,000	4,000	10,600
Other astrophysics explorers	1,080	430	9,036	2,798	1,613
Subtotal	6,966	1,478	19,592	11,137	16,191
Total	29,922	6,500	33,000	30,238	35,000
(Expendable Launch Vehicles Program)					
Delta	(3,900)	(1,900)	(7,300)	(8,300)	(9,400)
Scout	(1,200)	(900)	(---)	(---)	(4,600)

OBJECTIVES AND STATUS:

The Explorer Program, comprised of many individual projects and spacecraft, provides the principal means of conducting astronomical studies and long-term investigations of the geophysical and near-earth interplanetary environment which do not require large observatories. Included in the present program are missions to study atmospheric and magnetospheric physics, the several magnetospheric boundaries; interplanetary phenomena; and X-ray, gamma-ray, ultraviolet, radio, and infrared astronomy.

Explorer spacecraft have been launched at an average rate of about three to four missions per year on both Delta and Scout launch vehicles. Future planning includes use of the Space Shuttle as a launch vehicle. The design of Explorer spacecraft depends upon the nature of the particular missions involved. Often, missions have been grouped into families which can be accommodated by a basic spacecraft design such as the Interplanetary Monitoring Platform, Atmosphere Explorer, and Small Astronomy Satellite series. Conceptual and systems studies to support projected missions are carried out on a continuing basis. In addition, NASA engages in cooperative missions with other Government agencies and foreign countries whenever these missions will assist in achieving NASA objectives. These cooperative missions have averaged about two launches per year.

Solar Terrestrial Explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites extending from the very lowest reaches of the upper atmosphere, being investigated by the Atmosphere Explorers, to the interplanetary medium beyond the Earth's magnetosphere, being investigated by the Interplanetary Monitoring Platform (IMP) series. The solar terrestrial program is in a transition from the early discovery and mapping phase conducted over the past decade to a phase in which the cause and effect interactions of the fluctuating 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), a cooperative effort with the European Space Agency (ESA). Integration and start of flight acceptance tests for the ISEE-A and -B missions are on schedule for launch in 1977. ISEE-C is scheduled for launch a year later. Other activities underway include initiation of development activities for a dynamics explorer program designed to investigate for the first time the coupling of energy and mass between the cold ionosphere plasma and the hot magnetosphere. In addition, work will begin on the San Marco D mission, a cooperative program with Italy. Acquisition, processing, and analysis of data from operational satellites are continuing, as are definition studies for possible future missions.

Astrophysics Explorers provide the means for carrying out astronomical studies relating to the 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 International Ultraviolet Explorer (IUE), which is an international cooperative effort with the United Kingdom (UK) and the European Space Agency (ESA); the Infrared Astronomy Satellite (IRAS), a cooperative program with the Netherlands and the United Kingdom. Astrophysics Explorers have been instrumental in opening up the X-ray, gamma ray and low frequency regions of the electromagnetic spectrum by performing all-sky surveys. The significant result of these missions is the discovery of new scientific information through application of low cost approaches in the newly emerging disciplines of science. Once the frontiers are defined, more efficient use can be made of the large complex observatories such as the HEAO in performing the detailed investigations that follow.

Major efforts being supported in FY 1977 for the astrophysics program include final integration, test, and launch of the IUE mission; hardware and subsystems procurement and experiment fabrication for the IRAS, planned for launch in 1981; and continuation of acquisition, processing, and analysis of data from operational satellites. In addition, definition studies will be conducted on a limited number of possible future missions selected from proposals.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The decrease of $2.8 million reflects the requirement to provide additional FY 1977 funds for the HEAO program in order to solve unanticipated technical problems. Redistributions within the Explorer program are the result of rephasing of funding requirements for ISEE, IUE and IRAS; and initiation of development effort for a dynamics explorer program and the San Marco D mission.

BASIS OF FY 1978 ESTIMATE:

Fiscal Year 1978 funds are required for final integration, test and launch of ISEE-C; continuation of hardware and subsystems procurement and experiment fabrication for the dynamics explorer program; continuation of work on San Marco D mission; continuation of hardware and subsystems procurement and experiment fabrication for IRAS; future mission definition studies; and continuation of acquisition, processing, and analysis of data from ISEE-A and -B, IUE, and other operational satellites.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ORBITING SOLAR OBSERVATORIES (OSO)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	---	---	---	---	---
Experiments	1,700	---	---	---	---
Mission operations and data analysis	1,900	625	1,000	1,000	1,270
Total	3,600	625	1,000	1,000	1,270

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 Orbiting Solar Observatories 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 Apollo Telescope Mount 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 onboard which are measuring X-ray emissions from a variety of stellar and galactic sources and obtaining information about the Earth's atmosphere.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, funding will be used to support the scientific experiment teams necessary to operate the instruments and analyze operations 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 for commanding the observatory in orbit. These funds will also provide for analysis of data obtained by the scientific experiments.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ORBITING ASTRONOMICAL OBSERVATORIES (OAO)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
OAO mission operations and data analysis.....	2,300	490	2,600	2,600	1,980

OBJECTIVES AND STATUS:

OAO-3 (Copernicus), launched in 1972 and still operational, is providing an accurately stabilized automated facility for observing 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 both stars and the interstellar medium at high resolution, and the University College of London instrument to investigate celestial X-ray sources. FY 1977 funds support the operation of OAO-3 and the analysis of data obtained by the Princeton experiment. Support is also being provided for 30 of the 120 Guest Investigators approved to date from universities, Government institutions and seven foreign countries. These Guest Investigators, utilizing both the Princeton and University College (London) instruments, have covered a wide variety of problems ranging from a study of the chlorine content of the terrestrial atmosphere to a search for X-ray sources in the ultraviolet. One of the most significant results from the Guest Investigator Program was the detection in the ultraviolet of a star which had remained a hidden enigma for 40 years--a detection which solved a long-standing debate.

During the past four years, new techniques have been developed which have extended the usefulness of OAO-3 by allowing the observation of objects six times fainter than could be observed at launch and which have extended the useful spectral range in the near ultraviolet. As a result, many new classes of objects can now be studied by this observatory.

BASIS OF FY 1978 ESTIMATE:

FY 1978 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.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Sounding rockets	20,000	6,200	20,700	20,700	20,700
Airborne research	3,800	1,000	3,800	3,800	3,800
Balloon program	1,000	300	1,500	1,500	1,500
Total	24,800	7,500	26,000	26,000	26,000
(Expendable Launch Vehicles Program)					
Scout	(400)	(---)	(---)	(---)	(---)
	Sounding Rockets				
	20,000	6,200	20,700	20,700	20,700

OBJECTIVES AND STATUS:

The Sounding Rocket Program provides a low cost and versatile tool for scientific research in the suborbital space environment. This program provides broad-based support of all of the scientific disciplines, including the study of the earth's upper atmosphere and ionosphere, magnetospheric physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted both on a domestic and an international cooperative basis. The current level of activity is approximately 60 rocket flights per year.

The specific objectives of the Sounding Rocket Program are as follows:

1. To conduct a coordinated research program utilizing experiments with flight requirements which cannot be met by vehicles with different performance characteristics such as balloons, aircraft and satellites and which 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 Program by providing the means for flight testing instruments and experiments being developed for flight on satellites, observatories, and space probes; and for calibrating or obtaining vertical profiles in correlation with currently orbiting spacecraft.

In the magnetospheric physics area, continued emphasis is being placed on lower ionospheric measurements and vertical profiles which can only be done with sounding rockets. In January 1976, as part of a NASA/DoD cooperative program, a series of 26 sounding rockets was launched from the Wallops Flight Center in support of the Winter D-Region Campaign. This campaign was a coordinated program to study winter days of "normal and "anomalous" electron densities in the ionsopheric D region. Continuing aurora measurements were conducted in 1976 using rockets fired from Alaska, Canada, Norway, Greenland, and Sweden.

The Solar Physics sounding rocket program continues to play a major role in the NASA solar program. Since 1976 was the year of minimum activity in the current solar cycle, considerable emphasis was placed on the investigation of minimum activity conditions in the solar chromosphere, transition region and corona. Complementary studies from the OSO-8 satellite benefited from the flight of a calibration rocket which enabled instrumental drifts in the two satellite ultraviolet spectrometers to be accurately determined. An accurate measurement was also made of the total radiative output from the sun during its quietest period. This will be compared with similar measurements from rockets, the Solar Maximum Mission, and Spacelab during increasingly active periods of the cycle, to determine whether there is a cyclic variation in the solar constant.

In the astronomy area, continuing emphasis is being placed on measurements of stars and extended sources in both the UV and X-ray regions and on correlative measurements of the same objects in different portions of the electromagnetic spectrum. Many observations are following up on the earlier measurements obtained by satellites such as UHURU and OAO-2. The Gravity Probe-A project, designed to confirm with improved accuracy the gravitational redshift (relativistic frequency shift) predicted by Einstein's Theory of Relativity, was successfully launched in June 1976; data analysis is underway and final reports will be prepared during FY 1977. Of special interest is the preparation for a series of seven sounding rocket flights to make

X-ray, UV and ionospheric observations in the southern skies from the launch site at Woomera, Australia during 1977. Scientifically interesting objects in our galaxy and in certain nearby galaxies cannot be viewed from the Northern Hemisphere and must, therefor, be observed from the Southern Hemisphere.

BASIS OF FY 1978 ESTIMATE:

FY 1978 will see a continuation of most of the above efforts with emphasis on the coordination of near-simultaneous launches of several rocket payloads and on correlation with satellite observations. FY 1978 payloads will be used to further refine the instruments needed for vertical profile studies as well as to flight-test new types of instruments for active studies of the ionosphere and magnetosphere. These instruments include an electron accelerator, a UV spectrograph, a chemical release package, an X-ray detector, a shaped-charge system to accelerate barium ions to high speeds as magnetospheric tracer particles, and an airglow detector. New instrument development in the solar physics area will be continued and the two newly developed high resolution ultraviolet imaging systems will be utilized to study the detailed structure of the cooler portions of the solar atmosphere. In the astronomy area, special instrumentation will be flown in order to test new types of equipment and to make measurements, such as those which depend upon film for data recording, which cannot be made with existing satellites.

Airborne Research

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,800	1,000	3,800	3,800	3,800

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in Physics and Astronomy since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the earth. It also may be transported readily to high operational altitudes, near 15 km (50,000 feet) in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this cloud-free altitude has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from one micrometer to 1 millimeter. The airborne platform has the further advantage of enabling scientists to participate directly in space research.

The Airborne Research program utilizes two aircraft, the C-141 instrumented with the 91-cm IR telescope and the Lear Jet instrumented for unique individual missions.

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).

During the past year, the principal scientific investigations were in three areas: stellar formation using far infrared photometers, planetary atmosphere spectroscopy with high spectral resolution interferometers, and emission spectroscopy of the interstellar medium. Long wavelength photometers used with the high spatial resolution attainable in the airborne observatory have begun to reveal the inner structure regions in our galaxy where protostellar formation is in progress. High resolution Fourier spectroscopy of Jupiter from the aircraft has revealed the existence of PH_3 (phosphene) in the Jovian atmosphere and IR emission spectroscopy of the interstellar medium in the infrared, 10 to 100 microns, has for the first time succeeded in observing the lines from doubly ionized sulphur and oxygen at 18 and 88 microns.

The FY 1977 Airborne Research Program funds are being used to support approximately sixteen scientific groups using the C-141A. This includes an expedition to Australia to observe Uranus occultating SAO star No. 158687 in March 1977. The Lear Jet astronomical program continues to support infrared astronomy objectives utilizing a 30-cm telescope carried aboard the aircraft. At present, about eight groups are involved in this program.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, Airborne Research funds will be used to continue operations of the Airborne Observatory. The requirements cover support for the astronomical groups, acquisition of subsystems, and operations of the C-141A and the Lear Jet.

Balloon Program

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)			
1,000	300	1,500	1,500	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 above most of the obscuring atmosphere and therefore well suited for many astrophysics payloads. In many instances, it is least expensive to fly these experiments on balloons. In addition, the ability to remain in the upper atmosphere for long periods of time makes balloons a valuable tool for upper atmospheric research. The feasibility of ballooning as an economical tool for conducting research has been established by important scientific discoveries including the detection of rare ulta heavy cosmic rays, and the detection of an event for which the current explanation involves the possibility of a magnetic monopole or a heavy nucleus of anti-matter. 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 (SR&T).

The FY 1977 funding provides support for about 50 flights, including 11 flights for upper atmospheric research.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funding is required to support essentially the same number of flights as in FY 1977, including some "superpressure" balloons to meet the longer duration requirements of the science investigators. These funds will also provide for several balloon flights in support of the FY 1978 upper atmospheric research program.

BASIS OF FUND REQUIREMENTS:

SUPPORTING ACTIVITIES

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Supporting research and technology (SR&T)...	14,478	3,600	14,700	15,200	16,800
Upper atmospheric research.....	3,500	1,000	11,600	11,600	11,600
Data analysis.....	10,882	2,800	9,000	9,000	8,600
Spacelab science payload definition.....	3,500	900	4,000	4,000	4,000
Out-of-the-ecliptic (OOE) advanced technological development.....	---	---	---	---	1,000
Space telescope (ST) - advanced technological development.....	5,000	2,000	---	---	---
Solar maximum mission (SMM) - advanced technological development.....	1,000	975	---	---	---
Total.....	38,360	11,275	39,300	39,800	42,000
Supporting Research and Technology (SR&T)	14,478	3,600	14,700	15,200	16,800

OBJECTIVES AND STATUS:

The Supporting Research and Technology 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 cover 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 phenomena and predict new ones; and (3) optimization of the return expected from future missions by problem definition, development of advanced experiments and concepts, and sound definition of proposed new missions.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's environment and comparative studies of other planetary environments. It includes the study of Sun-Earth environmental factors. The work in solar physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary and planetary environments. Research supported in astronomy involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, radio observation of solar and galactic processes and observations by ground-based and balloon-borne instruments are also supported. In addition, advanced development work is carried out on the experimental test of Einstein's general Theory of Relativity.

During FY 1977, about 225 tasks are being supported at universities, nonprofit and industrial research institutions, NASA centers, and other Government agencies. These include continuing studies of advanced missions; advanced technological development of solid state detector devices and improved photodetectors; and superfluid helium research. Extensive effort is being placed on the development of an exceedingly accurate gyroscope to test Einstein's Theory of Relativity.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

FY 1977 funding has been increased by $500 thousand, consistent with Congressional Authorization action providing for additional SR&T effort to help assure the viability of future research in Physics and Astronomy.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, continued support will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy Program. Special emphasis will be placed on studies for advanced instrumentation involving image tubes and solid state devices which will increase both the sensitivity and resolution of detectors. These instruments will be designed to detect and display astronomical data with extreme fidelity.

In solar physics initial efforts are planned on the definition of a comprehensive ground-based solar optical and radio flare observing program to complement the Solar Maximum Mission. Some new ground-based solar velocity field measurements will also be initiated to provide a better understanding of the solar convection and circulation processes and to probe the convective envelope of the sun. A variety of new instrument developments will also be initiated, including possible miniaturized magnetographs and coronagraphs to study the structure of the solar poles and the strength and the polar longitudinal magnetic fields from the Out-of-Ecliptic Mission, and large-scale high energy (X-ray and gamma ray) experiments for flight on Spacelab missions.

Space plasma physics research will place increased emphasis on developing theories which predict the interactions of the different space particle and field regimes, including instabilities that cause F-region irregularity structures or the generation of terrestrial kilometric radiation. More work will be devoted to development of instruments to be employed using the Shuttle/Spacelab as a laboratory in space to perform active, controlled experiments by perturbing the plasma medium with a known stimulus and detecting the response.

In astronomy, intensive work will continue on the development of advanced detectors for future space astronomy missions. In addition to continuing previous work on ultraviolet/optical detectors, work will be started in the area of infrared detectors. In support of the launch of IUE (International Ultraviolet Explorer), increased emphasis will be placed on the theoretical and ground-based observational studies of stellar chromospheres and coronae which are the subjects of a substantial number of the IUE Guest Investigator programs. Studies in infrared astronomy will continue to concentrate on the problem of star formation and the physics of cool, dense, interstellar clouds; as part of this effort, there will be an emphasis placed on an observing program from the Southern Hemisphere.

In high energy astrophysics, instrument development will be continued leading toward future Spacelab and post-High Energy Astronomy Observatory (HEAO) free flyer missions. Important preliminary testing of these instruments will be accomplished with balloon flights. Emphasis will also be given to theoretical studies to incorporate the diverse results obtained to date into a more coherent understanding of energetic natural phenomena.

Upper Atmospheric Research

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,500	1,000	11,600	11,600	11,600

OBJECTIVES AND STATUS:

The overall goal of the NASA Upper Atmospheric Research Program is to acquire sufficient understanding of the physical and chemical processes occurring in the Earth's atmosphere so that perturbations in the stratosphere caused by man's actions can be accurately assessed and associated changes in the atmospheric transmission of solar radiation can be determined. The long-term basic science objective involves development of an organized solid body of knowledge of the physics, chemistry, and transport processes occurring in the

Earth's stratosphere. For the short-term, program resources are applied to focusing results of the basic science program toward assessing the effects on stratospheric ozone of perturbations due to chlorofluoromethane (CFM) releases, Shuttle and aircraft effluents, and other chemicals. A program plan for Upper Atmospheric Research has been published which outlines these goals and objectives as well as the NASA program for achieving them.

The short-term assessment program is well underway. An assessment of the effect of Shuttle exhausts on stratospheric ozone has been completed and a final report written. Assessment of the stratospheric effects of CFM releases is progressing toward a scientific workshop in January 1977 and a final report for use by the Federal regulatory agencies by September 1977. Basic science results are contributing to the long-term objective of developing knowledge of the stratosphere. Measurements of CFM concentrations in the stratosphere have confirmed that these compounds do reach that portion of the atmosphere. The first stratospheric measurements of chlorine and chlorine oxide provided validation of the concept of ozone destruction in the stratosphere. Laboratory studies have provided values for important chemical reaction rates, spectroscopy of stratospheric species, and data on the potentially important stratospheric constituent, chlorine nitrate. Both the field measurements and laboratory studies focus on the development and validation of 1-, 2- and 3-dimensional theoretical models of the stratosphere, and these models provide the means for assessing the effects of many activities on the stratosphere.

BASIS OF FY 1978 ESTIMATES:

In FY 1978, the focus of the Upper Atmospheric Research Program will be on the continuing development of a long-term basic science program aimed at providing an organized body of knowledge concerning the stratosphere and stratospheric processes. Extensive treatment will be given to the physics and chemistry of ozone in the stratosphere including the photochemistry and dynamic processes which determine ozone distribution and variability. Investigations of stratospheric species other than ozone which could affect solar transmissions will be included. A continuing goal of the program is to be able to apply the increasing body of basic knowledge to understanding and evaluating other potential threats to the stratosphere.

Data Analysis

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
10,882	2,800	9,000	9,000	8,600

OBJECTIVES AND STATUS:

The purpose of this effort is to obtain the maximum return on the investment represented by the data gathered in the Physics and Astronomy Program. Since a number of spacecraft have survived well beyond their originally planned lifetimes, continued operation is sometimes authorized for specific investigations that have high scientific potential, with preference being given to correlative operations designed to illuminate physical problems and to the exploitation of unusual scientific opportunities such as unexpected encounters with comets. Work using existing data is also supported with emphasis on correlative studies using data acquired from two or more spacecraft.

Considerable support is still being given to the analysis and interpretation of the 171,000 photographs, 2,920 hours of photoelectric data, and the vast quantity of complementary ground-based observatories and satellite solar wind measurements which were collected as part of the Skylab Apollo Telescope Mount (ATM) program. In addition to a significant ongoing data analysis effort involving investigations of the physics of solar flares, coronal holes, active regions, bright points, solar atmospheric heating processes, and a variety of other solar features and phenomena, a series of Skylab Solar Workshops have been established to encourage the synthesis of the many complementary solar data sets. The first of these workshops, on the subject of coronal holes and their role in solar wind generation, has just been completed. The second, on the subject of solar flares, commenced in October 1976.

As a result of the considerable success enjoyed by the workshops, an ATM Guest Investigator Program has now been established to provide support for some of the non-ATM theoreticians and ground-based scientists who, as a result of workshop activities, are now working with the prime ATM data.

The operation of the National Space Science Data Center (NSSDC) is also supported under this project. The NSSDC, located at the Goddard Space Flight Center, was established to serve as a central repository and clearinghouse for scientific data resulting from space investigations. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft, so that our efforts of data acquisition and analysis can be concentrated at times when several spacecraft are especially favorably situated for correlative geophysical studies.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will provide support for the operation of the NSSDC and for the data analysis activities of more than 100 principal investigators at approximately 45 institutions including NASA field centers. Funding in FY 1978 will provide for study of magnetospheric data on Jupiter and Mercury and additional studies in high energy astrophysics using data returned from SAS 1 and 3, Pioneer 10 and 11, and Mariner 10.

Also included in the FY 1978 program are the ongoing ATM Data Analysis Program, the Skylab Solar Workshops, and the ATM Guest Investigator Program. These programs support approximately 70 scientists and data technicians who are involved directly in the analysis and interpretation of the ATM data, and approximately 30 other scientists who are involved in the workshop activities but who receive their primary research support from other sources.

Spacelab Science Payload Definition

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,500	900	4,000	4,000	4,000

OBJECTIVES AND STATUS:

Initial Spacelab Science Payload studies have provided the data necessary for the development of programmatic and budgetary plans for Space Science program operations in the Space Transportation System (STS) era. The initial studies concentrated on establishing the feasibility of performing discipline-dedicated missions and multidiscipline missions employing both facility-class and principal investigator-class (sounding rocket and balloon) instrumentation in their conceptual payload configuration. These studies have identified the benefits which can be realized by re-flying instruments and facilities and have established the feasibility of Shuttle-borne research laboratories and experiments employing many common, reusable facility-type and investigator-class instruments to study phenomena in all astronomy and physics discipline areas. During FY 1977, further payload definition involving detailed descriptions of instruments, payload configurations, and operational mission profiles is continuing.

BASIS OF FY 1978 ESTIMATES:

During FY 1978, detailed studies of specific facility-class instruments will be continued. Definition of the new generation, high resolution optical observatory facility with different optical configurations for several major instruments has already been considered for the Solar Spacelab Program. The facility instruments which have the highest priority for early development are currently identified as the Solar Optical Observatory and the grazing incidence extreme ultraviolet observatory.

These studies will also include further definition of instrument pointing systems applicable to facility-class instruments and telescopes. FY 1978 funding will be used to continue studies begun in previous years and to initiate studies for new types of instruments that have emerged during the past year. Before construction of some of the more complex instruments is undertaken, more detailed studies will be necessary on selected instruments and subsystems.

Out-of-the-Ecliptic (OOE) - Advanced Technological Development

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
---	---	---	---	1,000

OBJECTIVES AND STATUS:

Exploration of the Sun and its emissions from a spacecraft at high solar latitude has become recognized as a scientifically important mission option. It has become increasingly clear that observations made within the narrow slice of solar latitudes to which we are presently restricted are not typical of the rich assortment of solar phenomena.

In the second half of 1974, a mission definition study of an "Out-of-the-Ecliptic and Solar Stereoscopic Mission" was performed by the European Space Agency as part of an analysis of several cooperative space missions between NASA and the European Space Agency. In the European Space Agency study, two different missions with a goal of placing one or more scientifically instrumented spacecraft into a high inclination solar orbit were examined. One spacecraft trajectory is designed to take it over the north pole of the sun and the other over the south pole. This method is identified as the Jupiter Swingby (JSB) method.

The successful Jupiter encounters of Pioneer 10 and 11 demonstrated, to a large extent, the feasibility of using the Jupiter gravitational assist to inject a spacecraft into a high inclination polar orbit. A scientific spacecraft in such an orbit could make first-time measurements of the sun and its emissions from significantly more than 7 degrees from the solar equatorial plane. Thus the primary scientific objective of the Out-of-the-Ecliptic mission is to enhance our knowledge of the sun, its emissions, atmosphere and environment by making exploratory measurements far out of the solar equatorial plane. A secondary objective is to contribute to man's understanding of the interplanetary medium by employing two spacecraft to help resolve spatial from temporal effects.

During FY 1977 NASA is conducting studies to identify the scientific requirements and spacecraft capabilities for an Out-of-the-Ecliptic mission. NASA is working closely with the European Space Agency to develop a plan of sharing development and operations tasks to reduce the cost of such a mission.

BASIS OF FY 1978 ESTIMATE:

During 1978 it is planned to conduct a definition study of specific scientific payloads and to identify specific spacecraft systems required to support an Out-of-the-Ecliptic mission. These studies will provide detailed information on technical, management, schedule, and cost approaches. These data will be necessary for making decisions leading to a possible Out-of-the-Ecliptic mission with a launch date of 1983.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Viking	39,500	11,600	24,200	25,400	20,000
Pioneer Venus	56,600	15,300	42,800	42,800	19,000
Mariner Jupiter/Saturn 1977	82,400	22,100	50,300	50,300	14,300
Jupiter Orbiter/Probe	---	---	---	---	20,700
Pioneer 6-11	3,900	879	3,700	2,600	3,600
Helios	1,200	200	900	900	700
Planetary Flight Support	29,200	8,700	27,900	27,900	25,000
Supporting Activities	41,450	8,685	41,300	42,000	44,900
Total	254,250	67,464	191,100	191,900	148,200

Distribution of Program Amount by Installation:

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Johnson Space Center	10,815	1,364	11,925	9,516	7,942
Marshall Space Flight Center	22	---	---	---	---
Goddard Space Flight Center	9,564	3,271	8,625	6,866	3,862
Jet Propulsion Laboratory	97,306	25,693	70,150	75,925	61,843
Wallops Flight Center	55	11	50	11	---
Ames Research Center	62,103	16,628	48,220	46,628	32,347
Langley Research Center	49,002	15,729	27,008	25,465	20,068
Headquarters	25,383	4,768	25,122	27,489	22,138
Total	254,250	67,464	191,100	191,900	148,200

LAUNCH SCHEDULE

Project	Mission	Calendar Year
Mariner Jupiter/Saturn 1977	MJS77-A	1977
	-B	1977
Pioneer Venus	Orbiter	1978
	Probe	1978
Jupiter Orbiter/Probe	JOP	1981

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, meteoroids, asteroids, comets, and the particles and fields of interplanetary space. The major objectives of the program are to understand the origin and evolution of the solar system and to apply the results of these investigations toward a better understanding of the planet Earth. The program has been highly successful, providing pioneering information on the nature and characteristics of the Moon and the planets Mercury, Venus, Mars, and Jupiter.

The scientific investigation of Mars is currently receiving major attention in the wake of the successful landings of Vikings 1 and 2. While the two Orbiters continue mapping the planet, the two Landers are giving us our first measurements from the surface of another planet and their biology instruments are searching for evidence of life on Mars. FY 1978 funding will continue support of the Viking extended mission, permitting scientific observations through an entire Martian year of 25 months. Daily and seasonal variations will be measured and additional biological data will be acquired. Several alternatives are being considered for a Mars follow-on mission which would take advantage of the scientific results of Viking and utilize its technological inheritance. These alternatives and the associated technology will be studied in detail in FY 1978.

Our first close-up views of Mercury and Venus were provided by Mariner 10 in 1974. In 1978, two Pioneer missions will be launched to conduct detailed investigations of Venus. One of the two missions, a multi-probe, will give us our first in situ measurements of the Venusian atmosphere. The Pioneer Venus spacecraft will be launched in May and August of 1978. FY 1978 funds will be used for final assembly and test of the spacecraft/experiment systems, launch operations, and the design and development of the mission operations system.

The program of exploration of the outer planets, begun with Pioneers 10 and 11, will continue with the launch of two Mariner Jupiter/Saturn spacecraft in the fall of 1977. Pioneer 10 is now escaping the solar system and Pioneer 11 is on its way to encounter Saturn in September 1979. The Mariner Jupiter/Saturn 1977 missions will expand our knowledge of these two planets, and will also make the first scientific measurements of several of the satellites of these two giant planets. An option exists to target one of the spacecraft to proceed on to Uranus. FY 1978 funding will support mission operations during their cruise periods to Jupiter. Initial science data will be analyzed and encounter period software development will continue. The Jupiter Orbiter/

Probe mission, planned for initiation in FY 1978 and launch in 1981, will sample the Jovian atmosphere with an instrument-bearing probe, obtain data on the planet's magnetosphere and atmosphere, and observe the Jovian satellites.

At the center of our solar system, the Sun is being studied from closer range than ever before by Helios A and B. These highly successful missions, launched in December 1974 and January 1976, are the result of cooperative efforts of the United States and the Federal Republic of Germany.

During FY 1978, planetary flight support funds will continue to support Pioneers 6-11, Helios, and Viking. Flight operations for Mariner Jupiter/Saturn 1977 and for Pioneer Venus will also be supported.

A strong science research and technology effort is continuing in support of the lunar and planetary program. Laboratory and theoretical research provide both new data and new understanding of existing information. Earth-based remote observations gather important data via optical, radio, and airborne instruments, which complement and supplement the spacecraft measurements and provide a test bed for new techniques. Laboratory analyses of meteorites and lunar samples provide a reference base for better understanding of remote measurements. A concentrated scientific effort is underway to analyze and synthesize the large amount of data available from past flight programs and earth-based sources to gain new insight into the history of the solar system and to aid in planning of new missions. The development of instruments which can provide answers to increasingly sophisticated questions is also an important part of the supporting research program. The lunar laser ranging program has provided information from which the orbit of the Moon around the Earth has been well determined. With this data base, and the establishment of new operating stations in Hawaii and by the government of Australia, we will begin to correlate measurements of the movements of Earth's crust. A portable ranging station now being constructed will allow measurement of relative movements within the continental United States, as well as at other locations around the world.

The supporting activities funding for FY 1978 will provide for the advanced technological development and scientific studies required to undertake future planetary missions and, most importantly, will support the scientific activities described above that have grown out of past missions. These activities are directed toward achieving the fundamental goals of NASA's lunar and planetary exploration: to understand (1) the origin, evolution, and current state of the solar system; (2) the past and present processes that affect Earth through comparative studies of solar system bodies; and (3) the relation of the chemical history of the solar system to the origin and evolution of life.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

VIKING

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Orbiter operations and data analysis.....	14,500	7,700	2,300	2,300	---
Lander operations and data analysis.....	25,000	3,900	1,600	2,300	---
Extended missions operations and data analysis..	---	---	20,300	20,800	20,000
Total.....	39,500	11,600	24,200	25,400	20,000

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 is being placed on obtaining biological, chemical, and environmental data relevant to the existence of life on the planet.

Viking began a new chapter in the exploration of Mars when the two Viking Landers made their historic touchdown on the planet's surface and began their detailed scientific investigations. The scientific goals of these missions are to search for life-related evidence on Mars and to obtain a diversity of other scientific information which will help us to better understand the evolution of Mars and its relation to Earth and the entire solar system.

The Viking 1 spacecraft was launched on August 20, 1975, and was inserted into a Martian orbit on June 19, 1976. Viking 1 landed on July 20, 1976.

Viking 2 was launched on September 9, 1975, and was inserted into Martian orbit on August 7, 1976. Viking 2 landed on September 3, 1976.

The Viking primary mission was successfully completed and the extended mission was initiated in mid-November, 1976.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $1.2 million results from efforts associated with the landing delay of the Viking 1 Lander, and final contract adjustments.

BASIS OF FY 1978 ESTIMATE:

At the beginning of FY 1978, the extended mission portion of the Viking program will be about half completed. The four spacecraft (two orbiters and two landers) will continue to be operated by a reduced flight team to accomplish science which could not be performed during the primary mission. In particular, the objectives of the extended mission will be to use the functioning spacecraft to obtain data on seasonal variations, to permit long term sampling for statistically important experiments, and to obtain additional data to try to better understand the results already obtained relating to the biology question. These activities will be continued through June 1, 1978 to complete operations of the Vikings for one full Martian year.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

PIONEER VENUS	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	36,900	8,000	24,500	24,500	9,300
Experiments	17,700	5,600	12,300	12,300	5,400
Mission operations and data analysis	2,000	1,700	6,000	6,000	4,300
Total	56,600	15,300	42,800	42,800	19,000
Atlas/Centaur (Expendable Launch Vehicles Program)	(6,400)	(2,700)	(16,100)	(15,300)	(12,800)

OBJECTIVES AND STATUS:

There are two complementary missions in the Pioneer Venus Project: an orbiter mission and a multiprobe mission. These missions are designed to investigate the Venusian atmosphere and to perform scientific investigations of many other aspects of the planet's environment. The Pioneer Venus orbiter will be launched in May 1978, and will begin orbiting Venus in December 1978. The multiprobe mission will be launched in

August 1978 and the probes will penetrate the dense Venusian atmosphere in December 1978. Achievement of the primary goal of these missions, which is to determine the nature, dynamics and evolution of the Venusian atmosphere, will significantly advance our understanding of the dynamic processes taking place in the Earth's 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 scientific data to help understand the origin and evolution of the solar system.

Development efforts leading to the launches in 1978 are progressing. The spacecraft final design review was held in May 1976, and spacecraft qualification testing is in process. Testing of design verification models is in process for the science instruments. Structural and thermal testing of the total spacecraft systems will be completed in 1977, and assembly of the two flight spacecraft will follow.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will support final assembly and test of the Pioneer Venus spacecraft and experiment systems, as well as actual launch operations for the orbiter in May 1978, and the multiprobe mission in August 1978. Design and development of the mission operations system will be completed, and planetary cruise operations will be supported.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

MARINER JUPITER/SATURN 1977

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	58,400	16,000	29,100	29,100	---
Experiments	18,700	4,200	13,300	13,300	5,300
Mission operations and data analysis	5,300	1,900	7,900	7,900	9,000
Total	82,400	22,100	50,300	50,300	14,300
Titan/Centaur (Expendable Launch Vehicle Program)	(30,200)	(3,400)	(11,100)	(9,900)	(1,000)

OBJECTIVES AND STATUS:

The objective of this mission to the outer planets is to conduct comparative studies of the Jupiter and Saturn systems, including their numerous satellites and the rings of Saturn. There will also be an opportunity to perform new investigations in the interplanetary and interstellar media. The massive outer planets constitute the major portion of the planetary mass in our solar system. This mission will yield scientific information which can only be obtained by sending spacecraft such as these out to the great distances where the gigantic planets are located. Information from Jupiter and Saturn has great significance in the study and understanding of the origin and evolution of the solar system and will aid in understanding the dynamic processes which shape the Earth's environment.

In 1977, two Mariner-class spacecraft will be launched on trajectories which enable them to reach the outer planets of Jupiter and Saturn. If the primary objectives are met and conditions are favorable, the second spacecraft to arrive at Saturn may be targeted to proceed on to an encounter with Uranus. The launch vehicle for these spacecraft will be the Titan IIIE/Centaur D-IT, and the spacecraft will carry a jettisonable propulsion module to provide the final required increment of velocity. These space flights are made possible by a rare alignment of Jupiter and Saturn which permits a spacecraft launched to Jupiter to reach Saturn and eventually escape from the solar system through the acceleration provided by Jupiter's gravity. The opportunity to perform such a gravity-assisted swingby mission only occurs approximately every 20 years. The two spacecraft will encounter Jupiter in March and July 1979, and will reach Saturn in November 1980 and August 1981. If the option is exercised to go to Uranus, one spacecraft would encounter that planet in January 1986.

During FY 1977, the proof test model spacecraft systems test and environmental test efforts will be completed. The assembly, test and science instrument integration activities for the two flight spacecraft are underway in preparation for shipping the spacecraft to the Eastern Test Range in the spring of 1977. Mission operations planning activities are proceeding well. Specific encounter trajectories at Jupiter and Saturn have been selected and significant progress has been made on developing the science profiles for these trajectories. During the remainder of FY 1977, planning, testing and training for launch and early flight operations will be completed. Final spacecraft compatibility with the launch vehicle, the Deep Space Network, and the integrated ground data system, will be demonstrated. During the period of August - September 1977, the two spacecraft will be launched. Immediately after launch, scientific measurements will be made of the Earth-Moon system and near-Earth interplanetary medium.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, both spacecraft will be in their cruise periods to Jupiter. FY 1978 funding requirements will provide support for the mission operations team involved in operating the spacecraft, performing the detailed planning for the remainder of the flight, developing the software for the encounter periods and analyzing early science data.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

JUPITER ORBITER/PROBE (JOP)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	---	---	---	---	11,800
Experiments	---	---	---	---	8,900
Total	---	---	---	---	20,700

OBJECTIVES AND STATUS:

The objective of this project is to conduct a comprehensive exploration of Jupiter, its atmosphere, physical environment, and its satellites by combined observations from an orbiting spacecraft and an atmospheric entry probe. Primary emphasis will be on entry measurements, characterization of the magnetosphere, and observation of the Jovian satellites. Scientific interest in Jupiter has been enhanced by the remote sensing data provided by the Pioneer 10 and 11 flybys, which will be augmented by results expected from the Mariner Jupiter/Saturn missions to be launched in 1977. The Jupiter Orbiter/Probe mission represents the next logical step in the exploration of the solar system.

The JOP spacecraft will consist of an orbiter and an atmospheric entry probe. The orbiter will be of dual-spin design, a concept used previously on operational spacecraft, wherein part of the spacecraft is spinning to provide stability and the other part is de-spun. The probe and fields and particles instrumentation will be mounted on the spinning section, while imaging will be conducted from the de-spun portion.

The orbiter/probe combination will be launched in December 1981 by the Shuttle/Interim Upper Stage (IUS). The entry probe, designed to survive a descent to a pressure of at least 10 to 20 Earth atmospheres, will be separated from the orbiter prior to Jupiter encounter. Scientific data gathered by the probe during entry will be relayed to Earth via the orbiter. Shortly thereafter, the orbiter will be inserted into Jovian orbit and the orbit will be adjusted to permit multiple satellite encounters.

In FY 1977, preliminary design efforts are being carried out under Advanced Technical Development. These include probe and orbiter system definition studies and tentative experiment selection. In addition, discussions have been held with the Federal Republic of Germany (FRG) concerning the possibility of the FRG providing equipment to permit pre-entry science measurements from the probe and providing the orbit insertion motor for the JOP orbiter. These discussions will be concluded early in FY 1978.

The current planning estimate for the Jupiter Orbiter/Probe is $275 to $295 million. This includes development through launch and in-flight checkout for an additional 30 days.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, design and development activity will be initiated for both the probe and orbiter. A probe system contractor will be selected and probe design activity will be targeted toward a preliminary design review by the end of the fiscal year. Orbiter system design will be carried to the point of permitting start of subsystem design in FY 1979. Procurement of parts for both probe and orbiter systems will also be initiated. Experiment definition will result in final selection early in FY 1978, and experiments are scheduled to be under definitive contract before the end of the fiscal year.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

	PIONEER 6-11				
		Transition	1977		1978
	1976 Actual	Quarter Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)				
Mission operations and data analysis.....	3,900	879	3,700	2,600	3,600

OBJECTIVES AND STATUS:

The objective of the Pioneer 6-9 series is to explore the interplanetary region near the earth orbit distance from the sun, defined as one astronomical unit (A.U.). Pioneer 10 and 11 were designed to explore the interplanetary region beyond one A.U., the Asteroid Belt, and the environment of Jupiter. 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.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $1.1 million reduction in FY 1977 results from rephasing of the funding requirements for Pioneer 10 and 11 during interplanetary cruise periods.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will support continued flight operations for the Pioneer 6-11 spacecraft. Pioneers 6-9 will be supported to the extent allowed by the availability of the Deep Space Network. Pioneer 10 and 11 flight operations will continue, with emphasis on acquisition of particles and fields data from the interplanetary medium. In addition, analysis of Pioneer 10 and 11 data will continue.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

HELIOS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Mission operations and data analysis.....	1,200	200	900	900	700
Titan/Centaur (Expendable Launch Vehicle Program).....	(1,300)	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the Helios program is to investigate the properties of and processes in interplanetary space in the direction of and close to the Sun. United States participation in this two-mission, cooperative effort with the Federal Republic of Germany (FRG) includes provision of the launch vehicles, technical support, and three instruments as well as tracking, flight operations and data analysis support. The FRG provided the spacecraft and seven instruments, and is also responsible for tracking, flight operations and data analysis.

Helios A was launched into heliocentric orbit on December 10, 1974 and Helios B followed on January 15, 1976. Both spacecraft are operating normally, in orbits which take them to within 0.3 AU of the Sun once every six months. Analysis of the Helios data has shown that the solar wind is much more turbulent close to the Sun, having many shock fronts and irregularities; that strong solar wind streams with marked wave structure appear to be associated with coronal holes; and that solar cosmic rays appear to be accelerated by the waves in the solar plasma. These studies will continue next year with emphasis again during the April and October times of perihelion.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funds will provide for the U.S. portion of the mission operations and analysis of data collected by the U.S. experiments.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

PLANETARY FLIGHT SUPPORT

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
29,200	8,700	27,900	27,900	25,000

OBJECTIVES AND STATUS:

The purpose of the planetary flight support program is to provide for required integrated computing and computer-related activities which support the tracking, telemetry and command functions for all planetary automated spacecraft. The requirements also include general purpose scientific and engineering computing at the Jet Propulsion Laboratory, and selected project-peculiar activities, such as preparation of data records, computer analysis time, and provision for the mission support areas.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, funds will continue to provide mission control and computing support for Pioneers 6 through 11, Helios A and B, and Vikings 1 and 2. Flight operations for the Mariner Jupiter/Saturn 1977 spacecraft, which will be launched in August/September 1977, will also be supported.

Test and training for the Pioneer Venus missions will continue, with launch and flight support starting in May 1978 for the orbiter mission and in August 1978 for the multiprobe mission. Planning and implementation for future lunar and planetary missions will also continue during this period.

During FY 1978, the Planetary Flight Support funds will continue to support the tracking system analytic calibration efforts for all missions; the development of lunar and planetary data systems standards; and the definition of Shuttle/Interim Upper Stage interfaces with lunar and planetary spacecraft. These are all on-going activities at the Jet Propulsion Laboratory. In addition, the planning, design, development, and testing of the improved support system utilizing minicomputers for real time support will continue for the Mariner Jupiter/Saturn 1977 missions during FY 1978 and for all subsequent missions.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SUPPORTING ACTIVITIES

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Supporting research and technology	14,654	3,267	13,200	13,100	13,000
Data analysis	9,320	1,682	11,500	11,500	12,200
Advanced technical development	5,200	1,300	5,200	6,000	5,200
Mars follow-on mission definition	---	---	---	---	5,000
Advanced studies	1,200	236	1,200	1,200	1,200
Lunar science operations	5,126	1,000	5,000	5,000	4,500
Lunar sample analysis	5,950	1,200	5,200	5,200	3,800
Total	41,450	8,685	41,300	42,000	44,900
Supporting Research and Technology	14,654	3,267	13,200	13,100	13,000

OBJECTIVES AND STATUS:

Supporting Research and Technology sponsors research efforts that provide new data necessary to interpret information obtained from spacecraft missions and to formulate science objectives for new missions. The Supporting Research and Technology objectives include early definition of advanced instrumentation, as well as necessary steps to insure technological readiness of instruments for new flight missions. Specific research tasks fall into the following categories: earth-based observations, analog studies, theoretical studies, laboratory simulations, instrument development, cometary research, and meteorite studies. These tasks are a vital part of the continuing planetary exploration program and contribute to the fundamental objectives of the Lunar and Planetary Exploration Program.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The reduction of $100 thousand reflects procurement deferral of a scanning electron microscope for meteorite studies.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, the Supporting Research and Technology project will continue investigations within the disciplines of planetary atmospheres, planetary geology, planetary astronomy, cometary science, and lunar science. Laboratory studies of molecular reaction rates and spectroscopic properties of atmospheric gases will be used to interpret flight experiment data and to understand and predict the response of atmospheres to solar and other energy inputs and to perturbations by contaminates or other influences. Geological analog and surface process studies will continue wherein comparisons between planetary bodies will be made with regard to such phenomena as wind-produced, glacial and volcanic features. A number of laboratory studies of chemical differentiation processes will continue to provide basic data necessary to interpret the origins of the various rock types on the Moon and inner planets. Over forty planetary observational research programs will continue, with the major areas of emphasis being the outer planets and their satellites and planetary radar astronomy. Studies of analogs of lunar and planetary craters will continue to provide insight into the cratering processes that have modified the surfaces of all inner planets. Emphasis will be placed on studies of meteorites and interplanetary dust, using the scientific knowledge obtained from lunar sample analysis, because these materials provide vital information regarding the composition of the primitive solar system and condensation process.

Advanced instrumentation concepts will also be developed to support the scientific preparation for new flight programs. Instrument development will emphasize experiments for the outer planets, experiments to detect the important atmospheric components in small or trace amounts, planetary subsurface water detectors, chemical analysis instruments, and instrumentation capable of in situ mineralogic identification of soil and rocks.

Data Analysis

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
9,320	1,682	11,500	11,500	12,200

OBJECTIVES AND STATUS:

The objective is to provide for post-project analysis of the wealth of data obtained from previous lunar and planetary programs. These efforts support continuation of data analysis by flight experimenters after the period of funding by the flight project has passed; analysis and interpretation of flight data by other investigators not associated with or funded by flight projects; and synthesis of information on the Moon and planets. The latter endeavor is primarily a comparative planetology effort that will make use of rapidly accumulating spacecraft data and the vast store of information being derived from studies of returned lunar samples to refine current concepts of the origin and history of the solar system. The results of the synthesis efforts will provide the information base necessary for intelligent planning of future planetary exploration. Interdisciplinary studies of results from Apollo, Mariner, Pioneer, and Viking missions, as well as from Earth-orbital satellites, such as Atmospheric Explorers, will be undertaken. Atmospheric scientists will concentrate on problems of the origins of planetary atmospheres, as well as more detailed analysis of the structure, composition, and circulation of atmospheres of specific planets. Geoscientists will continue to extract mission information from existing spacecraft data with regard to planetary structure, composition processes and history, but will emphasize comparative planetology studies to take advantage of the enhanced capability for discovery that this mode of study offers.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, atmospheric scientists will initiate intensive analysis of atmospheric data resulting from the Viking missions to Mars and the valuable data available from previous Earth-orbital satellites and the Mariner and Pioneer missions to Mercury, Venus, Mars, and Jupiter. Critical analysis and examination of all these data, reflecting a wide range of planetary characteristics, is expected to improve our grasp of the theoretical and mathematical models used to describe atmospheric behavior, and to lead to a more detailed understanding of the behavior of the Earth's atmosphere. Geoscientists will continue to synthesize results of lunar sample studies and Apollo Lunar Surface Experiments to obtain a refined view of the Moon's history, and will extend their interpretations of planetary history and processes through photogeological studies using Apollo, Mariner 9 and 10, and Viking 1 and 2 data sources. The Viking data will provide a major new resource that will impact the scope of work to be performed in a significant way. With these data, geoscientists will have comparable kinds of information for the Earth, Moon, Mars, and Mercury, and correlative analysis of these data is expected to provide significant advances in our understanding of the Earth, its terrestrial planetary neighbors, and the evolution of the solar system as a whole.

Advanced Technical Development

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,200	1,300	5,200	6,000	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 1977, the major area of emphasis is support of preliminary spacecraft design and experiment definition for the Jupiter Orbiter/Probe mission. This effort includes the issuance of an Announcement of Opportunity and tentative experiment selection for orbiter and probe, competitive probe system definition studies and supporting technology tasks, orbiter mission and system design with supporting advance development in appropriate subsystem technologies, and science working group experiment definition activities.

Two other activities carried out in FY 1977 are the development of solar sailing technology for high energy missions, and advance planning for a post-Viking Mars mission. Solar sailing is the technique by which a spacecraft, using a very large and extremely lightweight sail, may be propelled by the solar wind. The solar sailing effort is conducted in cooperation with technology development supported by the Office of Aeronautics and Space Technology, and concentrates primarily on the spacecraft, total system and mission analysis aspects. Planning for a post-Viking Mars mission will be directed toward assessment of several mission alternatives, such as an orbiter mission with penetrators, or a mission with semiautonomous roving vehicles, with a long-range goal of a Mars surface sample return mission in the late 1980's. In addition, advanced development of several technologies with multimission applications is underway. This effort includes work on an advanced star tracker with reliability and lifetime characteristics suitable for future long duration missions, long-term life testing of propellants with various propulsion system materials, techniques for navigation with low thrust propulsion, and studies directed toward defining potential areas of commonality in future planetary orbiters.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

In response to Congressional recommendations on strengthening activity in Supporting Research and Technology, as reflected in the FY 1977 Authorization Conference Committee report, the FY 1977 funding support was increased by $800 thousand. The additional funds support the FY 1977 solar sailing advanced technology development activities and preliminary Mars Follow-On Mission planning.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, emphasis will be placed on definition of a possible Halley rendezvous mission and on advanced technological effort associated with a possible Venus Orbital Imaging Radar (VOIR) mission. The Halley rendezvous mission would utilize low thrust propulsion, either solar sail or solar electric, and the advanced efforts will concentrate on spacecraft definition and mission design consistent with low thrust propulsion and the interfaces peculiar to it. Advanced preparation for VOIR will include study of the application of existing synthetic aperture radar technology, development of radar compatible data system technology, and supporting mission and system design activity.

Additional activities will include the completion of effort on the advanced star tracker, continuation of orbiter commonality studies and propellant/materials testing, and the study of spacecraft interfaces with the Space Shuttle that are unique to future possible planetary missions.

Mars Follow-on Mission Definition

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
---	---	---	---	5,000

OBJECTIVES AND STATUS:

The immediate objective of the Mars follow-on mission activity is to provide for definition of a logical and productive next step to the highly successful Viking mission. The Viking spacecraft are returning extremely valuable scientific information and at the same time raising important questions to be answered by future missions to Mars. The most obvious need is for further investigations to clarify and expand our initial findings with respect to the existence of life on Mars. Alternatives currently under study include: (1)

a surface rover to address the local diversity of the Mars surface; (2) instruments which directly address the chemistry/biology ambiguity issues raised by Viking; (3) orbiter instruments to conduct a global resources survey of the planet, and (4) means for implanting on Mars an instrument network.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will provide for the identification of new instruments and exploration techniques that can most effectively respond to Viking results with a mission during the 1984 launch opportunity. Efforts will include rover technology and science instrument studies, and preliminary mission and system design.

Advanced Studies

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
1,200	236	1,200	1,200	1,200

OBJECTIVES AND STATUS:

The objective of the Advanced Studies project is to provide a sound 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 which are performed both under contract and in NASA Centers, range from mission analysis and system feasibility to preliminary mission design and engineering. Only through these studies can a logical, timely, and economical program of solar system exploration be implemented.

During FY 1977, studies of mission performance capabilities of solar electric propulsion and solar sailing concepts will allow evaluation of these technologies for application to a Halley Comet mission and other high energy missions which require propulsive augmentation beyond the Shuttle-Interim Upper Stage capability. Mission concept definition/feasibility studies are being conducted during FY 1977 for Mars, Mercury, Venus, Jupiter, Saturn, and Uranus.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funding requirements will provide for mission studies for the inner and outer planets, their satellites, and small bodies of the solar system (comets and asteroids), and continuing general studies on adapting planetary spacecraft to the Space Transportation System.

A detailed study for an orbiter mission with synthetic aperture radar to map the surface of Venus will be conducted in FY 1978. This effort will provide necessary mission, system, and science definition for a subsequent new start project proposal. A Saturn-Uranus probe mission, designed to study the atmospheres of Saturn and Uranus in the mid-1980's, will receive greater study as the Jupiter Orbiter/Probe design becomes better defined and its applicability to the Saturn-Uranus mission can be assessed. Effort will continue on spacecraft design characteristics for application of solar electric propulsion or solar sail technology based on the FY 1977 technology evaluation. Assessments of exploration techniques for asteroids and outer planet satellites conducted during FY 1977 will be expanded into baseline mission definitions for planning activities to be conducted during FY 1978. The results of these studies will be focused toward generation of technical and programmatic data necessary to support near-term to long-range NASA planning for future missions.

Lunar Science Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,126	1,000	5,000	5,000	4,500

OBJECTIVES AND STATUS:

This program has, in the past, supported the curation and distribution of lunar samples for scientific research, the performance of Lunar Laser Ranging experiments from Earth-based observations and the operation of the Apollo Lunar Surface Experiment Packages (ALSEPs). Continued support is required for curation and distribution of lunar samples and for the very active Lunar Laser Ranging experiment project. Both of these efforts support essential scientific programs and provide a continuing source of basic scientific data.

The Lunar Sample Curatorial Facility at the Johnson Space Center provides protection for the lunar sample collection against physical damage and chemical contamination. It also supports an active research program by several hundred scientists by processing, allocating, and documenting several thousand sample transactions

each year. The facility has developed unique processing and data management techniques. It is an essential component of post-Apollo lunar science, and it continues to be an important resource for the future curation and study of all kinds of extraterrestrial material.

To provide long-term security for the sample collection, about 15 percent of the samples have been transferred to a newly-constructed Remote Storage Facility at Brooks AFB, San Antonio, Texas.

Highly accurate measurements of the Earth-Moon distance continue to be made at McDonald Observatory, Texas, using passive laser retroreflectors placed on the Moon by Apollo missions. By measuring how the Earth-Moon distance varies with time, we can obtain new information about the dynamics of the Earth-Moon system, the internal structure of the moon, and the relative motions of the Earth's crustal plates. Additional measurements have just begun at a new station at Haleakala Observatory, Hawaii. Complementary measurements from the two stations will provide more precise information about the internal structure of the Moon and the crustal motions of the Earth. A Transportable Laser Ranging Station is being designed. The contruction of this station, combined with upgrading of several foreign observatories (e.g., at Canberra, Australia), will provide a global network of ranging stations that can provide better data on the crustal motions and internal dynamics of the Earth.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding provides continued support of the Curatorial Facility operations and Laser Ranging studies. In addition, these funds will support the Transportable Laser Ranging Station operations scheduled to begin in FY 1978.

Lunar Sample Analysis

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,950	1,200	5,200	5,200	3,800

OBJECTIVES AND STATUS:

This project supports a wide variety of scientific studies of returned lunar samples, including their chemistry, mineral composition, age, physical properties, and effects from exposure to solar and cosmic radiation. Lunar samples are a unique source of otherwise unobtainable information about the Moon and the rest of the Solar System, and this research has long-term importance for investigating major lunar and planetary problems.

One goal of this work is to learn more about the Moon's composition, origin, and history. A second goal is to apply results of lunar sample data analysis to such general questions as the nature of planetary surfaces, the early histories of terrestrial planets such as Mercury and Mars, and the past history of the Sun's activity. In addition, these studies continue to provide important "ground truth" for interpreting remotely-sensed lunar chemical data and for planning future lunar and planetary exploration. Lunar sample research also continues to be an important source of knowledge regarding instrument development for planetary and terrestrial geological studies.

Studies of lunar samples have already provided much essential information about the nature and characteristics of the Moon. For example, the sample data have established the existence of widespread melting, bombardment, and magnetic effects during the Moon's early history, from 4.6 to 4.0 billion years ago. More recently, lunar sample research has evolved into more complex and general studies that use lunar data to help understand the origin and history of meteorites, asteroids, and terrestrial planets.

Lunar Sample Analysis has a unique and long-term role in the continuing study of the solar system. The continued value of this activity depends on maintaining a capability and support level sufficient to insure the continued participation of established scientists with unique skills, as well as the entry of new investigators and techniques into the program.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 budget will maintain a program broad and diverse enough to insure high quality sample data and permit certain new directions, with emphasis on such general lunar problems as: the search for young lunar lavas; the origin and timing of lunar volcanism; the nature of the gas produced in lunar volcanic eruptions; and the origin of the puzzling magnetism found in lunar rocks. Another group of studies will examine the records of solar and cosmic radiation trapped in lunar rocks and soil during the past four billion years. For these studies, multidisciplinary groups of scientists will carefully examine complex lunar rocks (breccias) and cores of lunar soil. Other scientists will undertake comparative studies of lunar samples and meteorites in order to understand the surface layers of asteroids and terrestrial planets.

Study of Russian Luna-16 and Luna-20 samples will provide new information about areas of the Moon not visited during the Apollo program. Negotiations are now underway for an exchange of the Luna-24 samples collected in August 1976 from Mare Crisium.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Common Operating Research Equipment.....	1,000	500	1,500	1,500	8,000
Vestibular Function Research.....	---	---	900	900	1,500
Integrated Life Sciences Shuttle/Spacelab Experiments.....	---	---	---	---	1,000
Supporting Activities.....	19,576	4,936	19,725	19,725	22,800
Total.....	20,576	5,436	22,125	22,125	33,300
Distribution of Program Amount by Installation:					
Johnson Space Center.....	5,925	2,077	6,000	7,530	14,446
Kennedy Space Center.....	55	---	1,000	60	200
Marshall Space Flight Center.....	366	---	---	---	---
Goddard Space Flight Center.....	---	---	500	---	---
Jet Propulsion Laboratory.....	1,498	393	2,100	1,911	1,900
Ames Research Center.....	8,574	1,872	8,375	8,857	12,725
Dryden Flight Research Center.....	100	---	100	100	100
Headquarters.....	4,058	1,094	4,050	3,667	3,929
Total.....	20,576	5,436	22,125	22,125	33,300

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Life Sciences program is to provide a sound research and development base for enhancing human health, safety, and effective performance in space flight; advancing knowledge in Earth medicine and biology; and understanding the origin and distribution of life in the universe. Major areas of emphasis focus on providing access to space to scientists without special flight training; preparing for long duration space flight life support requirements; and continuing the search for extraterrestrial life and related organic activity.

The knowledge gained from the Life Sciences program is made available to the scientific and technical community for application to and advancement of medical research, education, and technology. The applicability of knowledge derived from life sciences research continues to be significant. Program requirements to investigate basic biological interactions in the closed ecological environment of space capsules has direct feedback into environmental modeling of the earth's biosphere. Research into the deconditioning due to zero gravity indicates a strong parallel exists between space deconditioning and the problems associated with the long inactivity of the bed-ridden. Necessary concern with the preflight and inflight detection of disease has provided the impetus to develop valuable diagnostic techniques and instruments for health maintenance.

Continuing cooperation with the USSR Life Sciences community and joint working group meetings with the USSR have resulted in selection of five U.S. experiments to be flown on the next USSR biosatellite in 1977. The Common Operating Research Equipment (CORE) items requiring long lead-time development for Spacelab use have been identified and procurement has been initiated. Current activity involves the preparation of a work statement for use in acquiring a design, engineering and operations contractor for CORE in FY 1978 and the initiation of design definition studies for developmental hardware. The Vestibular Function Research (VFR) has progressed to the point of selecting an experimenter for the first flight and initiating procurement of flight hardware. Announcements of Opportunity to fly on the Spacelabs 1 and 2 missions elicited gratifying responses in terms of the number of Life Sciences experiments proposed for flight. From this response, Life Sciences has established a candidate group of experiments of the type to be flown as part of the Integrated Life Sciences Shuttle/Spacelab Experiments (ILSSE) program.

FY 1978 funding will provide for development of individual CORE items and the initiation of the design, engineering and operations contractor activities. Development and testing associated with the VFR experiment and other flight hardware will continue. The definition phase of the ILSSE program will be initiated during FY 1978. In addition, solutions to problems of space flight, such as motion sickness, and identification and assessment of problems which may arise when a wide spectrum of the population is given access to space will continue to be emphasized in FY 1978. The Planetary Biology research program will continue to investigate the Viking results and apply them in the search for new knowledge of soil and organic chemistry.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

COMMON OPERATING RESEARCH EQUIPMENT (CORE)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Integration	---	---	100	100	2,000
Equipment	1,000	500	1,400	1,400	6,000
Operational checkout	---	---	---	---	---
Total	1,000	500	1,500	1,500	8,000

OBJECTIVES AND STATUS:

The Life Sciences Shuttle/Spacelab Laboratory will provide scientists with an in-orbit, "shirt-sleeve" work environment. These capabilities will permit research observation and change in experiment approach during flight, as well as sophisticated specimen manipulation during complex experiments. The laboratory will be outfitted with equipment commonly used by all life science researchers such as specimen holding facilities, animal surgical capability, freezers, microscopes and support services of power, storage, data handling, and related requirements. This equipment will be procured "off the shelf", to the extent possible, and will be adapted to a modular buildup form so that integration and mission-to-mission change will be easy, rapid and economical. This modular characteristic will provide the versatility to build up from single experiment packages to any level of multiple experiment configurations. Thus, carry-on packages are feasible for location in the Shuttle's cabin and cargo bay, as well as in other discipline dedicated Spacelabs.

Schedules, priorities, and flight requirements are being developed for the CORE items as a result of studies, ground test simulations and planning schedules being derived in FY 1977. Prior studies developed the requirements for flight of the various Life Sciences CORE items. Each of the items is being analyzed to determine the scope of the work required and the time it will take. Ground test simulations of engineering and scientific approaches are carried out to identify and resolve potential problems. In FY 1977, a test will focus on a biology type mission with emphasis on the specimen holding facilities and the scientist's manipulation of the experiments. Test results indicating needed changes will be used to modify hardware designs in FY 1978 and planning for specific missions will provide the timetable that must be met to deliver flight-ready hardware.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, two major types of activities will be continuing in parallel. First, the development of the individual equipment items for CORE will be building up. Long lead-time developments started in FY 1977 will be continuing as the remainder of the equipment developments are begun. A design, engineering and operations contract will be awarded in early FY 1978 for the analysis, modification, fabrication/packaging, and testing of a multiplicity of systems and subsystems. Second, the final design layouts for the first dedicated Life Sciences Spacelab and a minilab for use on Spacelab 1 will be initiated. Based on proposed flight payloads, work will be started on the development and location of work areas; the integration and analysis of specimens, power, thermal and data requirements; and the assessment of manpower and skills requirements.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

VESTIBULAR FUNCTION RESEARCH (VFR)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Experiment	---	---	900	900	1,500
Total	---	---	900	900	1,500

OBJECTIVES AND STATUS:

The objective of the Vestibular Function Research program is to study equilibrium and postural (vestibular) mechanisms, their response to the zero-gravity environment, and the ways in which these responses can be

modified. It is planned to use small animals, with vestibular systems similar to human ones, flown on a series of zero-gravity missions and compared with a control group on the ground where all test parameters will be duplicated except for zero-gravity. The first mission is planned for a 1980 Shuttle launch, with return to earth for refurbishment and relaunch with new experiments.

In FY 1977, a Principal Investigator for the first mission will be selected. The Principal Investigator needs to test the experiment subjects in an extended duration mode. This testing assists in establishing the viability of specimen preparation techniques for extended durations and will determine the effects on the specimen life support system (skin shedding, urea buildup, etc.). In addition, it is necessary to start testing to provide the ground data base for comparison with flight results. Also during FY 1977, a request for proposals (RFP) will be issued for preliminary design of the VFR flight hardware.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 the Principal Investigator will continue to do laboratory testing to develop the procedures and ground data base for the flight experiment and for the postflight data analysis. To support this testing, the flight hardware contractor will fabricate, test and deliver to the Principal Investigator a boilerplate specimen life support subsystem. The contractor will also do component development and qualification tests for several of the flight subsystems.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

INTEGRATED LIFE SCIENCES SHUTTLE/SPACELAB EXPERIMENTS (ILSSE)

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
---	---	---	---	1,000

OBJECTIVES AND STATUS:

The objectives of the Integrated Life Sciences Shuttle/Spacelab Experiments (ILSSE) program are to provide an opportunity to investigate the effects of weightlessness and other unique space conditions (e.g., hard vacuum and radiation) on life systems; and to utilize the uniqueness of the space environment to an extent heretofore impossible. Investigations are planned to include determination of effects of space exposure on living organisms; development of countermeasures to any deleterious effects resulting from long-term space flight; development of special systems for optimizing human performance in space; research in the field of biological materials;

and basic research to improve understanding of the living organisms in the Earth environment. These activities will be conducted by research scientists and technicians in space.

In preparation for the FY 1978 start of ILSSE, facility requirements surveys (building space, spacelab mockup, special test equipment, ground support equipment) are being conducted, and general logistic support requirements are being determined. Development of generic requirements for a Shuttle/Spacelab Life Sciences data system is under review as is the development of an interim data system to support Life Sciences Spacelab Mission Development (SMD) tests. The SMD test series utilizes a ground-operated simulation, test and checkout facility configured like the Shuttle/Spacelab for the purpose of supporting Life Sciences in planning, developing, integrating, and operating Life Sciences payloads in the Shuttle/Spacelab era.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funding will support the establishment of an operational capability for the Life Sciences experiments program, at Ames Research Center (ARC), Johnson Space Center (JSC), and Kennedy Space Center (KSC). This will include the procurement of equipment to outfit laboratories at these Centers. Requirements for Common Operating Research Equipment (CORE) will be jointly established by this program and the CORE program. Life Sciences Shuttle mission planning will be supported at JSC, ARC, KSC, and NASA Headquarters.

Selection of and initial planning for Life Sciences experiments for Spacelab missions will start after the first two-year Announcement of Opportunity is developed and released in FY 1978. Spacelab Mission Development test activities will continue in FY 1978.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SUPPORTING ACTIVITIES

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Life sciences supporting research and technology	14,926	3,800	14,925	14,925	18,000
Planetary biology	3,300	836	3,300	3,300	3,300
Planetary quarantine	1,350	300	1,500	1,500	1,500
Total	19,576	4,936	19,725	19,725	22,800

OBJECTIVES AND STATUS:

The Supporting Activities of the Life Sciences program provide the ground-based research to develop the understanding and technology necessary to permit humans to function effectively in space and to determine the biological effects of the space environment. This multidisciplinary research program encompasses medical, behavioral and biological research, the investigation of all pertinent aspects of known and anticipated problems of human response to space flight, and the identification of life support and protective systems necessary to sustain humans during space flight.

In the Supporting Research and Technology areas, research is progressing toward solutions to the problems of space motion sickness; cardiovascular deconditioning; and bone, muscle, fluid and electrolyte changes. This ground-based activity uses analogs of space flight, such as bed rest, which closely simulate zero-gravity effects.

Biological research is being conducted in the synthesis of biologically significant organic molecules, and in the metabolic activity, growth and reproduction of microorganisms. The development of second generation prototype instruments for detection and characterization of life-related organic molecules on planetary surfaces or in planetary atmospheres is proceeding.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 Supporting Activities funding provides for continuation of research to develop the understanding and technology necessary to permit humans to function effectively in space. In FY 1978, funding is included for common engineering, scientific and technical support, and support contractor personnel at the Johnson Space Center.

Supporting Research and Technology effort in FY 1978 will continue to be directed toward delineation of anticipated flight stresses which may represent hazards to the individual or to the mission, and methods for predicting individual responses to them. Areas which will receive special emphasis in FY 1978 are the cardiovascular and vestibular systems, bone and muscle alterations, and fluid and electrolytes metabolism changes. Research will also be expanded to search for more economical methods of recycling and regenerating spacecraft atmospheres and water for human sustenance.

In FY 1978, Planetary Biology research will continue in the areas of chemistry, geochemistry, and biology to understand how simple organic compounds formed on the primitive Earth and whether they are now or have ever formed on other planets; under what conditions simple organic molecules become more complex and lead ultimately to the origin of life; and how we can detect extraterrestrial life. Results of the biological

experiments conducted on Viking have opened new research areas in soil chemistry and provided new understanding of the complex nature of planetary surfaces.

During FY 1978, in addition to the ongoing research, Planetary Quarantine research will focus on the quarantine measures which need to be applied to the Jupiter Orbiter/Probe planetary exploration mission. Quarantine measures which will be required should a Mars soil sample be returned to the Earth will also be studied.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS

SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Earth resources detection and monitoring	60,600	12,978	67,300	64,700	92,000
Earth dynamics monitoring and forecasting	8,000	1,900	4,600	4,900	7,900
Ocean condition monitoring and forecasting	22,200	8,100	30,600	30,800	19,200
Environmental quality monitoring	22,000	9,039	26,100	27,200	27,500
Weather and climate observation and forecasting	40,630	9,783	36,300	36,700	30,700
Materials processing in space	5,900	1,100	9,200	8,900	15,500
Space communications	13,000	2,600	13,800	15,500	22,800
Applications explorer missions	5,900	2,200	10,300	9,300	13,200
Earth resources operational systems	---	---	---	200	---
Total Applications	178,230	47,700	198,200	198,200	228,800
Space applications	(178,230)	(47,700)	(198,200)	(198,000)	(228,800)
Earth resources operational systems	(---)	(---)	(---)	(200)	(---)
Distribution of Program Amount by Installation:					
Johnson Space Center	31,585	6,650	32,815	32,515	34,320
Kennedy Space Center	610	95	700	605	650
Marshall Space Flight Center	6,926	1,924	11,155	12,010	19,480
National Space Technology Laboratories	611	137	548	600	300
Goddard Space Flight Center	88,514	24,451	89,953	88,514	120,030
Jet Propulsion Laboratory	18,109	6,186	28,980	30,220	25,100
Wallops Flight Center	5,168	1,888	5,542	5,950	5,450
Ames Research Center	8,078	2,065	8,553	7,506	4,650
Langley Research Center	9,327	2,967	9,324	9,941	7,840
Lewis Research Center	3,647	518	2,732	2,269	2,210
Headquarters	5,655	819	7,898	8,070	8,770
Total	178,230	47,700	198,200	198,200	228,800

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 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
	Launch of LANDSAT-D	1981
Ocean Condition Monitoring and Forecasting:		
Ocean Dynamics Satellites	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	First GARP Global Experiment	1978-79
Materials Processing In Space:		
Sounding Rocket Missions	Launch about 3 annually	
Space Communications:		
Search and Rescue Satellite Systems Test	Instruments to be launched on NOAA (TIROS-N series) spacecraft.	As early as 1980

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Applications Explorers:		
Heat Capacity Mapping Mission	Launch of HCMM	1978
Stratospheric Aerosol and Gas Experiment	Launch of SAGE	1979
Magnetic Field Satellite	Launch of MAGSAT	1979
Shuttle/Spacelab Missions	Orbital Flight Test #2	1979
	Orbital Flight Test #5	1980
	Spacelab Payloads	Beginning in 1981
Reimbursable Missions:		
GOES*	Launch of GOES B through F	1977-1985 (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 and transfer the applications of space-related technology, systems and other capabilities which can be effectively 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, and Applications Explorer Missions.

In each of these areas, programs are being conducted and planned to contribute to the solution of pressing national, as well as international, problems and needs.

Earth Resources Detection and Monitoring - The effective utilization of the world's finite natural resources requires that their extent and accessibility be surveyed, that their changes be monitored and that systems for wisely managing their exploration be developed. In the earth resources survey area, two objectives have been established: (1) to develop the capabilities for remotely sensing the earth's resources from aircraft and spacecraft in order to perform comprehensive global surveys; and (2) to apply the results to agriculture, water management, mineral and petroleum exploration, land use assessment, and improving the quality of world maps. Achieving these objectives will provide an information base that can be used in the management of the world's resources.

Significant activities are underway in the Applications Systems Verification and Transfer (ASVT) and LANDSAT-C projects. The ASVT activities are 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 extension to the entire world. LANDSAT-C, the third Earth Resources Technology Satellite, is being prepared for launch in early FY 1978; it will continue to gather multispectral data on earth resources after LANDSATS-1 and -2 cease to operate.

The major new initiative proposed for FY 1978 is LANDSAT-D, a project which will advance the technology and techniques for earth resources remote sensing by utilizing the capabilities of the second generation experimental multispectral scanner (the Thematic Mapper)--currently under development. This project will also test a total end-to-end data acquisition, processing, dissemination, and analysis system by bringing the satellite-sensed earth resources data to the users in a timely fashion (five to seven days) on a routine basis over a projected three-year test period.

The Thematic Mapper to be flown on LANDSAT-D will provide a significant improvement in the quality and usefulness of remotely-sensed multispectral imagery due to its higher resolving power and additional spectral coverage. These improvements in data quality will enhance the utility of remote sensing for mineral and petroleum exploration, expand the application of crop inventory techniques to small-field agricultural areas worldwide, and significantly increase the number and precision of land and water inventory applications in the United States.

Earth Dynamics Monitoring and Forecasting - This program's efforts are directed towards observing the physical character and dynamic motions of the earth. This information will lead to an improvement in our knowledge of the earth's gravity and magnetic field factors which are important for resource assessment; improvement of geodetic surveying and control techniques and the monitoring of local topographic changes; and improvement of our knowledge of earthquake mechanisms. Continuing efforts will be focused on validation of the various plate motion measurement techniques. The motions of these large solid plates (tectonic plates) which make up the surface of the earth are one of the causes of large earthquakes. The Magnetic Field Satellite (Magsat), an Applications Explorer, will provide information needed to allow the United States Geological Survey to update maps of the earth's magnetic field, to develop models of the global magnetic field, and to 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 - The monitoring and forecasting of sea state conditions, current systems and ocean circulation patterns have important implications for improving operations and costs associated with ship routing, offshore activities, fishing, and for improved weather forecasting. The program objectives will be achieved through the development of space platforms and related research as part of a concerted NASA/user effort to develop a global monitoring and forecasting capability for the oceans. Data on the sea surface topography are currently being acquired with the Geodynamic Experimental Ocean Satellite (GEOS-3) launched in 1975. SEASAT-A will be the first satellite having the extensive capability for observing and monitoring ocean conditions; upon its launch in mid-1978, SEASAT is expected to demonstrate and validate the use of ocean data for achieving operating economies in the marine environment.

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. A major focus of attention is upper atmospheric pollution; in this particular area, efforts are

concentrated on: (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.

Two spacecraft currently under development will provide a significant amount of new data on atmospheric and water pollution. The first of these, NIMBUS-G, is scheduled for a 1978 launch. The second, the Stratospheric Aerosol and Gas Experiment, an Applications Explorer Mission, will be launched in 1979.

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 improvements 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); (4) planning for the first international Global Atmospheric Research Program experiment to be conducted in 1978-1979; 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 the space environment 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 to the production of unique new products produced in space. Space Processing studies, investigations, and analysis of potential applications of space processing will be continued, and will include synthesis of space experiment results to identify potentials that are not predictable from ground data alone. Space results are now available from the experiments performed on the Apollo Soyuz Test Project and the initial two Space Processing Applications Rockets (SPAR) missions. The SPAR Project offers a continuing opportunity to investigate materials processes in space prior to the Shuttle era. The preliminary design of Space Processing Shuttle payloads was initiated in FY 1977 in preparation for beginning the full scale payload development in FY 1978. These Shuttle payloads will provide for systematic materials research and development in the early years of Shuttle operations so as to make practical applications possible in the later 1980's.

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 communications satellite systems. The current NASA effort is directed toward developing and demonstrating advanced technology, and providing expert advice and consultation on communications satellites 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 to demonstrate innovative application of communications satellites. 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 frequency assignments for all types of satellites. Based on NASA experiments and systems studies, the Interagency Committee on Search and Rescue--comprised of members from the Departments of Commerce, Defense and Transportation, the Federal Communications Commission and NASA--plus observers from the Aircraft Owners and Pilots Association and the National Association for Search and Rescue, has studied the application of space technology to aid search and rescue operations and has recommended that demonstration of a satellite-aided search and rescue system be implemented. The proposed Search and Rescue Satellite System is a cooperative U.S.-Canadian program, which will employ sensitive receivers and high gain antennas to be carried on operational polar-orbiting meteorological spacecraft to demonstrate the feasibility of obtaining a significant increase in the capability to detect and locate the distress signals carried by general aviation aircraft and certain marine vessels. Preliminary calculations indicate that such a satellite can position-fix these signals to an accuracy of about 15-20 kilometers.

Applications Explorer Missions - The Applications Explorer Mission (AEM) program was established to develop relatively low cost, Scout-launched spacecraft tailored to specific areas of research and orbital requirements. This program has the following missions under development: (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; the data obtained will have applications in 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 Stratospheric 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 to enhance our knowledge of the geologic structure of the earth.

BASIS OF FUND REQUIREMENTS:

EARTH RESOURCES DETECTION AND MONITORING

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
LANDSAT-1 and -2	5,100	---	---	---	---
LANDSAT-C	13,000	3,500	13,500	13,500	3,200
LANDSAT-D	---	---	---	---	21,900
Thematic mapper	---	---	4,000	4,000	14,800
Shuttle/Spacelab payload development	---	---	---	---	3,300
Shuttle/Spacelab mission design and integration	---	---	---	---	2,400
Applications transfer and demonstration program	10,400	2,500	14,800	13,900	13,400
Applications research and technology development	32,100	6,278	32,500	31,300	32,000
Follow-on data analysis and operations	---	700	2,500	2,000	1,000
Total	60,600	12,978	67,300	64,700	92,000

OBJECTIVES AND STATUS:

The objectives of this program are to develop remote sensing technology space systems and associated aircraft and ground support systems to improve the capability for monitoring, analyzing and managing the earth's resources; and to assist the public and private user community in developing practical applications and effective utilization of these capabilities. Examples of the kinds of uses to which satellite data can be put are: worldwide crop production estimation, mineral and petroleum exploration, flood hazard assessments and water resources studies.

The first dedicated earth resources satellite was LANDSAT-1, launched in 1972. LANDSAT-2 followed in 1975; LANDSAT-C is to be ready for launch in late 1977. The major new thrust in FY 1978 will be the initiation of the LANDSAT-D program which will test the second generation high resolution, remote sensing instrument called the Thematic Mapper, the development of which is being initiated in FY 1977; and which will provide a several-year test period for this instrument for current and prospective users of multispectral earth resources survey data.

The research technology and applications development activities will emphasize four major areas in FY 1978:

1. In the area of renewable resources, the major goal is to continue the development of techniques for monitoring from space the earth's changing potential capability to produce food, fiber and fresh water. The principal activity involves work with the USDA and NOAA on the Large Area Crop Inventory Experiment (LACIE) whose objective is to arrive at global wheat production forecasts that are more accurate and timely than those now available; research will be conducted to improve the efficiency of existing techniques and to extend LACIE results to other crops of world significance. Emphasis will also be placed on developing the capability for monitoring water supply and determining the water demands for irrigation and hydroelectric purposes.

2. In the area of nonrenewable resources such as mineral and petroleum supplies, the major goal is to improve existing techniques for the acquisition, processing and analysis of specialized space data concerning geological structures and features. When integrated into a total exploration program using standard geophysical exploration techniques, these data will significantly enhance the capability for exploration and exploitation of the earth's mineral and energy resources. Space-acquired data have already proven to be valuable in the quest for new sources to meet the expanding demand for extractive resources. NASA will continue, with the active involvement of the user community, to develop the capabilities of thermal infrared sensing (LANDSAT-C and Heat Capacity Mapping Mission), microwave systems, stereo systems and specialized orbits for the detection and understanding of basic geological structures necessary for mineral and petroleum exploration.

3. In the area of land use, NASA plans, with the active involvement of the Department of the Interior, the Environmental Protection Agency, the Census Bureau and a number of state and local agencies, to assist in the development of remote sensing techniques and procedures to meet the requirements of those agencies. These include monitoring changes in the extent of urban and suburban areas for measuring population shifts, monitoring the extent of land surface disruption and reclamation associated with surface mining, and updating maps of selected regions in the U.S. The major goal is to develop the capability to deliver land cover information for use in existing management systems.

4. To date, in the area of technology development, NASA has pioneered in the use of multispectral data in the visual and infrared wavelengths. For the future, active and passive microwave remote sensing has a very high priority because of the possibility it offers to acquire data at night and through clouds.

The accomplishments of the Earth Resources Detection and Monitoring program over the past years have included the successful operation of the experimental LANDSAT-1 and -2 satellites; the conduct of experiments using the Earth Resources Experiment Package on Skylab; and, ever-increasing collaboration with user groups

at the Federal, regional and state levels and with private enterprise, both in projects conducted as part of the Applications Transfer and Demonstration Program and in less formal projects conducted as part of the Applications Research and Technology Development activities.

The principal thrust during the balance of FY 1977 will be the completion of the assembly and test of the LANDSAT-C spacecraft; development of improved data management systems to handle the data to be returned from that satellite after launch; completion of the design of the Thematic Mapper which is being developed for flight on the newly proposed LANDSAT-D; and, formalization of agreements with cooperating Federal, state and private sector groups for the conduct of new Applications Transfer and Demonstration projects.

In FY 1978, major emphasis will be placed on initiation of development of the LANDSAT-D project which will be a major step in the continued development of advanced research and development techniques for satellite-based earth resources remote sensing systems. Increased emphasis will be placed on the development of payloads for the Shuttle/Spacelab era including provisions for advanced imaging sensors in both optical and microwave portions of the spectrum.

Also, a major effort will be initiated in FY 1978 to establish a consolidated Shuttle/Spacelab Mission Design and Integration program within the Earth Resources Detection and Monitoring Program to support all of the programs of the Office of Applications.

In FY 1978, in addition to the ongoing Applications Transfer and Demonstration Program projects, new projects will be initiated, such as:

- A Forestry and Rangeland Renewable Resources Inventory project with the U.S. Forest Service to test the utility of LANDSAT data to assist in meeting the requirements of the Resource Planning Act of 1974;

- A Water Demand project with the California Department of Water Resources to demonstrate the utility of LANDSAT data for measuring the acreage of irrigated lands and other types of hydrological land use to improve estimates of water demand for irrigation, power generation and urban use;

- An Eastern Land Cover Monitoring project with several eastern states and the Appalachian Regional Commission to monitor surface changes due to mining, urban expansion and the like; and,

- A Coastal Zone Management project in conjunction with several states to demonstrate the utility of of LANDSAT data to inventory and monitor coastal wetland areas as mandated by the Coastal Zone Management Act of 1972.

Earth Resources Technology Satellite (LANDSAT-C)

	Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
			(Thousands of Dollars)		
Spacecraft	7,855	2,765	8,430	8,655	2,425
Sensors	5,040	705	2,670	1,555	---
Ground operations	105	30	2,400	3,290	775
Total	13,000	3,500	13,500	13,500	3,200
Delta (Expendable launch vehicles program)	(1,800)	(800)	(3,000)	(2,100)	(---)

OBJECTIVES AND STATUS:

The primary objective of the LANDSAT-C project is to continue the development of technology which significantly contributes to the more efficient management and utilization of the earth's resources. LANDSAT-C will accomplish this by collecting, on a global basis, repetitive imagery in several discrete color bands, which are analyzed by both computer and photointerpretive techniques to improve our understanding of terrestrial conditions in a timely fashion. LANDSAT-C represents an improvement on the technology developed for and demonstrated by LANDSAT-1 and -2. This is accomplished by an improved Multispectral Scanner (MSS) and an improvement in the spacecraft television camera system referred to as the Return Beam Vidicon (RBV) system. The LANDSAT-C MSS differs from those previously flown in that a spectral band in the thermal range has been added to more effectively classify data characterized by temperature changes. This additional capability will allow improved monitoring of agriculture in the preharvest stage and will also improve LANDSAT's capability to monitor dynamic changes in other vital areas such as water pollution, geology, hydrology, and oceanography. The RBV system has been modified to provide a two-fold improvement in resolution (from 80 to 40 meters) over the previously flown RBV systems. This will increase the capability to locate and identify small agricultural fields and improve the cartography in poorly mapped areas of the world.

Spacecraft fabrication and assembly is well underway in support of launch readiness scheduled for the end of FY 1977. The deliveries of the MSS and RBV systems are scheduled for the first and second quarters of FY 1977, respectively.

CHANGES FROM FY 1977 ESTIMATE:

The fiscal year's totals remain unchanged although some adjustments took place in the allocation of resources among project elements. Some funds available because sensor development experienced fewer problems than expected were shifted to ground operations in order to insure timely system implementation.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will provide for the maintenance of a 90-day call-up launch capability for the period from October 1977 to March 1978 as well as for operations of the LANDSAT Control Center for LANDSAT-C orbital operations.

Earth Resources Technology Satellite (LANDSAT-D)

LANDSAT-D	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft (multi-mission modular spacecraft).....	---	---	---	---	12,500
Spacecraft systems integration and mission unique equipment.....	---	---	---	---	6,200
Ground data processing system.....	---	---	---	---	3,200
Total.....	---	---	---	---	21,900

OBJECTIVES AND STATUS:

The objective of the LANDSAT-D project is to continue the exploration of advanced research and development techniques for satellite-based earth resources remote sensing systems with the experimental Thematic Mapper.

The major technical focus of the LANDSAT-D project involves a test of both the Thematic Mapper instrument's capabilities and an improved ground data handling system. The Thematic Mapper--on which development is being initiated in FY 1977--offers higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of LANDSAT data and to enhance many current uses. The improvements in data quality will increase the utility of remotely sensed satellite data

for mineral and petroleum exploration, expand the application of crop inventory techniques to worldwide small field agricultural areas, and significantly increase the number and precision of land inventory applications in the United States.

LANDSAT-D will also provide the opportunity for the user community to test, under realistic conditions, a total information system (spacecraft, ground processing and data analysis), by bringing the satellite-sensed earth resources data to the users in a timely fashion (five to seven days) and on a routine basis over a projected three-year test period.

The space segment of the LANDSAT-D project involves the use of the Multimission Modular Spacecraft bus, an instrument module, mission unique hardware, and the experimental Thematic Mapper which will have 30-meter ground resolution capability. A single satellite, operating in an approximately 700 km circular orbit, will provide 16-day repetitive coverage of the earth. The satellite will have a precision attitude control and pointing system, which will significantly reduce the ground processing corrections needed to use the data for accurate map projections. The satellite will also include two data links--one through the Tracking and Data Relay Satellite System (TDRSS) for real time world coverage and the other as a down-link to U.S. and international ground stations for direct ground coverage. The spacecraft is to be launched on a Delta launch vehicle from the Western Test Range in the first half of 1981.

LANDSAT-D will utilize a Multimission Modular Spacecraft (MMS). The MMS is comprised of a common basic spacecraft structure and systems modules which will form the basic spacecraft systems for use on a number of future earth orbital missions. These spacecraft systems will be designed to take advantage of the capabilities of the Space Transportation System, such as on-orbit servicing and retrieval and reuse. The development of the MMS is being initiated in FY 1977 under the Solar Maximum Mission, which will be the first user. The systems modules being developed include an attitude control module, a power module, and a communications and data handling module. The Multimission Modular Spacecraft hardware for LANDSAT-D will be procured by exercising in FY 1978 the options in the basic MMS contracts providing for additional flight unit procurement.

To the basic structure and systems modules of the MMS, specific pieces of equipment will be added to meet the LANDSAT-D mission requirements. Included in this category are: the instrument module, the TDRSS compatible antenna, high power solar arrays, and direct ground readout communications link. The integration of the mission unique equipment and the Thematic Mapper with the MMS will be performed by a system integration contractor.

The ground data processing system will be designed to receive the Thematic Mapper data as transmitted through the TDRSS to the White Sands Test Facility and then to the Goddard Space Flight Center for initial processing. The Department of Interior's Earth Resources Observation System (EROS) Data Center will receive the Thematic Mapper processed data for final processing and distribution to the public.

The total cost estimate for the proposed LANDSAT-D project is $160-185 million. This represents a planning estimate. In addition, the cost of developing the Thematic Mapper instrument which will be flown on the LANDSAT-D spacecraft is estimated at $40-50 million; and, the cost of the Delta launch vehicle hardware is $8-9 million.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will be used to initiate the design and procurement of the mission unique equipment and the ground data processing system. A systems integration contractor will be selected in FY 1978 to perform these functions. In addition, FY 1978 funding will provide for the start of subsystem procurement and fabrication activities for the Multimission Modular Spacecraft which will include exercising the options in the existing MMS contracts for the Solar Maximum Mission.

Thematic Mapper

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Sensor development.....	---	---	4,000	4,000	14,800

OBJECTIVES AND STATUS:

The objective of this project is to develop a second generation multispectral scanner (an instrument which samples reflected energy from the earth in discrete spectral bands) which will permit the acquisition of data of suitable quality to permit the development of "thematic" maps at a 1:250,000 scale over a scene format of approximately 185 x 185 km. A ground resolution of 30 meters from an altitude of 705 km is planned. Optimization of the spectral bands and radiometric resolution will permit a significant improvement in the ability to classify major commodity crops such as wheat, corn, rice, cotton, barley, soybeans, etc. In addition, crop and forest stress due to disease, infestation, or lack of moisture will be discernable as subtle changes in reflectance values.

The Thematic Mapper will utilize six spectral bands (the ability to add a seventh will be built in to provide cost-effective growth potential) to provide the capabilities discussed above and also to aid in oil exploration and water pollution, geology, hydrology, and oceanography investigations. Accurate snow-cover mapping will also be possible.

The Thematic Mapper specifications have been developed and released to industry. Proposals have been received and are currently being evaluated. The prime contractor will be selected in early 1977 and will begin work on design and construction of a breadboard Thematic Mapper.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funds are required to begin the development of the engineering and prototype models of the Thematic Mapper and to conduct testing necessary to verify the performance capabilities of the instrument.

Shuttle/Spacelab Payload Development

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Sensor development.....	---	---	---	---	3,300

OBJECTIVE AND STATUS:

Among the many serious problems facing the world in the coming years, one of the most important is supplying its mineral and energy resources needs. These resources are basically nonrenewable and are becoming more and more scarce as they are used at an increasing rate. Improved exploration techniques using satellite remote sensing must be developed to find new sources and maintain an adequate level of mineral and energy resources supply. The objective of this project is to evaluate and demonstrate the applicability of spaceborne imaging radars and large format film cameras for mineral and petroleum exploration and for other geological applications. Experimental demonstrations will be conducted on early Shuttle/Spacelab missions.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funds will be used to begin the acquisition of two sensors. One instrument is a large format stereo camera system and the other is an active microwave imaging system. The film camera system will incorporate features to provide high quality stereo coverage from space. The active microwave imaging sensor will be either an adaptation of the Seasat Synthetic Aperture Radar (SAR) now under development or another existing SAR. Modifications will be made to meet the requirements for the geology mission. Both the SAR and the stero camera system, after return from flight and upon completion of analysis of the data by the principal users, will be scheduled for reuse on subsequent Shuttle/Spacelab missions.

Shuttle/Spacelab Mission Design and Integration

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Mission design and integration.....	---	---	---	---	2,400

OBJECTIVES AND STATUS:

The availability of the Space Transportation System will provide a new flexibility to the space applications programs: access to space will be more frequent; weight and volume of experimental hardware can be greater; short duration experimentation and instrument checkout can be accomplished in the Spacelab mode; and automated, continuous-monitoring satellites can be retrieved, refurbished, and redeployed--thus avoiding the loss of these structures and instruments after their useful lifetime is completed. In order to efficiently utilize this new capability, a focused activity is required to integrate a set of applications experiments into the Orbiter and/or Spacelab hardware that effectively allocates the available resources (e.g., weight, volume, power, cooling) across the requirements of the individual instruments. Preliminary mission analyses have been carried out in prior years with limited study funds. However, with the impending launches of the Shuttle and the increased activity associated with this effort, increased resources are required to perform this integration function and to provide centralized management attention.

BASIS OF FY 1978 ESTIMATE:

At present the Office of Applications has been assigned management responsibility for experiments on three Shuttle orbiters. These flights will have mission objectives that are of primary interest to Applications programs, and will include tests of the orbiter in an earth viewing mode and zero-G experimentation, especially for materials processing. The funds will be utilized for mission definition and integration of individual instruments into a total payload complement for the latter mission, for coordination of instrument candidates to be flown on missions emphasizing other disciplines, and for definition of subsequent launch requirements for applications investigations. Individual instrument/experiment development, packaging for flight, and data analysis will be funded and accomplished by the discipline projects.

Applications Transfer and Demonstration Program

	Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Applications transfer and demonstration program....	10,400	2,500	14,800	13,900	13,400

OBJECTIVES AND STATUS:

The Applications Transfer and Demonstration Program consists of both relatively large scale projects--termed Application Systems Verification and Transfer (ASVT)--and smaller projects known as Regional Applications Transfer projects.

The objective of the ASVT program is to select the most technically promising and potentially useful areas of utilization of remote sensing data and--through concerted and cost-shared efforts with user organizations and resources managers--to define, demonstrate, and transfer the practical capability to the user organizations. In contrast, Regional Applications Transfer projects are smaller in scale and involve direct cooperation between NASA Center personnel and local user organizations.

CHANGES FROM FY 1977 ESTIMATE:

The decrease of $900 thousand in FY 1977 reflects a transfer of funds from Earth Resources Detection and Monitoring ASVT funds to Space Communications Programs to permit initiation during FY 1977 of two ASVT's that were developed after submission of the FY 1977 budget.

BASIS OF FY 1978 ESTIMATE:

The largest of the ASVT activities in FY 1977 and FY 1978 is the Large Area Crop Inventory Experiment (LACIE), a joint investigation by the U.S. Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration of the Department of Commerce, and the National Aeronautics and Space Administration to test whether the use of data gathered by spacecraft and analyzed with the aid of computers can improve timeliness and accuracy of major crop forecasts. In FY 1977-FY 1978, the geographic scope of LACIE will be increased to include most of the major wheat producing regions of the world. In late FY 1977 and FY 1978 the design, installation and initial testing of portions of the data analysis and reporting system for the USDA will be completed. Other elements of this ASVT will extend beyond FY 1978.

In addition, six ASVT's initiated in FY 1977, will continue through FY 1978 as follows:

- The Pacific Northwest Land Resources Inventory ASVT is a joint investigation by the Pacific Northwest Regional Commission, NASA, U.S. Department of Interior Earth Resources Observation System, and the states of Idaho, Oregon and Washington, to test the utility of LANDSAT data in resource planning and management activities performed by a variety of agencies in these states.

- The Forest Resources Information System is the result of a proposal by the St. Regis Paper Company to develop remote sensing techniques for up-to-date information on the quantities and quality of timber and the condition of the land base on which it grows. Reports on this effort will be in the public domain and will provide a mechanism whereby remote sensing techniques for forest resources can be developed and disseminated to the forest industry in general.

- The Wildland Vegetation Inventory ASVT is 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 wildland vegetation. Investigations with LANDSAT-1 have demonstrated the capability of satellite remote sensing to monitor range conditions. These techniques will be refined to meet specific BLM information requirements.

- The Water Resources Management and Control Project will be conducted with the Corps of Engineers to test the utility of LANDSAT data in water supply situations that require the use of hydrological land use classification. The water supply/stormwater runoff forecasting effort would be responsive to the needs of the Corps of Engineers.

- The Census-Urbanized Area Project is a joint effort between NASA and the U.S. Bureau of the Census to test the utility of satellite data for census applications and to transfer the technology to the Bureau of the Census. More specifically, LANDSAT digital multispectral scanner data will be utilized to define the major land cover types included in the built-up areas adjacent to the nation's larger metropolitan centers. This, in turn, will assist in the delineation of the final urbanized area boundaries and will form a data base for solving other census-related problems.

- The Land Cover Change and Update Program involves the U.S. Geological Survey (USGS) and NASA in a joint endeavor to update the USGS Land Use and Data Analysis System by using LANDSAT to detect change in surface land cover.

Four new ASVT's are planned for initiation in FY 1978 as follows:

- The Forestry and Rangeland Renewable Resource Inventory will be a joint undertaking between NASA and the U.S. Forest Service to test the utility of LANDSAT data in the inventory of forest and rangeland renewable resources required by the Resource Planning Act of 1974. The Act requires a current assessment of forest and rangeland resources in terms of type, condition, location and acreage.

- The Water Demand Project will be conducted with the California Department of Water Resources to demonstrate the utility of LANDSAT data for improving estimates of water demand by measuring irrigated lands acreage and other pertinent hydrological land use classifications. These estimates are needed for efficient management of water resources for irrigation, power generation and urban needs.

- The Eastern Surface Mine Monitoring and Related Land Cover Change Detection Program is the result of the expressed interest of several eastern states and the Appalachian Regional Commission in developing remote sensing techniques as an operational tool for the identification and monitoring of surface mining activities and urban development. The critical national concerns over energy resources and environmental preservation have increased pressures on state governments to monitor surface mining operations and reclamation efforts. At the same time, newly developed remote sensing techniques, involving satellite and aircraft, have shown the potential for gathering crucial information on the effects of surface mining and urban development in a timely and accurate manner.

- A Coastal Zone Management ASVT is planned in conjunction with several states to demonstrate the use of LANDSAT data to inventory and monitor coastal wetland areas. These areas of the U.S. are recognized as being of major importance, biologically and economically. Legislation, typified by the Coastal Zone Management Act of 1972, places the burden of management of these areas on state and local governments. Research has shown that LANDSAT data is useful in the inventory and change detection of coastal wetland areas.

In FY 1978, additional emphasis will be placed on the smaller-scale regional applications transfer activities. NASA Centers are being encouraged to work closely with industry, state and regional governments and universities to conduct relatively short term projects to transfer already developed technical capabilities based on remote-sensing to local planners and resource managers for subsequent operational use.

Applications Research and Technology Development

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Data interpretation techniques, special investigations and data analyses	22,600	4,218	22,300	22,200	22,500
Development of advanced flight experiments for earth resources detection and monitoring	600	300	600	400	500
Aircraft support for development of capabilities in remote sensing of earth resources	5,500	960	6,000	5,200	5,000
Studies in applications of earth resources detection and monitoring technology	1,600	200	1,500	1,400	1,500
Definition and design of payloads for earth resources applications	1,100	600	2,100	2,100	2,500
Other studies and support	700	---	---	---	---
Total	32,100	6,278	32,500	31,300	32,000

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 also includes the aircraft support for the development of remote sensors, sensing techniques and collecting of "ground truth" data; Space Shuttle flight studies including sensor definition, and design, 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 recording system.

CHANGES FROM FY 1977 ESTIMATE:

The reduction in Advanced Flight Experiments reflects a decision to reduce the scope of effort in the development of a synthetic aperture radar. The decrease in Aircraft Support reflects a reduced need for support to research tasks.

BASIS OF FY 1978 ESTIMATE:

The thrust of this program in FY 1978 is shifting from exploratory research toward testing of information-gathering systems under realistic resources management conditions and adoption of these techniques to meet user requirements. In order to carry out a coherent, phased approach, this program includes aircraft support, Shuttle payload studies and advanced instrument development. The airborne platforms will be used in FY 1978 to conduct flights in support of Earth Resources programs such as soil moisture measurement experiments. Airborne measurements will focus on the application of microwave sensors to agriculture and hydrology and water problems. Support will be provided for Heat Capacity Mapping Mission (HCMM) sensor and algorithm development. The availability of the Shuttle will provide opportunities for sensor development, verification of measurement techniques, and in-flight calibration of free-flying satellites. Plans are being made to use the Shuttle as an integral part of the development process for the future active and passive imaging microwave systems. Studies will also be performed to optimize the design of Shuttle-launched spacecraft and support systems for future long term orbital missions.

Follow-on Data Analysis and Operations

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)			
LANDSAT-1 and -2 extended operations.....	---	700	2,500	2,000	1,000

OBJECTIVES AND STATUS:

Both the LANDSAT-1 and -2 spacecraft have considerably exceeded their design lifetime but continue to transmit useful data. These extended operations permit the continued development and application of multispectral data in the classification and measurement of crop acreage, and in the areas of geology, hydrology, land use, forestry, and coastal zone management. The objectives of the LANDSAT follow-on data analysis and operations project are, therefore, to continue the acquisition of data from the LANDSAT spacecraft now in orbit.

CHANGES FROM FY 1977 ESTIMATE:

The previous FY 1977 budget estimate included estimates for investigator support requirements and for contractor award fees for extended spacecraft operations. These requirements are less than anticipated.

BASIS OF FY 1978 ESTIMATES:

Activities at the Operations Control Center for LANDSAT-1 and -2 will continue during FY 1978 in order to continue to manage these spacecraft in orbit and to continue to collect data from them.

BASIS OF FUND REQUIREMENTS:

EARTH DYNAMICS MONITORING AND FORECASTING

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Laser geodynamic satellite (Lageos)	200	---	---	---	---
Tectonic plate motion	2,600	700	1,900	1,900	2,200
Applications research and technology development (ARTD)	3,300	900	1,300	1,600	3,800
Follow-on data analysis and operations	1,900	300	1,400	1,400	1,900
Total	8,000	1,900	4,600	4,900	7,900

OBJECTIVES AND STATUS:

The objectives of the Earth Dynamics Monitoring and Forecasting Program are directed towards the development and validation of methods, using space techniques, for observing the physical character and dynamic motions of the earth. Applications of these techniques are expected to lead to: improvement in our knowledge of the earth's gravity and magnetic field for resource assessment; refinement of the global geoid and extension of geodetic control to inaccessible areas including the ocean floors; improvement of geodetic surveying techniques; the monitoring of local topographic changes; and improvement of our knowledge of earthquake mechanisms. While progress is being made in the identification, development, and application of ground and space systems, additional work is needed to support the demonstration and verification of these systems in specific applications areas. The overall NASA activity in this area is being done in concert with the U.S. Geological Survey (USGS), National Geodetic Survey (NGS), Department of Defense and, to a lesser extent, other government organizations.

The Laser Geodynamic Satellite (Lageos) is a nearly permanent reference point in space for use in earth dynamics studies. Launched in May 1976, Lageos permits very accurate laser ranging measurements and is the first satellite compatible with the precision earth motion measurements required for crustal motion and earthquake studies. As an example, in 1976, ranging to Lageos was used to measure the distances across the San Andreas Fault in an effort to determine any plate motion that may have occurred since the 1972 and 1974 surveys of the fault were conducted.

A related spacecraft development project, which is separately budgeted under the Applications Explorer Missions (AEM) Category, is the Magnetic Field Satellite (Magsat). This mission, planned for launch in CY 1979, will provide accurate magnetic field mapping of the earth. This information is required by the U.S. Geological Survey (USGS) 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 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 and are believed to be one of the prime forces that cause earthquake. The project includes several joint efforts involving the U.S. Geological Survey and the National Geodetic Survey (NGS). These include the use of laser tracking of satellites to determine surface motions along an active fault (San Andreas Fault Experiment - SAFE) and the use of Very Long Base Interferometry (VLBI) for crustal motion studies. In FY 1978, it is planned to continue these experiments including the acquisition of additional data at three instrumented sites in support of SAFE; the extension of a regional effort in California to demonstrate the use of VLBI techniques for measurement of regional crustal motion; and the establishment of additional baselines in a multifaceted effort to determine the relative motions of the Pacific Plate and the North American plate, using VLBI techniques.

The Applications Research and Technology Development (ARTD) Program supports experimental studies of the earth's gravity and magnetic fields, of crustal and polar motion, of variations in the earth's rotational speed, and of local topographic changes. These studies are required because of their potential application to resource assessment, geodetic surveying and hazards forecasting.

The Follow-on Data Analysis and Operations Program is designed to support the continuing analyses of data acquired from satellites and ground-based instruments so that this data and associated analysis can be applied to resource assessment, geodetic surveying, hazard prediction and improved timekeeping.

Tectonic Plate Motion

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Tectonic plate motion.....	2,600	700	1,900	1,900	2,200

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. This motion is one of the prime forces that cause earthquakes. Support is provided to the following primary areas of activity: the refinement of the national horizontal and vertical geodetic networks (in support of NGS); the monitoring of vertical motions in certain regions (in support of NGS and USGS); the monitoring of horizontal motion associated with the accumulation of strain in faulted zones; and the determination of polar motion and earth rotation (in support of NGS and the Naval Observatory). Specific experiments are associated with rectifying discrepancies in coastal sea level slopes, monitoring crustal deformation in southern California, and detecting relative plate motion along the San Andreas fault system.

In the past year, experiments related to the detection of plate motion and to evaluation of the feasibility of precursor earthquake monitoring systems have included: (a) A joint effort with the U.S. Geological Service (USGS) to demonstrate the feasibility of using satellite tracking lasers to determine surface motions along an active fault (San Andreas Fault Experiment - SAFE); (b) A regional effort in California to demonstrate the use of Very Long Baseline Interferometry (VLBI) techniques for the measurement of regional crustal motion, using distant stars as a reference; and (c) A multifaceted effort to determine the relative motions of the Pacific plate and the North American plate, using VLBI techniques.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will provide for continuation of these experiments. Lageos, together with new and improved lasers being developed by the Office of Tracking and Data Acquisition, will be used in support of the FY 1978 SAFE Program including the acquisition of additional data at three instrumented sites in support of SAFE and the extension of VLBI measurements to regions beyond the Los Angeles basin area in support of NGS and USGS. In addition, the new experimental programs associated with monitoring of the coastal sea surface slope and crustal uplift in southern California are to be initiated.

Applications Research and Technology Development (Earth Dynamics)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Measurement systems, forecasting techniques and modeling/advanced studies	2,200	700	1,300	1,300	2,700
Advanced earth dynamics flight experiments	300	---	---	300	800
Flight support for earth dynamics	300	100	---	---	---
Earth dynamics systems analyses	300	100	---	---	300
Spacelab payload definition for earth dynamics experiment	200	---	---	---	---
Total	3,300	900	1,300	1,600	3,800

OBJECTIVES AND STATUS:

The application of earth dynamics techniques to resource assessment, geodetic surveying and hazards forecasting requires extensive analytical and experimental studies of the earth's gravity and magnetic fields, of crustal and polar motion, of variations in the earth's rotational speed, and of local topographic changes. The objective of the ARTD program is to support studies of advanced systems and sensor technology, the definition of system requirements, the verification of techniques through ground and aircraft measurements, the evaluation of the economic effectiveness of earth dynamic technique applications, and demonstration of these applications.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The addition of $300 thousand in FY 1977 reflects an adjustment to provide for development of a spaceborne laser ranging system for monitoring horizontal and vertical motions in local regions for detection of subsidence and crustal uplifting.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, funding is required: to proceed with an improved model of the earth's gravity field based on data obtained from the GEOS-3 spacecraft altimeter; to obtain improved laser ranging data for use in resource assessment studies planned with Magsat; to continue the application of laser ranging to geodetic

surveying and subsidence; to develop an experimental device for improved spacecraft orbit determinations; and to improve techniques for the detection of the crustal uplifting associated with earthquakes.

Follow-on Data Analysis and Operations (Earth Dynamics)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Follow-on data analysis and operations.....	1,900	300	1,400	1,400	1,900

OBJECTIVES AND STATUS:

This project supports the continuing analysis of data acquired through the use of satellite and ground-based instrumentation. These data include observations of physical distances made through laser ranging to satellites and interferometer techniques; gravity field potential inferred from perturbation of satellite orbits, from direct geoid measurements using satellite altimeters and from gravity gradiometer traverses; magnetic field potential measured by satellite and ground instrumentation; and observations of motions of the earth including wandering of the polar axis and changes in rotational speed. These data and associated analysis have application to a global inventory assessment of the potential mineral and energy resources available; geodetic surveying for detecting and mapping of subsidence; earthquake and other hazard prediction models; and improved standard timekeeping.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, data acquired from satellites and ground-based instruments, and specifically GEOS-3 and Lageos data, will be analyzed in support of the objectives outlined above. Specific investigations will be selected on the basis of proposals submitted by users in response to an announcement of opportunity for Lageos and a follow-on announcement for GEOS-3. GEOS-3, having demonstrated that the instrument has gone well beyond its performance specifications, has made possible additional experiments, such as topographic mapping, which could not be planned for previously.

Earth related studies and analyses of data obtained from the Seasat-A program will also be initiated in FY 1978.

BASIS OF FUND REQUIREMENTS:

Ocean Condition Monitoring and Forecasting

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Ocean dynamics satellite (Seasat-A)	15,800	6,000	25,300	25,300	11,400
Applications research and technology development (ARTD)	4,800	1,600	3,500	3,700	5,000
Follow-on data analysis and operations	1,600	500	1,800	1,800	2,800
Total	22,200	8,100	30,600	30,800	19,200

OBJECTIVES AND STATUS:

The objectives of the Ocean Condition Monitoring and Forecasting Program are directed toward achieving operating economies for activities in the marine environment such as shipping; off-shore oil extraction, gas well and general construction and operations; and fishing. In addition, the monitoring and forecasting of ocean conditions is expected to contribute significantly to the development of both short- and long-range global weather and sea condition forecasting. The objectives will be achieved through the development and demonstrated application of measurement techniques associated with determining and monitoring of ocean conditions including current systems and circulation patterns, air/sea boundary conditions, and sea surface topography.

A major goal of this program is to determine, through a joint NASA and user effort, the feasibility of developing a satellite system capable of operational use in the mid-1980's. Seasat-A, currently under development and scheduled for launch in mid-1978, will provide for the first time the global oceanic data needed to demonstrate and validate the use of satellites for ocean applications. Data acquired by the Geodynamic Experimental Ocean Satellite (GEOS-3), launched in April 1975, is providing new information on the ocean geoid and related topographic features of the ocean bottom, sea state or roughness, ocean currents, and deep ocean tides.

Ocean Dynamics Satellite (Seasat-A)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft and support	9,875	1,065	15,315	15,315	7,147
Sensor development	5,840	4,875	8,715	8,715	738
Mission operations	85	60	1,270	1,270	3,515
Total	15,800	6,000	25,300	25,300	11,400
Atlas F (Expendable launch vehicle program)	(1,400)	(---)	(3,400)	(2,600)	(6,000)

OBJECTIVES AND STATUS:

The Seasat-A mission will provide for the first time an extensive capability for observing and monitoring ocean conditions. Experimental data acquired with Seasat-A are expected to make important contributions to the definition and development of forecasting systems which will more accurately define ocean conditions (sea state, global circulation, and current movements) and to extended worldwide weather forecasting.

The satellite will weigh 2,300 kg and be launched into a nearly polar, circular 800-km high orbit. It will utilize a spacecraft bus equipped with three active sensors: radar altimeter; synthetic aperture imaging radar; and a microwave wind scatterometer. A scanning multifrequency microwave radiometer and a visible and infrared scanning radiometer are passive sensors that complete the payload. These instruments will provide the capability to monitor the world's oceans every 36 hours, and to detect sea state (wave height), wind speed, wind and wave direction, ocean temperature, and ocean surface topography from which ocean currents and geoid parameters can be derived.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will be used to complete testing of each of the Seasat-A sensors and the satellite bus. Integration of sensors into a sensor module that is attached to the bus will begin in July 1977 and will continue through early CY 1978 in preparation for a mid-CY 1978 launch. Mission operations will begin at that time for a planned one-year duration.

Applications Research and Technology Development (Ocean Condition)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Measurement systems, forecasting techniques, and modeling/advanced studies	900	300	900	900	1,900
Advanced ocean dynamics flight experiments	900	400	---	---	700
Ocean surface truth measurements	2,400	800	1,900	2,100	1,700
Ocean dynamics systems analysis	600	100	700	700	700
Total	4,800	1,600	3,500	3,700	5,000

OBJECTIVES AND STATUS:

The objective of this program is to support modeling of ocean-related phenomena and the development of experimental techniques and systems. These activities include theoretical studies, assessment of requirements of ocean data users, definition and development of sensor technology and support systems required to meet these requirements, the design of advanced sensors for future planned flight missions, and the evaluation of the economic effectiveness of ocean satellite systems.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $200 thousand in the FY 1977 budget estimate reflects an adjustment in the number of flight hours for aircraft in support of Seasat-A flight sensor software development.

BASIS OF FY 1978 ESTIMATES:

In FY 1978, studies will be expanded to emphasize the development of sensor and system technologies required for the evolutionary growth toward future ocean satellite system capability for the mid-1980's. This includes development of new sensors, including enhanced satellite position location and orbit determination technology, expansion of mesoscale modeling of ocean currents, and advanced techniques of modeling and verification through the surface truth program.

Follow-on Data Analysis and Operations (Ocean Condition)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Follow-on data analysis and operations.....	1,600	500	1,800	1,800	2,800

OBJECTIVES AND STATUS:

The analysis of data acquired by satellites, primarily GEOS-3 and Seasat-A, provides the basis for the development of techniques and models to be used in monitoring and forecasting ocean conditions. These analyses are important to understanding the formation and development of the various levels of sea state; the global ocean circulation pattern; the meandering of ocean current systems (such as the Gulf Stream); and the significance of the air/sea boundary interaction for long-range global weather forecasting.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, it is planned to continue investigations of the ocean geoid, circulation, current systems mapping, and weather forecasting. With the launch of Seasat-A in 1978, both new and improved data will be available. In addition, the continued successful performance of GEOS-3 indicates that extended operations can be anticipated. To provide for the analysis of data from these missions, an announcement of opportunity for Seasat-A and a follow-on announcement for GEOS-3 will be issued. Because GEOS-3 has demonstrated that its instruments have gone well beyond their performance specifications, it is possible to conduct additional experiments relating to sea state and ocean current boundary detection.

BASIS OF FUND REQUIREMENTS:

Environmental Quality Monitoring

Air pollution and oceanographic observing satellite (Nimbus-G).....	13,000	6,700	15,400	15,400	14,700
Shuttle/Spacelab payload development.....	---	---	800	800	2,600
Applications research and technology development..	9,000	2,339	9,900	11,000	9,200
Follow-on data analysis and operations.....	---	---	---	---	1,000
Total.....	22,000	9,039	26,100	27,200	27,500

OBJECTIVES AND STATUS:

The basic objectives of the Environmental Quality Monitoring Program are: (1) to develop analytic techniques and models to interpret sensor data to establish and predict the state of the environment; (2) to develop remote sensors to detect pollution; and (3) to evaluate and apply remote sensors to environmental monitoring projects through cooperative efforts with users.

Pollution of the earth's air and water environment occurs on local to global scales. The lower atmosphere, or troposphere, and the water are strongly impacted by man's activities, and it has been shown that local problems in both air and water often become regional in their extent. Global pollution effects such as occur in the stratosphere are often related to man's activities as well. As a balance is sought between the demands placed on the environment by man's economic and social activities and the desire to maintain environmental quality, it is clear that the environment must be monitored to determine its present state to establish the basis for determining possible consequences of continuing uncontrolled activity, to evaluate the effectiveness of control strategies, and to provide the understanding needed to predict more accurately the consequence of alternative choices for the future.

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 their consequences are being increasingly questioned, especially in the light of other activities of benefit to the nation. Also, it has been found that many locales cannot meet ambient air standards because they are seriously affected by pollutants transported from adjacent regions in addition to pollution from local sources. The required monitoring functions are now being performed almost exclusively by in situ sensors. Remote sensors now being developed will supplement in situ sensors both in characterizing pollution sources and in providing the synoptic coverage needed to address local and regional scale problems. Comprehensive field tests utilizing aircraft flights of existing passive and remote tropospheric pollution sensors will be conducted to establish the applicability of these techniques to the regional monitoring and control of tropospheric pollutants. The monitoring capability for carbon monoxide, ammonia, methane, and sulfur dioxide will be extended to permit the eventual mapping of these constituents. Comparative evaluation of several instrument concepts will permit focusing of research effort on selective development for future space mission opportunities. Also planned is a program of university research to study the basic physics of remote sensing of atmospheric pollution from aircraft and satellites, as well as the analytic techniques required to interpret measurements and predict pollution dispersion.

At the present time, the atmospheric layer of primary concern on a global scale is the upper atmosphere (stratosphere). The technology either exists or is being developed to detect many of the natural and man-made pollutants that enter the stratosphere either directly, as from volcanoes or supersonic transports, or indirectly by diffusion from the troposphere through organic processes or industrial activities. As a

part of the NASA Upper Atmosphere Research Program that is coordinated by the Office of Space Science, the Office of Applications directs its research primarily toward the instrumentation and data analyses required for remotely monitoring the stratospheric constituents of interest. This effort will result in the comprehensive information required to describe the global baseline stratosphere. Currently, aircraft flights and sounding rockets are providing data on the distribution and variability of constituents such as aerosols, ozone, and nitric oxide on a near-global scale. These efforts provide the basis for satellite instrument development. The Nimbus-G satellite will make a first step in providing complete global coverage of a number of important gaseous constituents such as the oxides of nitrogen. The Applications Explorer Mission-B, Stratospheric Aerosol and Gas Experiment, will be conducted in the same time frame as Nimbus-G and will provide similar coverage of atmospheric aerosols. Future plans include the development of advanced instrumentation, such as the Mark II interferometer to be flown on the Shuttle, to permit measurements of other constituents of environmental importance. This baseline data, together with information on sources, sinks, distribution, and variability of atmospheric constituents and pollutants are needed for validation of atmospheric models which will assist in data analysis and provide forecasts of pollutant dispersion and its impact. When completed, these models will be available to other agencies for their use in guiding and planning regulatory actions.

The detection from space of water pollution can be accomplished whenever pollutants give rise to variations in water color. For example, acid wastes and sewage sludge dumps, industrial effluents, heavily sedimented rivers, and algal blooms have already been detected from space. Understanding the optical properties of water pollutants remains the basic and continuing research objective needed to establish sensor design requirements and analytical techniques for data interpretation. This research, accomplished through laboratory investigations, sensor development, and exploratory airborne measurements using NASA aircraft, will facilitate going beyond the mere detection of pollutants to the determination of how much of a specific pollutant is present. The result of such research has led to the development of the Coastal Zone Color Scanner (CZCS) to be flown on Nimbus-G. The CZCS will permit quantitative measurements of sediment, chlorophyll, and salinity. These tasks are conducted cooperatively with other federal and state participation. The thrust of the increased activities in the water quality program is to substantially increase support for laboratory and analytical work by the university community, especially in the spectral/optical properties of pollutants and radiative transfer theory for data interpretation.

Air Pollution and Oceanographic Observing Satellite (Nimbus-G)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft	6,309	3,246	5,300	3,400	4,800
Sensors and data analysis	6,671	3,454	7,100	10,000	7,900
Ground support	20	---	3,000	2,000	2,000
Total	13,000	6,700	15,400	15,400	14,700
Delta (Expendable launch vehicles program)	(---)	(---)	(2,500)	(2,800)	(3,100)

OBJECTIVES AND STATUS:

The detection and measurement of atmospheric and water pollution constituents on a global basis requires the collection of remotely sensed repetitive data from space. The Nimbus-G spacecraft will provide this capability on this scale for the first time.

Four of the spacecraft sensors will detect and measure constituents related to atmospheric pollution, specifically constituent gases and particulates. Taken on a global basis, these measurements will be used to analyze pollutant concentrations and movements and to determine their sources and life cycles.

Two other sensors will be used to obtain high spatial resolution ocean color measurements near the coastlines (relating to nutrients, pollutants, and salinity) and microwave measurements of the ocean/atmosphere interface characteristics. The data will be used in practical applications, such as in support of ocean-food investigations and in survey of ocean pollution as well as in providing better knowledge of the interactions between the ocean, atmosphere, and sun.

The remaining spacecraft sensor will be used to continue the collection of data pertaining to the earth's radiation budget begun on earlier Nimbus spacecraft. This will be accomplished in order to establish a long-term baseline of data leading to a better understanding of the earth's thermal balance. This, in turn, will provide the capability to detect and understand changes to that balance, particularly those resulting from the activities of man and large-scale geophysical phenomena.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

Unanticipated sensor development problems resulted in cost growth for the FY 1977 period, thus requiring shifting of funding from the spacecraft and ground support elements. These latter two areas were not substantially affected, however, since their development is progressing better than anticipated.

BASIS OF FY 1978 ESTIMATE:

All sensor and spacecraft equipment will have been delivered by the first quarter of FY 1978. During FY 1978, the Nimbus-G spacecraft will undergo subsystem and system testing and will be prepared for delivery to the Eastern Test Range. Ground data processing systems will undergo final systems checkout and verification in preparation for launch and flight operations support. Launch is scheduled for first quarter FY 1979.

Shuttle/Spacelab Payload Development (Environmental Quality)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Payload development.....	---	---	800	800	2,600

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 will 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. Payload development activity 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 (HCI), an important gas species in the chemistry of ozone depletion.

BASIS OF FY 1978 ESTIMATE:

The design and development of the Mark I predecessor to the Mark II High Speed Interferometer have been carried out under Applications Research and Technology Development. That sensor has been tested in the laboratory, in balloon flights, and in flights on the U-2 and the Anglo-French Concorde. The initial version of Mark II will fly on a balloon in FY 1977 and will provide design verification for the Shuttle/Spacelab flight sensor. In FY 1978, the design of the Spacelab flight sensor will be completed, and fabrication activities will begin.

Applications Research and Technology Development (Environmental Quality)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Sensor definition and feasibility evaluation modeling	4,200	1,039	4,200	4,200	4,700
Development of advanced flight experiments for environmental quality monitoring	1,100	300	1,300	1,600	1,000
Aircraft support for development of capabilities in remote sensing of environmental quality	2,600	700	2,600	4,000	2,300
Studies in applications of environmental quality monitoring technology	600	100	700	700	700
Definition of Spacelab payloads for environmental quality monitoring applications	500	200	1,100	500	500
Total	9,000	2,339	9,900	11,000	9,200

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. The basic techniques and instruments are developed as part of the sensor definition and advanced flight experiments activities and are supported by the airborne operations.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The principal changes in this area reflect a reallocation of resources associated with increased requirements for aircraft support in conjunction with sensor development and field testing partially offset by a reduction in Spacelab payload definition studies.

BASIS OF FY 1978 ESTIMATE:

The application of remote sensing technology and analytic tools to the problems of the lower atmosphere will receive increased emphasis in FY 1978. Second-generation advanced sensors will be evaluated on local and regional scales using high and low altitude aircraft. Initial field testing will be completed on laser devices to measure vertical profiles of tropospheric constituents, and on extending present capabilities to include sulphur dioxide and ozone. Development of these devices has brought remote sensor capabilities to the point where comparative evaluation will allow selection of the best sensor for future aircraft or satellite missions.

In FY 1978, stratospheric sensor development will focus on instruments for monitoring the constituents needed to understand and assess the potential depletion of stratospheric ozone. Aircraft measurements will continue in support of sensor development. Studies will continue on the definition of post-Nimbus-G pollution monitoring requirements with emphasis on utilizing the capabilities of the Space Shuttle and the Spacelab.

Research in the detection and monitoring of water pollution is presently focused in areas of applications related to ocean dumping, red tides, and the eutrophic classification of lakes. Each investigation uses multispectral data from satellite and aircraft instruments. The work in eutrophic classification using remotely sensed data will be completed this year. Ocean dumping investigations, conducted cooperatively with NOAA, will use the capability to discriminate between and map sediment concentrations, sewage sludge, and acid wastes. This data will be used in mathematical models for predicting the dispersion and transport of these dumped materials. The red tide research will detect and discriminate between harmless algal blooms and harmful red tide blooms in the gulf coastal water of Florida. A new focus will be the application of

remote sensing in making environmental baseline measurements in coastal regions of the U.S. Monitoring of the Great Lakes and the east coast will provide data required for the near-shore and outer continental shelf activities.

Incorporated within this Environmental Quality Program is a program of university research to study the basic physics of remote sensing of atmospheric and water pollution from aircraft and satellites. The emphasis of the research will be placed on the development of data reduction and analysis techniques and the identification of required measurement capabilities.

Follow-on Data Analysis and Operations (Environmental Quality)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Data analysis	---	---	---	---	1,000

OBJECTIVES AND STATUS:

Serious questions concerning possible alterations of the stratospheric ozone layer by man's activities have been raised in recent years. This layer absorbs much solar ultraviolet radiation prior to its reaching the earth's surface, and the layer hence acts as a life preserving solar shield. The absorption of the solar radiation also heats this layer of the atmosphere and hence has an important influence on climate. It is speculated that these alterations occur as a result of high flying aircraft, industrial activity, and agricultural activity. However, it is not currently possible to address these hypotheses because the stratospheric ozone layer is variable in both space and time. It is not yet possible to establish the extent of which sources are influencing this variability. In order to understand the causes of this variability it is necessary to develop an extended set of baseline data concerning the stratospheric ozone layer. The satellite data from the Backscatter Ultraviolet (BUV) instruments on Nimbus-4 are available. Data also are available from a number of balloon, aircraft, rocket, satellite, and ground-based sensors. These data, when properly and completely reduced to useful physical parameters, analyzed, and disseminated to the scientific and user communities in practical form, are expected to be applied directly to the important national and global problem of understanding the stability of the earth's ozone layer, its natural variability, and its susceptibility to changes caused by man's activities.

BASIS OF FY 1978 ESTIMATE:

The data reduction processing for the Nimbus-4 data has proceeded at a low level under Applications Research and Technology Development. It is important that this data reduction effort be augmented in FY 1978 to provide a basis for addressing the following broadened requirements for the data: detailed analysis of data for applications to the important problem of ozone depletion, data-use investigations by the user community, and transfers of data-use capabilities to the user agencies.

Weather and Climate Observation and Forecasting

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Operational temperature sounding satellite (TIROS-N)	8,000	2,100	8,600	10,100	2,100
Shuttle/Spacelab payload development	---	---	---	---	2,700
Global atmospheric research program (GARP)	7,000	1,800	6,000	5,100	5,000
Severe storm research program	7,900	2,200	7,100	8,000	6,500
Applications research and technology development (ARTD)	12,030	3,383	13,000	11,900	11,900
Follow-on data analysis and operation	---	300	1,600	1,600	2,500
All weather atmospheric sounding experiment satellites (Nimbus-5 and-6)	5,700	---		---	---
Total	40,630	9,783	36,300	36,700	30,700

OBJECTIVES AND STATUS:

NASA's Weather and Climate Observation and Forecasting Program includes research on global weather systems, local forecasting, climate variation and change, and fundamental atmospheric processes. NASA contributes unique capabilities from space-related technology to national efforts in meteorological research and forecasting improvements.

The understanding and extended prediction of weather requires that information be available and processed on a global basis. The length and accuracies of forecasts are dependent on the global models to describe the interaction of various atmospheric processes, and the utilization of these models with data

obtained on a global basis. Weather satellites, with their capabilities to observe basic parameters and dynamic processes of the atmosphere, are providing the basic global information needed. Quantitative soundings of the global atmosphere for use in weather forecasting, data for advanced research of atmosphere processes, and global viewing of clouds and storm systems are being provided by current polar-orbiting satellites. These satellites include the Improved TIROS Operational Satellite (ITOS) series and the Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite (SMS/GOES) series developed by NASA for the National Oceanic and Atmospheric Administration, and the Nimbus research and development weather satellite series. A prototype of the third generation operational satellite of this kind (TIROS-N) is currently under development.

The Global Atmospheric Research Program (GARP) focuses on the design, development, and testing of a series of atmospheric models based on the data provided on a global basis. Using current observation facilities, the Data Systems Test (DST) programs are testing on a smaller scale the integration and modeling of measurements which will be available during the First GARP Global Experiment (FGGE). The DST program is developing the required data processing and management techniques and implementing data utilization methods. Planning and associated research will continue and will accelerate as FGGE approaches. NASA is also providing space-related technology in the development of support systems to FGGE such as communications facilities and measurement of winds in the tropics with aircraft and other means.

NASA's goal in the area of local forecasting is the application of unique space capabilities to the high priority national problem of the detection, monitoring, prediction, and warning of severe storms. To meet the objectives of local forecasting, NASA has a well coordinated program consisting of Applications Research and Technology Development (ARTD), satellite observations, and satellite sensor development. The ARTD effort consists of studies to develop systems to detect and locate tornadoes and other severe storm activity from satellites. Data for study have been obtained from satellite systems, specialized aircraft flights, and ground-based systems, and are being used in computer model simulations to develop diagnostic and prediction techniques for severe storms.

The short-time duration of severe local storms, such as tornadoes, necessitates very frequent observations. The present SMS/GOES geostationary spacecraft, with essentially continuous observations, provides information on the cloud amount and type and cloud-top temperatures. An improved sensor for SMS/GOES (visible Infrared Spin Scan Radiometer Atmospheric Sounder) is being developed which will provide information on temperature and humidity with the frequency that is required for detecting such storms. To provide for more frequent and accurate information, the three-axis stabilized Stormsat satellite is being studied. The baseline meteorological sensors on Stormsat would be the Advanced Atmospheric Sounding and Imaging Radiometer (AASIR), and a microwave atmospheric sounding radiometer which would provide vertical soundings in cloudy areas.

The impact of climate variability and climate change on the agricultural, economic, and social fabric of the world has focused the need for climatic research and necessitated the development of a climatic forecasting capability. NASA is a major participant in a national climate program with special emphasis on the contribution that satellite systems can make to the monitoring and climate modeling elements of the program. A key concern in climate research is the possible depletion of atmospheric ozone due to human activity, in that significant variations in ozone concentration may well affect climate.

Other factors that may influence climate are the ice cover, surface water, precipitation and ocean surface temperatures. These are being measured with infrared and microwave imaging and nonimaging radiometers aboard Nimbus-5 and -6 and the operational weather satellites. Studies based on these data will be continued in FY 1978.

The goals in the basic technology and fundamental atmospheric processes area are to develop and demonstrate the application of satellite data to the investigation of basic meteorological processes--an essential element to the understanding of regional and global weather. One objective is the development of new remote-sensing techniques. New instruments will be developed and demonstrated on specially-equipped aircraft, and eventually flown in space. In addition, this program will include the investigation of basic areas such as radiation transfer, atmospheric models, the earth's energy budget, air-sea interactions, atmospheric composition, and solar radiation.

A very important tool in the essential investigations of the fundamental atmospheric processes will be the Atmospheric Cloud Physics Laboratory (ACPL) to be flown on early Spacelab missions. Operating in a near-zero gravity environment, the ACPL will significantly increase the present knowledge of cloud microphysical processes by permitting experiments which cannot be accomplished effectively in ground-based laboratories because of the effects of gravity.

Operational Temperature Sounding Satellite (Tiros-N)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft and support	5,515	1,511	6,500	8,025	2,100
Sensor development	2,332	399	1,875	1,850	---
Operational station equipment	153	190	225	225	---
Total	8,000	2,100	8,600	10,100	2,100
Atlas-F (Expendable launch vehicles program)	(2,000)	(---)	(2,800)	(3,600)	(3,300)

OBJECTIVES AND STATUS:

The objective of this project is to develop a prototype satellite and sensors capable of meeting stated future requirements of the National Oceanic and Atmospheric Administration (NOAA) for obtaining quantitative data of the earth's atmosphere on a daily basis. 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 sounder 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 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 Tiros-N instruments are nearing completion and will all be delivered in 1977. The spacecraft bus will complete integration and test by mid-FY 1977 after which time the instruments will be installed.

CHANGES FROM 1977 ESTIMATE:

The increase of $1,500 thousand in the FY 1977 budget estimate reflects cost growth due to unexpected costs associated with tape recorder development, additional spacecraft ground test equipment, and the cumulative effect of higher than expected inflation in recent years.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will provide for completing the development, test, launch and orbital checkout of the integrated spacecraft. The launch is planned for the first half of CY 1978.

Shuttle/Paylab Payload Development (Weather and Climate)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Payload development.....	---	---	---	---	2,700

OBJECTIVES AND STATUS:

The initial objective in this area is the development of the Atmospheric Cloud Physics Laboratory (ACPL) for flight on an early Space Shuttle mission. The ACPL will provide a unique, very-low-gravity, multipurpose laboratory facility in which research into the very-small-scale (microphysical) atmospheric cloud processes will be conducted.

Over the past several years, our understanding of large-scale atmospheric processes has progressed to the point where we can predict with reasonably good success the movement of large masses of air and the significant cloud and weather conditions that accompany them. However, what man generally refers to as "weather", and is affected by, are the small-scale but very important processes that occur inside the clouds. These internal forces are so small that their study in earth-based laboratories is severely restricted, with the "pull" of the earth's gravity being the foremost handicap. However, in the very-low-gravity conditions of the ACPL, these important cloud processes can be studied in near-total isolation. The properties of clouds formed under very carefully controlled conditions can be measured with unprecedented precision over relatively long periods of time.

The experiments planned for the ACPL will lead to advances in our understanding of very-small-scale cloud processes which will lead to improved weather and climate prediction. The ACPL will be housed in the Spacelab habitable module and will be operated by the payload specialist in close coordination with the ground-based investigators.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, the final design of the protoflight ACPL will be completed, and the manufacture and testing of critical components will be started. The continuing, active participation of the scientific community will ensure the scientific integrity of the ACPL and that its design meets the necessary scientific requirements. The Principal Investigator and his supporting team will be selected. They will plan and develop specific experiments for use as inputs to the ACPL's critical design review.

Global Atmospheric Research Program (GARP)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Data systems test support	934	56	312	716	250
Simulation studies	4,880	1,563	4,170	3,699	2,845
First GARP global experiment (FGGE)	310	105	993	6	1,080
Long range forecasting (LRF)	90	---	---	115	170
Technology support	786	76	525	564	655
Total	7,000	1,800	6,000	5,100	5,000

OBJECTIVES AND STATUS:

The major objectives of the Global Atmospheric Research Program (GARP) are improvements in the forecast accuracy and length of time over which weather forecasts can be made, and the understanding of the physical processes that affect climate and climatic changes. The current program centers on the following tasks: (1) the conduct of meteorological research studies using the unique global data sets acquired during the Data Systems Tests (DST); (2) the development of data products and techniques for the First GARP Global Experiment (FGGE); (3) the implementation of the tropical wind system for FGGE; and (4) the development of a climate modeling and long-range forecasting capacility.

A number of meteorological research studies were initiated using the DST data sets. These studies determined the adequacy of the DST/FGGE observing system, improved the methods for extracting the meteorological parameters from sensor data, developed improved methods for data analysis and assimilation in the numerical forecast models, and improved those models. A concentrated effort is currently being made to demonstrate the full potential that satellite temperature sounding data can have on operational weather forecasting.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The decrease in program total results from technical changes in activities supporting the Tropical Wind Measuring System, an element of FGGE. Increased funding was allocated to provide for additional research tasks using Data System Test data sets and for climate statistical modeling efforts in long range forecasting.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, the meteorological research studies using the DST data sets will be completed. Work will continue on the development of techniques to extract relevant weather and climate parameters from operational and experimental satellites during FGGE with increasing emphasis on the development of systems to efficiently process the data. The products include rainfall amounts and cloud cover characteristics (amount, type, height, etc.) from the operational GOES satellites, earth radiation budget parameters from Nimbus-G, and sea ice, rain rate, ocean surface wind velocity, sea surface temperature and atmospheric water vapor from both Nimbus-G and Seasat-A. Data acquisition and processing for FGGE will begin in September of 1978 and continue through September 1979. NASA support to the observational program includes development of an automated aircraft-to-satellite data link to transfer aircraft meteorological data in real time, the contribution of data sets from available experimental satellites, and direct support of the aircraft dropsonde portion of the FGGE Tropical Wind System. Long-range forecast activities will continue with the development of additional climate-related data products such as monthly mean sea ice maps, earth surface albedo, soil moisture and snow extent. Climate model development will continue with increasing emphasis on the investigation of possible climatic feedback mechanisms.

Severe Storm Research Program

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Advanced techniques in observing and forecasting..	2,700	800	2,700	2,800	3,500
Research and development for improvements to operational satellite systems.....	2,400	500	1,100	1,600	2,100
Aircraft support for testing sensors and techniques in severe storm research.....	1,000	300	1,000	1,000	900
Stormsat definition studies.....	600	300	300	600	---
Management of severe storm research data.....	1,000	300	1,000	1,000	---
Definition of Spacelab payloads for monitoring and detection of severe storms.....	200	---	1,000	1,000	---
Total.....	7,900	2,200	7,100	8,000	6,500

OBJECTIVES AND STATUS:

The primary objective of severe storm research is to develop and demonstrate space-related capabilities for the detection, prediction, and early warning of short-lived violent and destructive storms. The research program includes ground-based studies, aircraft field work, modeling studies and satellite system studies. Basic research on the microphysical processes taking place in clouds is also needed for understanding cloud development and dynamics and their relation to severe storms. NASA will develop theoretical models of cloud processes in experiments to be conducted in the Atmospheric Cloud Physics Laboratory on Spacelab. Development of this payload in FY 1978 builds on the definition activities being conducted in the Severe Storm Research Program in FY 1977.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $900 thousand in FY 1977 provided for increased funding for development of the Atmospheric Sounder instrument for the GOES-D spacecraft; and additional funding to study payload options for a future Stormsat mission.

BASIS OF FY 1978 ESTIMATE:

Efforts to specify sensor characteristics and physical measurement concepts for detecting and monitoring tornado development and growth will be continued during FY 1978. In studying the characteristic features of severe storms, the Atmospheric and Oceanographic Information Processing System (AOIPS) will be used for the management, display, and enhancement of meteorological data. Microwave radiometer technology will be developed in FY 1978 for the global surveillance of tropical storms (hurricanes) to obtain essential descriptive data such as precipitation rates, cloud liquid water content, cloud structure, and surface wind speeds.

Aircraft measurements will be obtained in FY 1978 on the growth and decay of overshooting cloud domes, temperature differences between the dome and the surrounding anvil cloud, and other parameters around and inside the cloud system. These aircraft investigations will be conducted in cooperation with the National Severe Storm Center utilizing their ground-based instrumentation and radar. Concurrent SMS/GOES and special ground-based observations will provide a coordinated three-dimensional description of the storm and its environment. Development of specialized remote-sensing instruments for the aircraft program will continue. These instruments will also support NASA participation in the NOAA national severe storm projects, Stormfury and the Severe Environmental Storms and Mesoscale Experiment (SESAME).

Applications Research and Technology Development (Weather and Climate)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Advanced techniques in observing and forecasting..	3,049	683	3,000	3,000	4,000
Research and development for improvement of operational satellite systems.....	3,181	1,400	3,400	3,400	3,500
Exploration of the atmosphere using meteorological sounding rockets.....	1,900	400	2,100	2,100	2,100
Development of advanced flight experiments for research in weather and climate.....	1,600	200	1,600	1,300	100
Aircraft support for development of techniques in observing and forecasting.....	1,300	400	1,600	800	200
Studies in application of weather and climate observations and forecasting systems.....	1,000	200	1,000	1,000	1,500
Spacelab payload definition.....	---	100	300	300	500
Total.....	12,030	3,383	13,000	11,900	11,900

OBJECTIVES AND STATUS:

The objective of this project is to apply space technology to the achievement of improved understanding of the physical principles of the earth's atmosphere upon which new remote sensors can be based and to improved techniques for the acquisition of descriptive atmospheric data. In support of program planning and decisions, studies of the economic benefits to be realized from the development and use of space-related sensors and satellite systems are conducted.

The application of satellite technology to the development of a climate-monitoring system will be continued. A number of studies related to climate are underway and will continue through FY 1978. Examples are the study of atmosphere ozone and its relationship to solar activity and climate change, and the definition of future satellite systems to measure the long-term variability of incoming and out-going radiation. Effort will also continue on the development of climatic models to provide new insights into the understanding and prediction of climatic change.

The development and demonstration of satellite applications in the investigation of meteorological processes covering multiple scales of weather require the development of an improved microwave radiometer, a cloud physics radiometer, an infrared heterodyne sounder, and an ocean temperature scanner. Calibration and preliminary testing of these instruments will be performed on NASA aircraft in order to specify the requirements for future satellite systems and instruments. Present and future operational satellite systems will continue to be supported through the development of new instruments and the conduct of specific system improvement tasks. This effort involves 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.

CHANGES FROM FY 1977 ESTIMATE:

The reduction in FY 1977 results primarily from lower than planned utilization of the NASA research aircraft due to technical delays experienced in the development of advanced sensors for aircraft flight testing.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 the work initiated in prior years for the TIROS-N series will continue: the addition of the fifth channel to the Advanced Very High Resolution Radiometer to provide greatly improved sea surface temperature sensing accuracies will be completed; and the tropospheric sounding unit, High resolution Infrared Sounder which will use the 4.3 micrometer carbon dioxide band for the purpose of resolving the vertical temperature structure particularly in the lower and middle troposphere, will enter the flight hardware phases. Development will continue on instruments to monitor the incoming solar energy and radiation budget of the earth. Also in FY 1978, the study of a microwave sounding capability to follow-on satellites of the TIROS-N series will be initiated. In the aircraft program, effort will be devoted to supporting climate variability research and the development of remote sensing techniques. Engineering models of advanced instruments will be flown aboard appropriate aircraft to gain performance data which will further the development of optimized satellite sensors.

Follow-on Data Analysis and Operations (Weather and Climate)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Nimbus follow-on operations	---	300	1,600	1,600	1,500
Data analysis	---	---	---	---	1,000
Total	---	300	1,600	1,600	2,500

OBJECTIVES AND STATUS:

In addition to providing for the continued operation of the Nimbus-5 and -6 spacecraft, this effort will provide the analysis and data use investigations of atmospheric environmental data collected by rocket and satellite sensors for which development and flight project support has been completed. Data which has been only initially analyzed can yield vital information when additional analyses and user investigations are performed and additional corroborative data are collected. Urgent needs continue for these data which include, among others, global precipitation, soil moisture, and snow-and-ice-cover data from the microwave sensors of Nimbus-5; and important data on the earth's radiation budget from Nimbus-6. These data, when properly reduced to useful physical parameters and furnished to the scientific and data-user community in practical forms, are expected to be applied directly to specific national and global problems. Such problems include the trend of regional and world climate, severe storm analysis and prediction, and land use change detection.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will support the continued operation of the Nimbus control center, and the reduction and analysis of the data from Nimbus-4, -5, and -6. These data will be applied to investigations of critical physical, chemical and meteorological atmospheric problems by in-house and University researchers. Data utilization support will be provided by the operational Atmospheric and Oceanographic Information Processing System (AOIPS). Particular emphasis will be placed on investigations of large-scale climatic change and the development of future predictive techniques.

BASIS OF FUND REQUIREMENTS

MATERIALS PROCESSING IN SPACE

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Space processing applications rocket program (SPAR)	600	200	2,900	2,900	3,900
Applications research and technology development	5,300	900	6,300	6,000	5,300
Shuttle/Spacelab payload development	---	---	---	---	6,300
Total	5,900	1,100	9,200	8,900	15,500

OBJECTIVES AND STATUS:

Experiments on the Skylab and Apollo Soyuz Test Project (ASTP) missions as well as ground-based studies have shown that space can be an effective setting for basic and applied materials research, and have identified some types of products that may be feasible to manufacture in space for use on earth. Among the latter are cell preparations purified by electrophoresis, single crystal silicon ribbon, ultrahomogeneous semiconductors, high quality semiconductor and oxide crystals produced by vapor and solution growth, ultra-pure refractory metals and oxides, new types of optical glass, and controlled eutectic materials for optical, electronic, and specialty structural applications. All of these prospects require the low cost, easily accessible processing capabilities in orbit offered by the Space Transportation System.

Space Processing studies, investigations, and analysis of potential applications of space processing will be continued, and will include synthesis of space experiment results to identify potential applications that are not predictable from ground data alone. Results are now available from the experiments performed on the initial two Space Processing Applications Rockets (SPAR) missions. The SPAR Project offers a continuing opportunity to investigate materials processes in space prior to the Shuttle era. The preliminary design of Space Processing Shuttle payloads was initiated in FY 1977 in preparation for beginning the full scale payload development in FY 1978. These Shuttle payloads will provide for systematic materials research and development in the early years of Shuttle operations so as to make practical applications possible in the late 1980's.

Space Processing Applications Rocket Project

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Space processing applications rocket project (SPAR).	600	200	2,900	2,900	3,900

OBJECTIVES AND STATUS:

The Space Processing experiment results from Skylab and the Apollo Soyuz Test Project (ASTP) have identified a number of striking effects indicative of the promise for future applications. These results have elicited sharply increased interest in space processing from academic and industrial materials scientists, as evidenced by the user community response to the ASTP and SPAR Project flight opportunities. The user community has submitted 114 proposals in response to the first two SPAR Project Announcements of Opportunity.

The initial SPAR mission was launched on December 11, 1975, from White Sands Missile Range (WSMR) in New Mexico. The flights are continuing through 1980. Each payload is configured in response to user requirements and processes from 5 to 10 separate experiments. The individual payloads are fabricated using both experiment unique hardware and general purpose apparatus from the Project inventory. The general purpose apparatus is designed to process from 1 to 3 experiments and has a life expectancy of approximately three missions. In these respects, the SPAR Project has some similarity to the space processing activity planned for Shuttle. The Space Processing Applications Program is utilizing the SPAR flights to develop the scientific, engineering, and management expertise necessary to enter the Shuttle era with a more mature and productive program.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, requirements for preflight experiment development will reach their anticipated maximum level and the flight program will convert to the Nike-boosted Black Brant VC vehicle to increase payload capacity. Three flights of this configuration are planned to be undertaken. The Announcements of Opportunity will be issued annually as needed through the life of the Project.

Applications Research and Technology Development (Materials Processing)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Ground-based investigations, analysis, and studies.	3,500	800	4,500	4,500	5,000
Advanced materials processing system development...	700	---	500	---	---
Space processing systems analysis.....	300	100	300	300	300
Spacelab payload definition and preliminary design.	800	---	1,000	1,200	---
Total.....	5,300	900	6,300	6,000	5,300

OBJECTIVES AND STATUS:

The studies, investigations, and analyses provide the basic information needed: to select future flight activities in the space processing program, to plan experiments, and to investigate the implications of their results. The program includes technology development for future flight equipment and research and development work on materials and processes in metallurgy, electronic materials, biological preparations, glass and ceramics. All of the space processing experiments in the Apollo, Skylab and ASTP flight programs

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 Shuttle payloads have resulted from ground-based investigations; and the sounding rocket experiment project initiated in FY 1975-76 has been undertaken because ground-based studies showed that rockets could be effective for such experiments.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The reduction of $300 thousand in the FY 1977 budget estimate reflects the net result of two separate actions. First, a reduction of $500 thousand resulted from a determination that system development work on a solar furnace should be postponed pending more study effort. The second action provided an increase of $200 thousand to allow initiation of studies on a facility for conducting experiments in ultrahigh vacuum.

BASIS OF FY 1978 ESTIMATE:

With the advent of full-scale experiment operations in the rocket project and the development activity for Shuttle payloads, supporting research studies and technology development on the ground will continue to be essential to the space processing program. Topics to be covered in the ground-based program will include: assessments of feasibility and definition of requirements for experiments in areas such as semiconductor crystal growth that will be important in the Shuttle experiment but are only marginally feasible for rocket experiments; definition and advanced technology development for rocket experiments that have long lead times and will require relatively large investments when committed to payload development, such as automated electrophoretic mobility measurements; and synthesis of results from the Skylab, ASTP and rocket experiment programs to define new space processing potentials that could not be predicted on the basis of ground-based research results alone.

Shuttle/Spacelab Payload Development (Materials Processing)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Shuttle/Spacelab payload development.....	---	---	---	---	6,300

OBJECTIVES AND STATUS:

The Space Processing Shuttle Payloads project includes the design and development of a basic set of payload equipment for space processing experiment operations, and provisions for initial operations with this equipment through CY 1981. Included in the basic equipment inventory are processing facilities for biological preparations, electronic materials, glasses and metals. All of the equipment will be designed for repeated reuse and a long service lifetime, since materials research and development generally requires preparation of an extensive series of samples.

Requirements, design envelopes and equipment specifications for this payload equipment have been defined and experiment definition proposals are being solicited and selected during the first half of FY 1977. A request for proposals for the design and development of the payload equipment will be issued during the second half of FY 1977, with a view toward completing the contractor selection and negotiation process in time for a prompt start at the beginning of FY 1978.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, the equipment will be designed by a prime contractor to meet functional requirements set by the Principal Investigators selected in the previous year. An Announcement of Opportunity for experiment definition and for use of space processing payload equipment will be issued annually beginning in FY 1977, in order to provide continuing opportunities for industrial and other participants to participate and to prepare long lead time experiments for operation in later years. The Space Processing Program is currently scheduled to fly payloads on Spacelab missions in 1981, and it will be necessary to initiate design and development activities early in FY 1978 in order to meet these flight dates.

BASIS OF FUND REQUIREMENTS:

SPACE COMMUNICATIONS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Cooperative applications satellite (CAS-C).....	1,100	100	300	300	100
Technical consultation and support studies.....	2,100	500	2,600	2,600	3,100
Shuttle/Spacelab payload development.....	---	---	1,200	1,200	2,200

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Applications transfer and demonstration program....	---	---	---	900	900
Search and rescue satellite system.....	---	---	---	---	5,600
Applications research and technology development...	5,400	1,400	6,000	6,800	7,200
Follow-on data analyses and operations.....	4,400	600	3,700	3,700	3,700
Total.....	13,000	2,600	13.800	15,500	22,800

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. Efforts for FY 1978 include initiation of the development of the Search and Rescue Satellite System, conducting the fourth year of user experimentation using the Applications Technology Satellite-6 (ATS-6); operation of the Cooperative Applications Satellite-C (CAS-C); the development of communications concepts and technology anticipating future public and private service needs; the conduct of special communications studies and experiments to support our statutorily-required technical consultation services; and the utilization of the unique capabilities of Shuttle/Spacelab.

By 1980 we anticipate a greatly increased demand for public services using existing and new satellite communications capabilities in health, education, and other user areas. NASA has undertaken a number of studies focused on the delivery of public service via satellite. Public service may include health care, education, rural communications, emergency medical, public safety, disaster warning and relief communications, search and rescue, library retrieval, and state and local communications. The current program is focused on (1) delivery of services deemed necessary or highly desirable but not presently feasible or available due to economic and technical or geographical constraints, (2) delivery of existing services considered important to continue but whose quality and/or continuance is considered marginal due to cost-related systems limitations, and (3) delivery of existing services considered essential to continue but which can be performed more cost effectively via satellite or combined satellite/terrestrial system.

The anticipated growth of satellite services will impose spectrum requirements far in excess of allocations presently available. Frequency sharing has already become a serious problem in bands below 10 GHz. NASA's efforts in FY 1978 will be concentrated on relieving further overcrowding in already

widely used bands, and on a longer range interest devoted to developing technology to open higher, as yet unused, frequencies. It is clear that unless new allocations are obtained, new or modified frequency and orbit-sharing criteria and techniques developed and implemented, and more applicable technology developed and its transfer to the public and private sectors expedited, the growth of highly useful satellite services will have to be constrained.

Although U.S. industry still enjoys a favorable 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 technology base is now being laid for possible 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) 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; (3) aeronautical and maritime communication and position location services; and (4) direct reception satellites with interactive communications capabilities such as two-way video and voice to be used to deliver educational, health care or other social services.

In FY 1978, a new cooperative venture with Canada will be initiated to employ space technology in the detection and location of emergency signals transmitted from aircraft and ships that are in distress situations. Based upon studies conducted by the Interagency Committee on Search and Rescue, a space system appears to be the best near-term method for effectively providing distress alerting and locating for emergency-beacon-equipped ships and aircraft. A cost-effective system will be developed to place the required electronic equipment on-board operational meteorological satellites to be launched for NOAA. The Canadian government has expressed interest in a cooperative program in satellite-aided search and rescue. Their participation is expected to increase the system's capability and reduce the total cost to NASA by approximately one-half.

Cooperative Applications Satellite-C (CAS-C)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spacecraft testing	620	---	---	---	---
Experiments and operation	330	100	300	300	100
Mission analysis	150	---	---	---	---
Total	1,100	100	300	300	100
Delta (Expendable launch vehicles program)	(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 societal, 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 has been allocated 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 was launched on January 17, 1976, and was turned over to the Canadian Department of Communications who will continue to operate the spacecraft throughout its lifetime. The U.S. and Canada share satellite time 50/50, on an alternate-day basis. As of December 1, 1976, 16 U.S. experiments have been approved for CAS-C. Of these: one has been completed; nine are in experimental operation; six are yet to start; all are on schedule.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding will provide for the technical support to U.S. experimenters using CAS-C and for the operations of the ground equipment monitoring the performance of the NASA-supplied transmitter experiment package.

Technical Consultation and Support Studies

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,100	500	2,600	2,600	3,100

OBJECTIVES AND STATUS:

This program includes 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 effort is grouped into three main categories: orbit and spectrum utilization; satellite systems support; and communications satellite applications systems studies.

Orbit and spectrum utilization includes the development of techniques and strategies for standards and equipment design criteria and the determination of the effects of propagation phenomena and man-made noise on performance, design, and orbit and spectrum utilization of space telecommunication systems.

Satellite systems support includes design and flight readiness reviews and technical assessments on Intelsat and Domsat systems for the FCC and special studies on high priority FCC and NASA program office requests.

Communications satellite applications systems studies are structured to meet, primarily, statutory requirements and are presently concentrating on the delivery of public services via satellite. The studies will explore techniques applicable to improving the quality and reducing the cost associated with providing public services via satellite. Additional studies in process will be used to facilitate the growth of satellite services and to ensure compatibility of the new flight programs with other space and terrestrial services.

During FY 1977 a number of high priority tasks are being continued in preparation for the 1977 World Administrative Radio Conference (WARC) on Broadcast Satellites and the 1979 WARC for revision of the International Radio Regulations. The 1979 WARC will consist of 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 and may also result in major impacts on existing systems. More than 50 technical papers have been prepared and will serve as key inputs to the

1977 WARC and for domestic regulatory purposes. A similar major effort is expected to be completed in 1979 in support of the 1979 WARC with a major share of the work in support of NASA's long-term needs.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funds will be used to continue our efforts on the 1979 WARC preparations which are being done at the request of the Federal Communications Commission, the Office of Telecommunications Policy, and the Department of State.

Studies to be performed by NASA in FY 1978 will address such questions 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; spillover patterns of applications satellites; spectrum and orbit congestion; and the adverse effects of propagation phenomena.

Shuttle/Spacelab Payload Development (Space Communications)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Payload development.....	---	---	1,200	1,200	2,200

OBJECTIVES AND STATUS:

The objective of the Spacelab Payload Development Program is to develop promising communications, navigation, and data management payloads that can utilize effectively the unique capabilities of the Space Shuttle and Spacelab missions in the early 1980's time period. In FY 1978, development work will continue on 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 Federal Communications Commission and Office of Telecommunication Policy for future domestic frequency allocations and to guide the design of passive sensors and other NASA spacecraft design parameters; and (2) an adaptive multibeam 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.

BASIS OF FY 1978 ESTIMATE:

The two communications experiments to be developed for early Spacelab missions have been defined and detail design studies are planned to be completed in FY 1977. In FY 1978 contracts will be awarded for the space hardware for the experiments, and the detail designs are planned for completion on the ground elements of the experiments and the data processing needs.

Applications Transfer and Demonstration Program (Space Communications)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Applications Transfer and Demonstration.....	---	---	---	900	900

OBJECTIVES AND STATUS:

The Applications Transfer and Demonstration Program objective is to take the most promising applications areas and, through a concerted effort with user organizations and resources managers, conduct an integrated test of the total technical capability required to accomplish the specific application objectives. Demonstrations efforts began in FY 1977 in two significant areas.

The Public Service Communications demonstration is a joint investigation with NASA, the Department of Health, Education and Welfare, and the Public Service Satellite Consortium to establish and operate a satellite system ground station complex for the training of ongoing and new users in order to expedite the transfer and utilization of spacecraft telecommunications and technology to the public and private sectors.

The Airline Meteorology Link demonstration is a joint investigation with the Federal Aviation Agency and commercial airlines to demonstrate the use of satellite communications technology to provide near-real time satellite cloud cover information to aircraft in flight for the purpose of providing extended meteorological coverage which is not available over wide expanses of ocean and land areas through conventional terrestrial communications facilities.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

Funding was requested in FY 1977 for the Applications Transfer and Demonstration projects under the Earth Resources Detection and Monitoring program. Two communications demonstration projects were subsequently selected for FY 1977 and funding in the amount of $900 thousand in FY 1977 was reallocated to Space Communications for the two projects.

BASIS OF FY 1978 ESTIMATE:

For the Public Service Communications demonstration, FY 1977 and FY 1978 funding is being applied to the satellite system ground station complex preparations for ATS-1, -3, -6 and Cooperative Applications Satellite-C (CAS-C) operations. In FY 1978, the demonstration project will be focused on the process of transferring technical management and operational skills to the users will be initiated. System availability will be improved, programming will be initiated, and interactive remote terminals will be added to provide a quasi-operational environment. This process will also include expanding user and co-sponsor involvement both in funding and organizational participation.

Search and Rescue Satellite System

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Search and rescue satellite system.....	---	---	---	---	5,600

OBJECTIVES AND STATUS:

The Search and Rescue Satellite System is proposed as a cooperative U.S.-Canadian program. The objective of the program is to demonstrate the feasibility of utilizing satellites to provide a significant improvement in the capability for search and rescue forces to detect and locate the distress signals from general aviation aircraft and certain marine vessels during emergencies. Both the Canadian and U.S. governments have concluded that there does not presently exist a reliable system to monitor the emergency beacons required to be carried on general aviation aircraft and certain marine vessels or to fix the position of a downed aircraft or ship in distress. Consequently, the effectiveness of the present aircraft and ship distress beacons as an alert device is compromised.

The U.S. Government's Interagency Committee on Search and Rescue (ICSAR)--comprised of members from the Departments of Commerce, Defense, and Transportation, the Federal Communications Commission, and NASA, plus observers from the Aircraft Owners and Pilots Association and the National Association for Search and Rescue --has therefore recommended that a demonstration of a satellite-aided search and rescue system be implemented. The Canadian Government has indicated its interest in joining with the U.S. Government in a cooperative program for such a demonstration. Technical discussions are underway to delineate the assignment of responsibilities for the development activities. A Memorandum of Understanding is currently being drafted and is planned for completion in FY 1977.

The Satellite System will be comprised of three segments: a space segment consisting of an antenna, receiver, processor, and transmitter carried on meteorological satellites in 830-km, near-polar orbits; a ground segment of several local user terminals, each having a small antenna (approx. 2-3 meters in diameter) and receiving and processing equipment; and, an R&D effort to investigate and develop an improved emergency locator transmitter.

It is planned to modify the last four NOAA spacecraft of the Tiros-N series to accommodate the space transponder package, as a means to avoid the unnecessary development of a more costly dedicated system. The launch of the initial instrument-equipped spacecraft could occur as early as 1980. The ground segment involves the design and development of several small local user terminals, modifications to a NOAA ground station, and software development. The ground stations would be situated to provide coverage of the continental U.S. and most of Canada.

The planning estimate for the U.S. share of the cooperative program is $15-$20 million--approximately half of the total estimated program cost.

BASIS OF FY 1978 ESTIMATE:

FY 1978 funding is required to initiate the design and hardware modifications to an approved spacecraft (plans are to use the NOAA meteorological spacecraft) to accommodate a transponder electronics package capable of receiving the aircraft and ship emergency signals, recording the doppler signature and transmitting the data to a ground station for position location computation. Detail design studies will be conducted for the spacecraft transponder and antenna, and an improved emergency beacon. The U.S. Coast Guard and the U.S. Air Force will participate in review of these studies.

Applications Research and Technology Development (Space Communications)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Advanced communications research	1,500	400	1,900	2,100	3,900
Data management	3,000	700	3,200	3,000	2,000
Development of advanced flight experiments for communications research	100	---	100	500	300
Studies in applications of communications systems	600	200	300	300	500
Spacelab payload definition and preliminary design	200	100	500	900	500
Total	5,400	1,400	6,000	6,800	7,200

OBJECTIVES AND STATUS:

The Applications Research and Technology Development (ARTD) program consists of studies, definition and development programs, and experiments which provide new technology for public services, which would not be developed within the private sector because of high risk or high initial expense. This ARTD program can develop U.S. satellite communications technology through a vigorous effort supporting advances in commercial applications. Project objectives include: more efficient use of the available electromagnetic spectrum; expansion of communications capability into presently unused and uncluttered parts of the spectrum; development of technological solutions for radio interference problems; generation of improvements in radio-location technology for use in tracking and search and rescue; and the development of improved performance lower cost components. The spectrum efficiency and interference reduction improvements are being met by bandwidth compression techniques and new methods of forming antenna beams. Improved communications devices are being developed in the millimeter-wave band for future use and progress is being made in low cost, highly reliable, efficient communications components to operate at allocated space frequencies. All of these developments are expected to have commercial applications with high economic and public service value.

The objective of the data management effort is to extend current technology to accommodate increased volume, complexity, and the concurrent high rates of data, and to reduce origin-to-user transmission times. Users must also be provided with improved capabilities for rapidly storing and retrieving the required data products. An understanding of the current and near-term future technology exists and longer range technology needs are being analyzed.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $400 thousand in the current FY 1977 budget estimate for the Advanced Flight Experiments reflects funding for the multibeam antenna effort. The Spacelab Payload Definition and Preliminary Design budget estimate for FY 1977 has been increased by $400 thousand for the earth viewing applications laboratory effort. Both efforts were initiated after the FY 1977 budget submission.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 studies will begin on technology required for advanced communication capabilities. The need for 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. Advanced systems concepts will be studied and developed to identify the needed technological achievements. 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 serve small terminals with adequate received power will be studied.

A major effort will be made on spaceborne antenna development, the key element in providing needed services that will use small terminals. Electronically steerable, shaped beams will enhance overall communications capability, permitting new system interconnections while reducing interference and errors. Small ground-based antennas and transceivers will also be developed. High power transmitters, switches, filters and components will be studied to discover capabilities and limitations, and to permit the design of highly versatile satellite systems with simple ground receivers.

Future applications satellites are expected to have very high data rates and volumes fifteen times or more greater than those of LANDSAT-1 and -2, with stringent timeliness and accuracy requirements for delivered information products. In FY 1978, efforts will continue on modeling total data/information systems for future, likely NASA programs: to assure adequate capability, to demonstrate data compressibility (elimination of unneeded data for more cost-effective results), and to assure that advanced data technology is developed to system-ready status.

Development of an advanced multiple beam spaceborne antenna concept will be continued to provide the technology for application to a potential public service communication satellite. The laboratory equipment and tests of an adaptive digital video compressor will be completed; this compressor employes an advanced modulation technique providing about 6:1 compression ratio over conventional techniques. With emphasis on the delivery of public services via satellite, a group of systems studies will be completed in FY 1978; these will address the users' functional requirements, technical requirements (including frequency and bandwidth), system trade-offs, and cost-effectiveness.

Funds in the Spacelab Payload Definition and Preliminary Design program will be employed to complete the millimeter wave communications payload preliminary design so as to be ready for development work the following year; to continue the definition of a spaceborne interferometer for position location applications; and to continue studies of a large deployable spaceborne antenna for broadcast and public services applications.

Follow-on Data Analysis and Operations (Space Communications)

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Follow-on data analysis and operations.....	4,400	600	3,700	3,700	3,700

OBJECTIVES AND STATUS:

The objective of this project is to provide the 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. Cooperative Applications Satellite-C (CAS-C), launched in January 1976, has 16 approved experiments and the Applications Technology Satellite-6 (ATS-6) has some 30 proposals under review. Under the established procedures, the experimenter provides funding for support of his experiment; NASA funds the continued operation of the satellites, provides experiment time on the spacecraft, and technical consultation to the experimenters as required.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funding will provide for continuing support of the ATS-1, -3, and -5, experimentation and support activities for the CAS-C and ATS-6 experiments programs. Some thirty separate experiments, and fifteen to twenty ATS-6 and CAS-C support activities are anticipated. By the start of FY 1978 the CAS-C experiments program will have already been underway for a year and a half and it will continue into FY 1978 with the involvement of some twenty-five independent experiments. The third year of ATS-6 experiments with an expected complement of some twenty to twenty-five experiments will be continued into FY 1978. The ATS-6 Fourth Year Experiments Program will start early in the second quarter of FY 1978.

BASIS OF FUND REQUIREMENTS:

Applications Explorer Missions

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Heat capacity mapping mission	3,500	500	2,200	1,700	600
Stratospheric aerosol and gas experiment	2,400	1,700	6,100	4,100	2,400
Magnetic field satellite	---	---	2,000	3,500	10,200
Total	5,900	2,200	10,300	9,300	13,200
Scout (Expendable launch vehicle program)	(---)	(---)	(2,400)	(2,500)	(1,800)

OBJECTIVES AND STATUS:

The Applications Explorers program makes use of small, relatively low cost spacecraft, each dedicated to a specific mission objective, thus enabling the design of the spacecraft and the orbital parameters to be optimized to meet each objective. Included in the present program are missions to collect thermal inertia data of the earth's surface, to monitor stratospheric trace constituents, and to acquire global scalar and vector magnetic field data of improved accuracy.

Applications Explorer spacecraft have been designed to fly a wide range of Scout launch orbits. The system flexibility is such that a variety of earth observation instrument requirements can be accommodated without significant subsystem modification.

The first mission, the Heat Capacity Mapping Mission (HCMM, AEM-A), is designed to collect remotely sensed data for the development of thermal inertia maps of the surface of the earth. The predawn and early afternoon orbit was chosen so that surface temperatures near the maximum and minimum of the diurnal cycle can be measured using a thermal scanner. This data, when combined with ground truth information, will allow comparison of thermal inertia characteristics of various materials, which will lead to the identification of surface rock types. Oil and gas exploration rely substantially on identification of reservoir rock and local structures which might provide a trap for petroleum. The routing or location of major civil works, such as highways and canals, are critically dependent upon rock type identification. The feasibility of obtaining soil moisture information will also be tested. This moisture information would be a valuable input to the agro-meteorological models which are necessary to determine crop yield prediction.

Final design of the AEM-A spacecraft base module was completed and fabrication started in FY 1976. Modification of the Heat Capacity Mapping Radiometer (a spare Nimbus-5 Surface Composition Mapping Radiometer) will continue, leading to delivery of this instrument in FY 1977. In FY 1977, final assembly and checkout of the spacecraft base module and instrument module will be completed.

The second mission, the Stratospheric Aerosol and Gas Experiment (SAGE, AEM-B) to be flown on an Applications Explorer in 1979, is to develop a satellite monitoring technique to measure stratospheric aerosols and gases, map aerosol and ozone concentrations, and to investigate optical properties of aerosols and assess their effects on global climate. The presence and variations of aerosols and trace gases (e.g., ozone) in the atmosphere can have a significant influence on climate change. An understanding of the effects of this contribution is dependent upon further development of global climate theory, and on measurements sufficient to define a global data base which describes the spatial and temporal variations of the aerosols and trace gases. The orbit for this mission will enable the instrument to map stratospheric aerosols in the temperature and tropical latitudes. A similar instrument, Stratospheric Aerosol Monitor (SAM II), to be flown on Nimbus-G in the same time period will provide coverage of the polar regions. The combination of the two concurrent flights will provide the global system needed to obtain global distribution of stratospheric aerosols. An Application Explorer Mission bus will carry the experiment via a Scout-F launch vehicle to a 600-km near-circular orbit.

In FY 1976, a competitive contract for the SAGE instrument was awarded which will lead to delivery in in late 1978. Fabrication of the spacecraft bus was initiated late in the fiscal year. FY 1977 funds will be used to complete the sensor engineering model and to continue fabrication of the spacecraft bus.

The third mission, the Magnetic Field Satellite (Magsat, AEM-C), will measure the scalar magnitude and vector components of the earth's magnetic field on a global scale and with greater accuracy than previously possible. These data are needed to generate a global magnetic field map of the earth, to develop an accurate computer model of the earth's main magnetic field for the 1980-1981 time period, and to explore the feasibility of using magnetic field data for resource exploration. To date, magnetic field data use is limited by incomplete global coverage, coarse resolution, and lack of timeliness. The mission will provide the coverage and accuracies essential to generation of new models and will account for large scale field changes which amount to as much as 6 to 7 percent over a ten-year period. The U.S. Geological Survey will use the data to demonstrate the capability of using space-acquired magnetic data to meet their national commitments for periodic updating of regional and global magnetic charts. One application of the magnetic anomaly maps is in the long-range planning of mineral and hydrocarbon exploration programs. Sound knowledge of broad regional geology and geophysics is essential to mineral exploration, and this data will aid in selection of the most promising areas for future exploration. Magsat will be launched into a low elliptical orbit of approximately 325 km by 550 km by a Scout launch vehicle in late 1979. The mission duration will be limited by orbital life of the spacecraft to about eight months.

In FY 1977, development of the instruments and the attitude determination system has been started. Interface design on the instrument and the spacecraft control section will be completed during FY 1977.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

FY 1977 total funding for Applications Explorers has been reduced and adjustments in funding made among the missions as a result of the net effects of delays in initiating the base module contract (HCMM) and the instrument procurement (SAGE), and acceleration in the Magsat schedule in order to better satisfy user agency needs.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funds will provide for completion of the integration of the HCMM base module, instrument module, and spacecraft leading to a launch during the second quarter of 1978. For SAGE, the FY 1978 funds will provide for completion of the fabrication, assembly, integration and testing of the spacecraft bus and instrument. For Magsat, the FY 1978 funds will complete the integration of the control and instrument sections.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

EARTH RESOURCES OPERATIONAL SYSTEMS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Operational systems studies.....	---	---	---	200	---

OBJECTIVES AND STATUS:

The objective is to determine realistic approaches for a future operational version of a remote data sensing system based on the Landsat program. Studies will emphasize the early activities that need to be accomplished during the transition from a research and development to an operational mode.

In FY 1977, studies will be conducted on: appropriate user needs for an operational system and means of satisfying these needs; suitable space systems configurations for meeting these requirements; and approaches for developing such a system. Study areas include: system description and tradeoffs, user requirements, societal impact, data processing and distribution, resource requirements, and cost sharing.

CHANGES FROM FY 1977 ESTIMATE:

This line item was established by the Congress in the FY 1977 NASA Authorization Act to provide for early study activities that would facilitate transition of the Landsat system to an operational mode. These activities will continue beyond FY 1977 within the Earth Resources Detection and Monitoring Program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1978 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Programs	Budget Plan				
	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Aeronautical research and technology	175,350	43,800	189,100	190,100	231,000
Space research and technology	74,900	19,300	82,000	82,000	97,700
Total	250,250	63,100	271,100	272,100	328,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Research and technology base	84,659	21,035	89,700	89,140	97,550
Systems studies	2,716	560	3,000	2,935	3,000
Systems technology programs	42,251	13,084	60,800	57,145	72,200
Experimental programs	45,724	9,121	35,600	40,880	58,250
Total	175,350	43,800	189,100	190,100	231,000
Distribution of Program Amount by Installation:					
Johnson Space Center	627	85	575	810	810
Marshall Space Flight Center	780	186	800	750	950
Goddard Space Flight Center	100	---	200	100	---
Jet Propulsion Laboratory	1,295	347	1,215	915	1,000
Wallops Flight Center	415	235	365	490	500
Ames Research Center	44,132	8,201	33,708	34,026	37,700
Dryden Flight Research Center	17,181	5,347	17,015	17,863	14,250
Langley Research Center	62,053	17,836	80,309	80,355	99,950
Lewis Research Center	45,302	10,334	52,403	52,764	72,350
Headquarters	3,465	1,229	2,510	2,027	3,490
Total	175,350	43,800	189,100	190,100	231,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $1 million from the FY 1977 budget estimate for the Aeronautical Research and Technology program reflects the response to Congressional action providing additional funding for the variable cycle engine efforts. Funding adjustments between elements within the Aeronautical Research and Technology program have occurred in response to unanticipated opportunities and changing program requirements which have developed since the budget estimates were provided. More detailed explanations of significant funding changes and budget structure changes are provided under each of the individual programs involved.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, 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 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 a variety of aircraft types. 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 FY 1978 program enhances these activities in areas judged to be most critical by industry, advisory groups and other users of this technology within and outside of the Federal Government. The program places major emphasis on the aircraft energy efficiency technology efforts with initiation of the second phase of

activities on an energy efficient engine and energy efficient transport and initiation of a systems technology effort on an advanced turboprop. In the area of supersonic technology, the variable cycle engine components technology efforts have been expanded to include the design, fabrication and testing of testbed engines to assure technology readiness for a FY 1980 decision on an experimental engine program. In the area of helicopter technology, a systems evaluation of advanced technology helicopter transmission components will commence. The Rotor Systems Research Aircraft will also begin research operations. The activities associated with this activity have been incorporated into a new systems technology line entitled Rotorcraft Systems Technology. Increased emphasis will also be given to studies of the factors that influence the durability of composite materials in aircraft and engine applications under the Materials and Structures Systems Technology.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Materials research and technology	5,362	1,336	6,500	5,707	6,400
Structures research and technology	6,540	1,671	6,700	6,697	6,950
Propulsion environmental impact minimization research and technology	11,569	2,606	12,200	11,102	11,400
Propulsion components research and technology	10,352	2,636	10,000	10,721	11,300
Air breathing engine systems research and technology	7,395	1,305	7,800	6,982	6,900
Avionics research and technology	3,133	846	4,500	3,302	4,200
Fluid and flight dynamics research and technology	11,463	2,481	11,500	12,456	14,500
Low speed vehicle aerodynamics and flight dynamics research and technology	11,459	3,526	12,200	11,713	13,800
High speed vehicle aerodynamics and flight dynamics research and technology	8,894	2,251	8,900	10,881	11,700
Aircraft operations and safety research and technology	3,907	1,171	4,100	4,429	4,900
Human-vehicle research and technology	4,585	1,206	5,300	5,150	5,500
Total	84,659	21,035	89,700	89,140	97,550

Materials Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,362	1,336	6,500	5,707	6,400

OBJECTIVES AND STATUS:

The objective of this program is to provide the technology of advanced materials to enhance the safety, increase the longevity, decrease the cost, and improve the performance of civil and military aircraft.

The search for stiffer lighter-weight airframe materials has provided boron and graphite filaments for reinforcing resin or metal matrices. The efficiency and performance of turbine engines have increased as alloys capable of sustained operation to 1900° Fahrenheit have been provided. Direct powder processing and other advanced manufacturing techniques are providing lower cost turbine disks. The foreign object damage resisting characteristics of composites have been improved to a level where they can be seriously considered for turbine fan blades.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $793 thousand in Materials Research and Technology reflects an adjustment made to meet changing requirements and opportunities that have arisen within various other disciplines of the Research and Technology Base.

BASIS OF FY 1978 ESTIMATE:

Lightweight aircraft materials tasks will continue to emphasize composites with better filaments, matrices, and methods of combining the two. Hybrid composites for turbine blades will be compounded to provide increased resistance to damage by foreign objects. Studies aimed at reducing the flammability of organic materials will provide base technology for use in the Fire-Resistant Materials Engineering Systems Technology program.

Efforts to control fatigue and fracture behavior and predict useful lifetime will also be directed more toward composite materials. Computerized techniques will be applied to development and use of life prediction parameters.

Research will continue on improving the capability of high temperature materials for gas turbine blades, vanes, casings, disks, and seals. Efforts to achieve these objectives while minimizing the use of scarce alloying additions will be enhanced. Basic materials studies on understanding the strengthening and failure mechanisms of alloys, composite and ceramics will be included.

Structures Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
6,540	1,671	6,700	6,697	6,950

OBJECTIVES AND STATUS:

The objective of the Structures Research and Technology program is to improve the integrity, durability, economy, and efficiency of aircraft by providing advanced structures technology in critical technical areas.

Recent modifications to crash testing techniques will provide increased impact velocities for evaluating crashworthiness. New concepts are being evaluated for hypersonic structures, and an aeroelastic research wing has been fabricated for drone flight testing.

BASIS OF FY 1978 ESTIMATE:

Technology for advanced aircraft structures will continue to emphasize computer-aided analysis, improved crashworthiness, and hypersonic structures in FY 1978. Analytical and experimental studies of light aircraft crash damage will be augmented by development of design concepts for safer aircraft. Studies of advanced high temperature structures for hypersonic aircraft will continue.

Development of improved methods for the prediction of loads, aeroelasticity, and structural dynamics will continue to be pursued in FY 1978. Theoretical developments underway will be continued and extended in scope to provide for new technological concepts such as active controls and aeroelastic tailoring. The resulting design tools will be verified against wind tunnel model and flight test data. Existing data will be enhanced by ongoing research activities such as the Air Force/NASA B-1 flight data program and the Firebee II remotely piloted vehicle flight program.

The development of accurate life prediction methods for aircraft structures is a major part of efforts in research on structural integrity that will be continued in FY 1978. Development of analytical and predictive approaches will be verified by experimental programs.

Research will be continued on advanced composite structures for application to airframe and engine components. Laboratory studies involving improved composites and fabrication techniques will continue to be supplemented by data from several airline service evaluations of composite secondary structures. Improved concepts for turbofan engine fan blades and other components will also be investigated.

Propulsion Environmental Impact Minimization Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
11,569	2,606	12,200	11,102	11,400

OBJECTIVES AND STATUS:

The objective of the Propulsion Environmental Impact Minimization Research and Technology program is to reduce noise and exhaust emission pollutants from aircraft propulsion systems with little or no adverse impact on cost, weight or fuel economy.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $1,098 thousand results from adjustments and balancing of program efforts between the Propulsion Environmental Impact Minimization, Propulsion Components and the Air Breathing Engine Systems and other disciplines within the Research and Technology Base.

BASIS OF FY 1978 ESTIMATE:

In the area of propulsion noise reduction, basic research will be conducted to better understand the mechanisms of noise generation and suppression from pure jets, flow over surfaces, combustion, propellers, turbomachinery and of the effects of flight on noise generation and propagation. The effects of wing shielding and the processes of atmospheric noise propagation and attenuation will also be explored to arrive at more effective ways of noise control. Applied research will be performed on core noise sources, including combustors, turbomachinery and noise propagation through ducts.

Aircraft noise footprint prediction in airport areas will be further explored by developing advanced analytical techniques which incorporate state-of-the-art as well as advanced technologies. The computer program modules for each noise source will be updated as more sophisticated approaches are derived.

Efforts to reduce exhaust emission pollution from gas turbine engines will continue. Engine testing of newly developed clean combustors demonstrates favorable reductions in landing-takeoff cycle emissions for commercial wide-body jet aircraft engines utilizing these combustors. Studies will continue in exploring premixing/prevaporizing concepts, and catalytic and variable geometry combustors. Additional work will be performed in the development of advanced theoretical techniques to model chemical combustion phenomena. Research on piston engine emissions will continue with the development of high energy ignition systems and variable valve timing and the investigation of broad specification fuels.

Propulsion Components Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
10,352	2,636	10,000	10,721	11,300

OBJECTIVES AND STATUS:

The objectives of the Aeronautical Propulsion Components Research and Technology program are to increase air breathing aircraft engine efficiency and operating range, reduce fuel consumption, reduce weight, and improve reliability and durability of the many interactive components of the engine and installation. This program includes research investigations of gas path components, as well as mechanical components and fuels.

The bulk of the research emphasis for the past several years has been on energy conservation and alternative fuels. This trend continues with progress being made in the characterization of nonspecification fuels, as well as improvements to components such as seals, compressors, propellers, turbines and other components which will contribute to bringing fuel consumption down.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $721 thousand reflects the initiation of in-house research studies relating to high speed propellers and a rebalancing of program efforts between the Propulsion Environmental Impact Minimization, Propulsion Components and Air Breathing Engine Systems research and technology disciplines.

BASIS OF FY 1978 ESTIMATE:

Inlet research will extend present methods for analytically defining internal flows to include three-dimensional supersonic flows with shock waves and angle-of-attack effects. Experimental research will be conducted on inlet concepts capable of supplying the varying airflow requirements of advanced variable cycle engines. Nozzle research will provide experimental data on the heat transfer characteristics and cooling requirements of two-dimensional nozzles operating in an afterburning environment.

Fan and compressor research emphasizes the investigation of problems associated with advanced energy conservative engines, such as criteria for matching high pressure ratio stages, and limits of pressure ratio obtainable from high performance compressor stages consistent with high efficiency. Research on computational fluid dynamics applicable to fans, compressors and turbines will be continued, as well as work on the technology of very high pressure ratio, small centrifugal compressors applicable to helicopter turbine engines. Film cooling techniques for high temperature turbines will be further refined, and aerodynamic testing will take place on turbine with thermal barrier coatings on the blading.

Research programs are continuing on investigating the problems of operating a high performance combustor at the high pressures and temperatures identified with energy efficient advanced engines. A closely related program on fuels technology will continue to evaluate the properties of alternative fuels derived from coal and shale. Work will also continue on assessing the properties and systems effects of broad specification aviation turbine fuel.

Mechanical components research will emphasize improvement of gearing, seals, bearings and very high speed shafts typical of helicopter engines.

A program to advance propeller technology to the point of Mach 0.8 operation will continue, based on encouraging results obtained with scale model high speed propellers. Various propeller airfoil designs will be tested, and propeller/nacelle integration investigations will be started. Propeller acoustics research will also be continued.

Air Breathing Engine Systems
Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
7,395	1,305	7,800	6,982	6,900

OBJECTIVES AND STATUS:

The Air Breathing Engine Systems Research and Technology 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.

During FY 1977 significant progress is being made in the understanding of the aeromechanical instability phenomena in fan and compressor systems. Flight tests of a general aviation reciprocating engine equipped with a hydrogen enrichment system were completed and the first subscale aerothermal supersonic combustion ramjet module was tested in a wind tunnel.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $818 thousand reflects refinement of the estimates for ongoing in-house experimental engine research programs, as well as adjustments and balancing of research and technology efforts in Propulsion Environmental Impact Minimization, Propulsion Components, and Air Breathing Engine Systems.

BASIS OF FY 1978 ESTIMATE:

Dynamic behavior and control research will investigate the application of modern control theory to the problem of aircraft/propulsion control integration as a means of increasing engine life and improving the controllability of current and future high performance aircraft.

The joint NASA/Air Force full-scale engine research program will continue through FY 1978. Investigations of fan and compressor system aeromechanical instabilities and advanced control concepts will be completed. Evaluations of advanced concepts for performance improvement such as mixer nozzles and clearance control will be conducted during FY 1978 on a high bypass ratio turbofan engine.

Hypersonic propulsion research will include subscale hot aerothermal tests of a second generation scramjet module, and initiation of definition of an advanced hypersonic engine. The study of ramjet concepts, capable of generating static thrust, will be completed.

System studies to explore the potential performance improvements and reduced energy consumption possible in general aviation aircraft through improvements in the propulsion system will be completed in FY 1978. Advanced reciprocating and intermittent combustion engine concepts will be evaluated and preliminary design of the most promising concept will be initiated.

Avionics Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,133	846	4,500	3,302	4,200

OBJECTIVES AND STATUS:

The Avionics Research and Technology program supports the development of advanced electronics for application to both civil and military aviation. Major efforts are directed toward enhancing safety and efficiency while reducing costs through innovative developments in the areas of communication and navigation, guidance and control, and cockpit avionics.

Specifications for a highly reliable, fault tolerant computer are nearing completion while in the innovative avionics area, testing has begun on a family of new, low cost, microstrip antennas produced with the aid of recently developed computer-assisted design techniques. A low cost, automated, mid-air collision warning system is being investigated for use in uncontrolled air traffic terminal areas. Progress in automated avionics continues with the design of a dual-fail-operate inertial navigation system.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $1,198 thousand results from general realignment of in-house support activities among the research and technology base disciplines and projects.

BASIS OF FY 1978 ESTIMATE:

The current highly productive efforts in fuel-optimal guidance systems for climb, cruise, and descent will be extended to include optimization of lateral and temporal flight path components. Related efforts are directed toward the development of a full flight envelope autopilot.

Efforts in the area of innovative avionics will include experimental confirmation of recently derived antenna beam pattern theory to support current and future developments in communications systems. Also low-cost, automated mid-air collision warning system currently under development will undergo extensive field evaluation in FY 1978.

Systems definition studies to support the development of highly reliable fault tolerant computer hardware will continue in FY 1978 with both hardware and software fault compensation options under evaluation. A diagnostic emulator for software reliability assessment will also be developed.

In the automated avionics area, an integrated multifunction display will be developed featuring automatic system performance monitoring for enhanced safety and reliability.

Fluid and Flight Dynamics Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
11,463	2,481	11,500	12,456	14,500

OBJECTIVES AND STATUS:

The objective of this program is to advance understanding of aerodynamic phenomena and improve predictive capability to permit increased performance optimization of advanced aircraft during early design stages.

In accordance with this objective, integrated analytical and experimental efforts are continuing in computational aerodynamics, airfoil development, viscous drag and airframe noise reduction, stall/spin avoidance, and improved transonic test techniques.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $956 thousand supports expanded activity for study of a computer for processing complex fluid dynamics equations, acquisition of cryogenic technologies for improved wind tunnel testing capabilities, and an expansion in the flight dynamics research effort.

BASIS OF FY 1978 ESTIMATE:

A major effort is directed toward providing the capability to calculate complete flow fields and aerodynamic characteristics of complex aerospacecraft. In FY 1978, emphasis will continue to refine the transonic wing/body computational codes, investigate aerodynamic turbulence, and develop higher-order methods applicable to

complete aircraft at subsonic and supersonic speeds. Research will also concentrate on quicker and more stable numerical techniques for more efficient use of the high speed, large capacity computers in various other disciplines.

The FY 1978 airfoil development program will concentrate on the provision of the experimental characteristics of a number of theoretically-designed supercritical airfoils covering a range of thickness ratios and design lift coefficients, as well as of airfoils designed for rotorcraft, cargo transport and turbopropeller use.

Analyses and experiments will continue to pursue novel ways of reducing the turbulent drag of aerodynamic surfaces. The emphasis in FY 1978 will be placed on the investigation of the effects of surface oscillation on viscous drag. Research will also continue on methods to reduce viscous-induced airframe noise and on prediction and design techniques to avoid the lethal stall/spin problems faced by fighter and general aviation aircraft.

In addition, work will continue on the development of sophisticated flow diagnostic techniques, on new adaptive wall designs to minimize transonic tunnel wall interference effects, and on the development of magnetic suspension systems designed to operate in cryogenic tunnels for the elimination of support interference effects.

Low Speed Vehicle Aerodynamics and Flight Dynamics
Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
11,459	3,526	12,200	11,713	13,800

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 FY 1977 BUDCET ESTIMATE:

The FY 1977 decrease of $487 thousand reflects adjustments made to support increased efforts in Fluid and Flight Dyanmics, High Speed Vehicle Aerodynamics and Flight Dynamics.

BASIS OF FY 1978 ESTIMATE:

In the area of general aviation, full-scale wind tunnel tests will continue on promising wing modifications to achieve stall/spin avoidance. Flight tests will also be conducted to verify results of other wind tunnel studies indicating the effectiveness of various tail modifications in improving stall/spin characteristics.

The rotorcraft research program will include small and large-scale wind tunnel model studies of advanced rotors, including compliant and constant-lift concepts aimed at increasing rotorcraft performance and reducing vibration and noise. A large-scale research rotor, incorporating blades with the latest concepts of airfoils, camber, and twist, will be acquired for wind tunnel tests providing a tool to evaluate helicopter aeromechanic prediction methods.

In the area of advanced VTOL aircraft, wind tunnel studies will be initiated to investigate the low speed and cruise performance of advanced supersonic jet VTOL fighter/attack aircraft configurations. Studies will be continued to gain a better understanding of aerodynamic/propulsion interactions for lift-cruise fan configurations, with particular attention given to ground effects during low speed terminal area operations.

Powered-lift R/STOL aircraft research will include efforts to gain a better understanding of noise sources for upper and lower surface blown-flap concepts, and a means of reducing such noise. Wind tunnel tests integrating advanced turboprops and supercritical wings into practical aircraft configurations, potentially a promising means of reducing fuel consumption of future short-haul transports, will continue.

High Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
8,894	2,251	8,900	10,881	11,700

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 FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $1,981 thousand results from expanded in-house flight research on the F-15; increased research emphasis on nonaxisymmetric (2-D) nozzle technology; and redirection of the effort on propulsive lift enhancement.

BASIS OF THE FY 1978 ESTIMATE:

The development of complete and reliable aircraft design methodology and aerodynamic predictive techniques through evaluation of new conceptual designs and derivative cruise aircraft concepts will be advanced in FY 1978. Near-sonic oblique wing models, and supersonic and high supersonic speed models which incorporate component aerodynamic improvements such as variable camber wings, augmented-lift, and nonaxisymmetric nozzles will be tested. Range and stability improvements will 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 and range improvements to combat aircraft and missile configurations will be generated through evaluation of aerodynamic phenomena associated with high-angle-of-attack/high speed operation. Models, full-scale aircraft, and remotely piloted vehicles will be tested and resultant data compared to theory and net analytical approaches. Simulations will be programmed, using data from aircraft and missile model test results to analyze the benefit of incorporation of the advanced aerodynamic concepts on total pilot/aircraft/mission capability.

Representative hypersonic aircraft model configurations will be tested to establish a technology base for potential future aircraft.

In addition, assistance in new military development efforts through facility use, test assistance, and NASA consultatory service will continue for derivative configurations and new designs.

Aircraft Operations and Safety Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,907	1,171	4,100	4,429	4,900

OBJECTIVES AND STATUS:

The Aircraft Operations and Safety Research Technology program provides 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 improvements.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $329 thousand reflects higher than anticipated costs of in-house services for aircraft operations and safety efforts.

BASIS OF FY 1978 ESTIMATE:

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 long term process. FY 1978 research will continue the process of functionally defining atmospheric phenomena in a way that will facilitate use of this information by aircraft designers, operators, and meteorological forecasters. Characterization of wind shear, high altitude clear air turbulence, and severe storm gust front will be emphasized.

In aircraft safety technology, research is focused on developing a technology base which can be used to reduce accident opportunities and to minimize accident fatalities and damage. This effort includes in-flight

and post-crash aircraft fire prevention and protection, and lightning strike hazards reduction. In FY 1978, test and evaluation on interior aircraft cabin materials for fire worthiness will continue. Improved mathematical characterization of the fire hazard problem will provide a methodology to predict fire behavior and protection in various situations. Laser-Doppler systems will be employed in airport wind shear measurements from the ground and evaluated in flight for clear air turbulence detection and severe storm wind measurements. Ground simulations of aircraft wind shear encounters will seek definition of operational hazard boundaries. Simulation and analysis of aircraft accidents will continue in support of National Transportation Safety Board requests.

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 1978, new tire tread materials, previously evaluated on the Landing Loads Track at Langley Research Center and on the Federal Aviation Administration's Boeing-727, will be used in commercial operation for airline evaluation. Pilot-in-the-loop ground simulation of landing rollout will be refined to investigate hazardous control problems. Crosswind landing gear on the NASA Twin Otter airplane will be flight tested to demonstrate and evaluate various modes of operation.

Human-Vehicle Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
4,585	1,206	5,300	5,150	5,500

OBJECTIVE AND STATUS:

The objective of this program is to provide a research and technology base for solutions to the human factors influencing the growth, efficiency, or safety of air transportation. The program has three major areas of emphasis: human response to noise, flight management, and flight simulation technology.

During FY 1977 a number of research studies are being conducted within these major areas. Key efforts include investigations to assess the validity of laboratory experimental procedures to predict human response to aircraft noise exposure. Concepts are also being investigated that would lead to substantial reductions of aircraft interior noise levels. Several joint programs with the Federal Aviation Administration (FAA) are underway to enhance aircrew performance and alleviate the potential for human error. Among these are part- and full-mission simulation studies to assess the potential of head-up displays to aid in the transition from instrument to visual reference during landing approaches.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $150 thousand reflects lower than anticipated costs of in-house services for Human-Vehicle Technology tasks.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, the human response to noise research effort will be extended to assess the acceptability of potentially achievable future aircraft noise levels. Work will continue to improve the utility of noise exposure descriptors by taking into account the influence of ambient levels, low frequency components, and multiple noise exposure on annoyance and acceptability. Promising concepts for the attenuation of structure-borne noise transmission will be evaluated. The effects of noise on cockpit communications will also be investigated.

In a joint program with the FAA, studies will be conducted to enhance aircrew performance in future air transport systems. The occulometer and time-line analysis techniques will be evaluated as to their utility as objective methods for assessing crew performance. Studies to demonstrate the validity of alternative concepts for aircraft warning systems, such as voice warning, will be conducted. Research investigations dealing with advanced cockpit displays needed for flight management in the air traffic environment of the 1980's will continue.

In addition, flight simulation technology efforts to advance real time simulation techniques and to improve simulator fidelity will continue. Validated human-machine system models will be used to evaluate simulator performance. Refinements to improve fidelity through evaluation of motion cue substitution systems, improve logic for motion washout, and visual scene technology will be examined.

Systems Studies

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
2,716	560	3,000	2,935	3,000

OBJECTIVES AND STATUS:

System studies are conducted primarily as a means of identifying the needs for and assessing the impact of, technology advances. The objective of aeronautical system studies is to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies integrate the mutual effects of technology and a wide range of related factors.

BASIS OF FY 1978 ESTIMATE:

Studies of civil air transportation systems will emphasize the use of advanced technology for the reduction of operating and acquisition costs of transport aircraft and for the enhancement of airborne systems dedicated to cargo movement and utility missions. Specific studies will address applications of long- and short-haul air cargo vehicles, small transports for low density short-haul and commuter use, and aerial application systems. Efforts will continue in the areas of industry and market characteristics, technology-cost tradeoffs, foreign technology trends and world competition.

Studies of future military aviation systems will be responsive to expressed interests of the military services, with emphasis on vertical takeoff and landing (Navy), large cargo aircraft (Air Force), and heavy-lift hybrid airships (Navy).

Energy conservation in aeronautics will be a major objective of civil and military system studies and one of the principal factors contributing to operational cost reductions.

Systems analysis methodology and support activities will continue to emphasize air transportation demand, comparisons and integrations with other modes, and the understanding of technology transfer processes in the aviation industry.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

Systems Technology Programs

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
			(Thousands of Dollars)		
Materials and structures systems technology.....	4,235	1,650	6,400	6,480	9,060
Propulsion systems technology.....	4,300	1,224	18,000	14,120	22,150
Avionics systems technology.....	4,638	985	2,900	2,460	1,730
Aerodynamic vehicle systems technology.....	5,258	2,360	7,800	7,775	4,360
Aircraft operating systems technology.....	11,980	3,020	8,500	9,325	8,300
Human-vehicle systems technology.....	265	100	500	525	800
Advanced civil aircraft systems technology.....	7,430	3,125	16,400	11,950	21,000
Rotorcraft systems technology.....	1,922	440	---	1,900	2,900
Military aircraft systems technology.....	2,223	180	300	2,610	1,900
Total.....	42,251	13,084	60,800	57,145	72,200

Materials and Structures Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
4,235	1,650	6,400	6,480	9,060

OBJECTIVES AND STATUS:

The objectives of this program are to apply the technology from the Research and Technology Base program on materials and structures to the design of advanced airframe structures and engines and to accelerate design applications by practical demonstration of technical readiness.

Demonstration of the first group of advanced turbine engine materials will culminate with experimental engine tests scheduled for late FY 1977. Analytical studies of turbine engine flutter boundaries are underway in preparation for flutter testing.

BASIS OF FY 1978 ESTIMATE:

The Materials for Advanced Turbine Engines program involves demonstrating the potential of new turbine engine materials by obtaining engineering properties on advanced materials, followed by performance testing in test rigs and ground test engines. A second group of new materials and processes will be selected in FY 1978, contract supplements negotiated, and the efforts on scale-up, data acquisition, and engine demonstration will begin with these materials.

Integrated Program for Aerospace Vehicle Design (IPAD) is a computer software system which will aid the vehicle design process by automating and integrating many of the time consuming functions now required of the design staff, and provide a comprehensive data base for management review and control. Contractual development of IPAD will produce a preliminary computer-aided design system by the end of FY 1977, and incremental release of first-level IPAD codes will be initiated in FY 1978 for evaluation by the aerospace industry.

The Aeroelasticity of Turbine Engines program is a joint Air Force/NASA activity to provide an understanding of and prediction capability for aeroelastic instability phenomena in turbine engine fan blades. In FY 1978, the program will include fan blade testing in the flutter test rig, and continuation of studies of aeroelastic factors and aeromechanical coupling. This joint program is scheduled to produce the needed advanced design and test methods by FY 1980.

The Fire-Resistant Materials Engineering program was initiated in FY 1976 to develop fire-resistant, low-toxicity materials for use by commercial manufacturers of U.S. airliners. During FY 1978 the full scale testing of advanced wall panels for aircraft interiors will be completed and the development of fire-resistant windows and passenger seats will be emphasized. The systems testing of lavatory and cargo bay sections will be completed and the integrated cabin interior systems testing with concern for pool fire under the fuselage will be emphasized. A standardized toxicity testing procedure will be developed. The effort in FY 1978 will emphasize the transfer of technology to both the Federal Aviation Administration, through an interagency agreement, and to the U.S. aircraft manufacturers to provide for practical fire-resistant U.S. carrier aircraft in the 1980 time frame.

The factors which influence the durability of composite materials in aircraft and engine applications under long term service conditions will be studied in a Composites Durability Technology program to be initiated in FY 1978. This will include predictive methods for structural integrity and improved design concepts for long-

life airframe structures and turbojet engine components and new theoretical approaches for determining environmental effects on static and fatigue life of components with emphasis on improved resistance to moisture.

Propulsion Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
4,300	1,224	18,000	14,120	22,150

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.

Research in this area has been focused on energy conservation, general aviation propulsion, stratospheric cruise emission reduction, and helicopter transmissions.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $3,880 thousand results primarily from the cancellation of the Advanced Multistage Axial Flow Compressor program with transfer of funding to the Energy Efficient Engine program. The Energy Efficient Engine program has now been budgeted as an Experimental Program. This budget structure change is designed to provide adequate visibility to this program as it enters into Phase II in FY 1978.

BASIS OF FY 1978 ESTIMATE:

Following completion of program definition studies for the Quiet, Clean General Aviation Turbofan (QCGAT), both AiResearch and Avco-Lycoming were selected in FY 1976 to design, build, and test small experimental turbofan engines embodying advanced concepts for the reduction of noise and emissions. Engine design will be essentially completed in FY 1978, and contractor tests will be conducted prior to delivery of the engines to NASA in FY 1979.

A feasibility analysis consisting of design and economic studies will be undertaken in the Engine Component Improvement program to permit selection of the most promising candidates for improved performance. Component rig and engine ground tests will be conducted to evaluate design concepts which can be promptly introduced into production engines to reduce fuel consumption on the order of 5 percent in current commercial transports. Development work will continue in the area of engine diagnostics to identify the causes of engine deterioration and for the evaluation of methods to reduce performance degradation with time. This program is one of the elements of the aircraft energy efficiency effort.

In the stratospheric cruise emission reduction program efforts will be made to reduce exhaust emissions over the entire subsonic flight envelope. Special emphasis will be placed on achieving very low oxides of nitrogen emissions at stratospheric cruise conditions by extremely lean fuel-air mixture operation. After completion of initial basic studies the resulting combustor concepts will be integrated into engine system designs and assessed.

The variable cycle engine components technology program has been focused on development of critical technology for those novel and unique components which offer significant performance benefits combined with reduced noise and pollution characteristics. During FY 1978, two contracts will be awarded for the design and fabrication of testbed engines which incorporate this component technology. These testbeds will be utilized to demonstrate the capability to meet performance and environmental goals and to provide critical component/engine integration data. This verification of the operational potential of these advanced engine concepts will assure technology readiness for an experimental engine program in FY 1980.

The advanced turboprop system activities will be initiated and will include development, design and test effort in the areas of propeller aerodynamics, structures, and acoustics. This work will be based on the results of exploratory tests conducted in the Research and Technology Base program of previous years. The advanced turboprop design is expected to provide a 15-20 percent fuel savings over current high bypass ratio turbofan engines. This is one element of the aircraft energy efficiency technology efforts.

The helicopter transmission technology program will provide a systems evaluation of many advanced technology components which have been under investigation separately for a number of years. During the first year systems designs will be in progress, accompanied by some component testing. Examples of these components are high contract ratio gearing, traction drives, long life bearings and seals. The goal of this program is to establish a high level of confidence in the use of these advanced components in civil and military helicopter transmissions as well as in other applications requiring durable, light weight, high performance reduction gearing.

Avionics Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
4,638	985	2,900	2,460	1,730

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 avionics systems to the aircraft industry through experimental testing and verification in a realistic environment.

Currently in the Digital Fly-By-Wire (DFBW) program, initial flight demonstration tests are being conducted. In the area of advanced avionics for general aviation, the preliminary system design is underway and will be completed in July 1977.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $440 thousand reflects activities which have been deferred until FY 1978, in response to recommendations coming from the general aviation workshops.

BASIS OF FY 1978 ESTIMATE:

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 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. During FY 1978, approximately 24 flight demonstration tests will be conducted to complete the evaluation of advanced transport control laws in a representative environment.

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 FY 1978 an evaluation of the preliminary design will be completed, a system cost-benefit analysis accomplished and the final design and fabrication task initiated.

Aerodynamic Vehicle Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
5,258	2,360	7,800	7,775	4,360

OBJECTIVES AND STATUS:

The objective is overall system evaluation of advanced aerodynamic concepts for improving aircraft performance, efficiency, operating costs, safety, handling qualities, maneuverability, and other important aircraft characteristics.

BASIS OF FY 1978 ESTIMATE:

The System Technology Studies program encompasses preliminary design analysis of advanced concepts to assist in defining possible future system experimental investigations. A study of an advanced hingeless tilt-rotor concept will be completed in FY 1978.

In the Wake Vortex Minimization program, coordinated laboratory and flight investigation will continue to develop and demonstrate 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 flight research indicates that the goal of reducing the safe distance to two miles is feasible. This effort in FY 1978 will include continued 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 Airframe/Propulsion System Interactions program, flight tests will continue in FY 1978 with F-15 aircraft to obtain data specifically pertinent to a fundamental understanding of factors contributing to airframe/propulsion system interactions, especially inlet spillage and afterbody drag. This flight data will be correlated with data from previous NASA and Air Force laboratory tests using sophisticated wind tunnel 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.

In the Laminar Flow Control (LFC) program, efforts will continue on the development of technology leading to a practicable, reliable, easily maintainable LFC system. In FY 1978, the major emphasis will be on the engineering investigations, analyses, design studies and components tests necessary to evaluate alternatives in the design of LFC transports. Flight tests will be completed of various leading edge materials and devices for alleviating the insect contamination problem. Development of improved design tools will continue, and wind tunnel tests will be initiated of a large-scale model of a laminar flow wing. This program is one of the elements of the aircraft energy efficiency effort.

Aircraft Operating Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
11,980	3,020	8,500	9,325	8,300

OBJECTIVES AND STATUS:

This program will identify aircraft and flight management technology that will benefit terminal area operations for all classes of transport aircraft. Research will be conducted that will support improvements in terminal area capacity and efficiency, approach and landing capability in adverse weather, reduction of noise impact through operational procedures, and fuel conservation.

Research in previous years had identified airborne integrated flight management concepts for conventional take-off (CTOL), short take-off and landing (STOL), and vertical take-off and landing (VTOL) aircraft. These basic system concept investigations are being extended through the use of flyable hardware to systems flight evaluations and demonstrations which will serve to encourage the acceptance and application of emerging technology.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $825 thousand helped to provide for a 25-percent increase in the planned use of simulators; increased shop support required to replace the flight control computer on the Boeing-737 (Terminal Configured Vehicle) with increased capability general purpose whole word computers; and in-house fabrication of Microwave Landing Systems interface equipment.

BASIS OF FY 1978 ESTIMATE:

In the area of System Technology Studies, joint efforts with the Federal Aviation Administration (FAA) continue in two areas: (1) detailed design data development, projected life cycle cost data determination, and performance evaluation of a low cost microwave landing system avionics for low density STOL and small community business and general aviation, and (2) determination of the role of simulation technology in evaluation of failure modes in digital avionics and their effect on safety of flight.

In coordination with FAA, the Terminal Configured Vehicle program is oriented to the definition and validation of an integrated flight management system for CTOL aircraft which will meet Government and user needs while providing a tool to be used by researchers in the investigation of advanced control, guidance, and navigation concepts.

A related effort is being conducted in the STOL Operating Systems program for STOL aircraft under a joint agreement with FAA. The unique and complex performance capabilities of propulsive-lift aircraft impose unusual demands on avionics and flight control systems. This program explores advanced concepts of system integration and operation for the short-haul high performance transport.

In a joint effort with the Army, another activity involves simulation and flight experiments with airborne navigation, control, and guidance systems to evaluate and verify system technologies, criteria, and operational procedures for terminal area, transition, and cruise flight regimes of VTOL aircraft.

Human-Vehicle Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
265	100	500	525	800

OBJECTIVE AND STATUS:

The objective of this program is to reduce the occurrence of aviation incidents attributable to human error, investigate techniques and operational procedures that will ensure optimum performance in multicrew member aircraft and continue to operate an Aviation Safety Reporting System (ASRS) at the request of the Federal Aviation Administration.

In FY 1977 investigations to identify communication deficiences between air and ground personnel will continue. Analytical and experimental methods for assessing the safety contribution of new procedures and systems and the effectiveness of full mission simulation as a training technique are under investigation. A computer-based data management system is being brought on-line to aid in the analysis of safety reports.

BASIS OF FY 1978 ESTIMATE:

In FY 1978 full mission simulations will be conducted examining solutions to such problems as information transfer and decision making during low visibility approaches. ASRS will continue to be operated and new research investigations, based on problems identified from ASRS data, will be initiated.

Advanced Civil Aircraft Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
7,430	3,125	16,400	11,950	21,000

OBJECTIVES AND STATUS:

The objective of this program is to provide an integrated technology base for transport, energy efficient, and agricultural vehicles which includes the interactive effects of the various disciplines including 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 FY 1977 BUDGET ESTIMATE:

The FY 1977 reduction of $4,450 thousand results from the transfer of the Variable Cycle Engine Components Systems Technology project to the Propulsion Systems Technology line item and transfer of hypersonic research to the Military Aircraft Systems Technology program.

BASIS OF FY 1978 ESTIMATE:

System Technology Studies for civil passenger and cargo transports are performed to quantify technical advances that improve aircraft efficiencies, noise, emissions, and terminal area operation. Studies will include an assessment of the benefits that large cargo aircraft with span distributed load wings, liquid hydrogen aircraft, and better terminal area operation could have on future transport systems. System studies will be initiated in FY 1978 to investigate the application of advanced technology to the design of improved energy efficient and agricultural aircraft. Emphasis in the studies will be on lower initial and operating costs while maintaining safety, dependability and environmental compatibility. Factors limiting the precision and efficiency of the airborne distribution of chemicals and fertilizers in agriculture will also be analyzed to determine the most promising approaches to their solution. Baseline data will be generated on current aircraft and distribution equipment. Analytical studies, wind tunnel tests, and flight evaluations will be undertaken on equipment modifications that hold promise for rapid implementation by industry. Instrumentation requirements for necessary flight test evaluation and distribution system performance assessments will be identified.

In the YF-12 Flight Experiments program, NASA YF-12 aircraft will continue to be 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, engine, and flight control systems.

In the area of Energy Efficient Transport, work will continue on the development and evaluation of advanced aerodynamics and active controls technology for near-term application to derivative or new transport aircraft. In FY 1978, efforts will continue on expansion of the existing data base for high aspect-ratio supercritical wings, including evaluation of engine/airframe integration and improved high-lift devices. Investigations leading to reliable, maintainable, cost-effective implementation of active controls systems will be pursued. A major effort in FY 1978 will consist of conceptual studies of a high-aspect-ratio version of an existing wide-body transport, using active controls to obtain increased aerodynamic efficiency without a corresponding structural weight penalty. This program is one of the elements of the aircraft energy efficiency technology efforts.

In the Advanced Medium Short Take Off and Landing Transport (AMST) Aircraft and operating Systems Technology program work will continue on the development and evaluation of advanced powered-lift systems applicable to potential future civil short-haul transport developments. In FY 1978, NASA will continue its use of the AMST prototype aircraft for in-flight research during Air Force's AMST development program. The FY 1978 program will consist of technology experiments in the discipline areas of aerodynamics, structures, propulsion, acoustics, light dynamics, handling qualities, wake vortex, and avionics.

Rotorcraft Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
1,922	440	---	1,900	2,900

OBJECTIVES AND STATUS:

The objective of this technology program is to conduct broad-based research on promising rotorcraft systems for use in future civil and military applications. The major areas of concern are rotorcraft structural systems; propulsion; guidance, control and navigation; advanced rotor system concepts; and advanced concepts for vibration and noise reduction. The program involves coordinated research efforts in analysis, model testing, simulation, large-scale wind tunnel testing and flight testing of rotorcraft and subsystems. A key element in the program is the verification of analytical design methods by ground-based and in-flight experiments.

The Rotor Systems Research Aircraft (RSRA) is currently undergoing ground and flight testing at Sikorsky Aircraft under a joint NASA/Army contract. In addition, rotor system design studies have been completed which will provide the necessary information for the selection of the initial research rotors to be tested on the RSRA.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

This line item was added to the budget structure to provide increased visibility and emphasis on rotorcraft technology. The Rotor Systems for the Rotor Systems Research Aircraft project, previously budgeted under the Aerodynamic Vehicle Systems Technology line item, is combined with RSRA operations funding to form the new line item called Rotorcraft Systems Technology.

BASIS OF FY 1978 ESTIMATE:

The Rotor Systems Research Aircraft will be delivered to NASA in FY 1978. Under the Rotor Systems Research Aircraft Operations program, NASA and the Army will begin operations in late FY 1978. The first portion of the RSRA flight program will be devoted to developing testing techniques with the versatile vehicles. This testing will be done on the delivered, baseline, S-61 rotor system and will provide important data for preliminary correlation with available analytical methods relating to performance, flying qualities, vibration, stability and control, and maneuvering capability.

In the Rotor Systems for the Rotor Systems Research Aircraft program, the primary effort in FY 1978 will be to continue the preliminary design analyses and key concept assessment experiments on several rotor concepts offering promise for improved efficiency, performance, vibration, noise and maintainability, as a basis for selecting a research rotor system on which to begin detailed design in FY 1979, for flight validation on RSRA. Advanced rotor systems which have been studies to date in this program include the aeroacoustic, variable geometry, bearingless composite structure, and flexhinge rotor concepts.

Military Aircraft Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
2,223	180	300	2,610	1,900

OBJECTIVE 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. These programs are implemented through cooperative and/or joint Department of Defense/NASA technical efforts.

The joint USAF/NASA Transonic Aircraft Technology (TACT) F-111A program completed the initial validation of supercritical wing technology through wind tunnel testing and flight testing which ended in June 1976. These results were widely disseminated through program reviews with industry, airlines and universities. Based on the recommendations obtained during these reviews, an 18-month aerodynamic expansion program has been initiated to acquire detailed information in the research areas of vortex and wake flow and other interacting aerodynamic flow regions.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $2,310 thousand reflects the transfer of Hypersonic Research from the Advanced Civil Aircraft Systems Technology line item and increased in-house effort in support of scramjet and configuration testing at the Langley Research Center.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, the TACT 1/12 scale dynamic model wind tunnel test will be completed, wind-tunnel and flight test data evaluated and correlated, program results documented, and a major portion of the aerodynamic expansion program completed.

The ongoing activity in the hypersonic area will continue to evaluate the needs, technology readiness and expected benefits of a potential flight research program.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

EXPERIMENTAL PROGRAMS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
			(Thousand of Dollars)		
Composite primary aircraft structures	3,995	1,660	16,000	14,890	25,150
Energy efficient engine	2,010	706	---	6,440	18,500
Quiet propulsive lift technology	10,885	425	1,700	1,700	1,900
Quiet, clean short-haul experimental engine	10,000	2,050	3,300	3,250	600
Supersonic cruise aircraft research	8,834	2,090	8,000	8,000	9,000
Tilt rotor research aircraft	2,000	290	800	800	300
Rotor systems research aircraft	3,100	100	300	300	---
Highly maneuverable aircraft technology	4,900	1,800	5,500	5,500	2,800
Total	45,724	9,121	35,600	40,880	58,250

Composite Primary Aircraft Structures

19/6 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
3,995	1,660	16,000	14,890	25,150

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 future transport aircraft. The weight savings of composite materials will provide a 10-15 percent fuel savings as part of the aircraft energy efficiency technology efforts. The cost economy and long term reliability and maintainability of composites will be demonstrated by designing, fabricating, testing, certificating and installing composite components on scheduled airline aircraft.

Two of the component programs are currently underway. In the first, ten DC-10 rudder segments are being installed to initiate the flight phase of the program. The second component, the L-1011 vertical fin, has achieved 100-percent design release and is in the test verification phase of the program.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The decrease of $1,110 thousand reflects a $1 million transfer of funds between elements of the aircraft energy efficiency effort, i.e., the Composites Primary Aircraft Structures program and the Laminar Flow Control program which is carried in the budget under the Aerodynamic Vehicle Systems Technology line item. This shift of funds was made because of procurement delays in the Composite Primary Aircraft Structures program coinciding with increased requirements in the Laminar Flow Control program for systems design and concept evaluation.

BASIS OF FY 1978 ESTIMATE:

A total of six composite components, three secondary and three moderate size primary components, will be developed as part of this effort. The first ten DC-10 rudders will continue in commercial airline flight service. The L-1011 vertical fin program will achieve critical design review in FY 1978. The remaining four components will be designed and test verification programs will begin.

The objective of the wing effort is to design, fabricate, test, certificate, and fly a wing on a commercial transport aircraft. Three study contracts will be completed in FY 1978 that will evaluate structural concepts, support component definition, and define flight requirements for the development phase.

Energy Efficient Engine

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
2,010	706	---	6,440	18,500

OBJECTIVES AND STATUS:

The Energy Efficient Engine program is directed toward the development and demonstration of the technology base for achieving significant reductions in both engine specific fuel consumption and direct operating cost as compared to current high bypass ratio turbofan engines.

The ongoing Phase I portion of the program consists of engine definition studies, enabling technology development, and the detailed design of components for the core and turbofan engine. Contracts have been awarded to the two major commercial engine manufacturers, General Electric and Pratt and Whitney Aircraft, to conduct a preliminary engine design and perform engine/airframe integration studies. By the end of FY 1977, the basic features of the energy efficient engine, such as its thrust, size, thermodynamic cycle, and component configuration, will be defined.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The Energy Efficient Engine program has absorbed the funding of the advanced multistage axial flow compressor project and has been transferred from Propulsion Systems Technology to the Experimental Programs category. This budget structure change is designed to provide adequate visibility to the program as it enters into Phase II in FY 1978.

BASIS OF FY 1978 ESTIMATE:

Phase II of the Energy Efficient Engine program, to be initiated in FY 1978, will continue the refinement of the engine design. All components for the core will be fabricated and rig tested at full scale to demonstrate

performance. The engine core will be designed, fabricated, assembled, and tested. Modifications to the core will be made by incorporating new technology from ongoing component development work. All technologies will be integrated and demonstrated in a core/low spool system test. In FY 1978, fabrication of all components for rig testing will continue and performance evaluation tests will start. This program is one of the elements of the aircraft energy efficiency technology efforts.

Quiet Propulsive Lift Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
10,885	425	1,700	1,700	1,900

OBJECTIVES AND STATUS:

The objective of the program is to generate and verify a design and certification technology data base for efficient, quiet, short-haul transports with short takeoff and landing capabilities. Propulsive-lift offers the most effective means of accomplishing this objective and offers potential for airport congestion relief, community noise reduction and operational improvements for civil and military transports. Research includes experiments in aerodynamics, propulsion, handling qualities, noise, flight control systems, information displays and operations.

The Boeing Commercial Airplane Company was awarded a contract in February 1976 for the design, fabrication and test of one Quiet Short-Haul Research Aircraft. Preliminary design of the research aircraft is complete.

BASIS OF FY 1978 ESTIMATE:

The Quiet Short-Haul Research Aircraft (QSRA) program was initiated in FY 1974 to obtain, in a flight research environment, quiet propulsive-lift design and operational technology data for design and certification criteria for use in development of future quiet short-haul transport aircraft. Fabrication and vehicle assembly will take place during FY 1977. The FY 1978 program activity will involve aircraft rollout, ground tests, contractor flight substantiation and delivery to NASA for initiation of the flight test and research program. The Air Force, Federal Aviation Administration, and industry will participate with NASA in the flight research and experiments program.

Quiet, Clean Short-Haul Experimental Engine

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
10,000	2,050	3,300	3,250	600

OBJECTIVES AND STATUS:

The objective of this program is to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered-lift short-haul aircraft. The QCSEE program includes the design, fabrication and testing of two experimental turbofan propulsion systems, suitable for "under-the-wing" and "over-the-wing" externally blown-flap powered-lift aircraft installations.

The "under-the-wing" propulsion system was installed and tested at the General Electric Company test facility following completion of fabrication in July 1976. This test program demonstrated structural integrity and verified capability to meet performance, noise and pollution goals prior to delivery to NASA. A similar test program is in process on the "over-the-wing" propulsion system.

BASIS OF FY 1978 ESTIMATE:

The contractor test program on the "over-the-wing" propulsion system will be completed in early FY 1978. Following delivery of this propulsion system to NASA, the contractor will provide engineering support for continuing NASA tests of both propulsion systems with appropriate wing/flap sections throughout the remainder of the fiscal period.

Supersonic Cruise Aircraft Research

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
8,834	2,090	8,000	8,000	9,000

OBJECTIVES AND STATUS:

The objectives of this program are 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.

Design studies of the several configurations using either of the two candidate variable cycle engine concepts indicate long range flight capabilities between 4000-5000 nautical miles with no fuel consumption penalty in supersonic operation and a 20-30 percent reduction in subsonic fuel consumption while still meeting all noise and pollution design goals.

BASIS OF FY 1978 ESTIMATE:

The three design study concepts, each having different configurations and cruise Mach number, can integrate the variable cycle engine without serious performance penalties and no loss in environmental compliance. Detailed analysis and refinement efforts begun in FY 1977 will be completed in FY 1978. These studies focus on problem areas, identification of technology unknowns, provide sensitivity and trade-off comparisons and provide direction to discipline research activities.

The emphasis in propulsion in FY 1978 continues to be directed to low emission combustion concepts and verification of the coannular noise effect in large scale hardware at forward velocity.

Aerodynamic studies of improved aircraft planforms for achievement of optimizations in subsonic, transonic and supersonic flight regimes will continue through extensive wind tunnel testing and refinement. Wing-body blending studies will continue as a means to reduce aircraft drag and reduce gross weight. Structural refinement and design improvement of the four configurations will continue in FY 1978.

Composite material formulation and long life cycle testing of structural panels to the 50,000-hour duration will be continued. Superplastic forming and diffusion bonding techniques developed in the B-1 program are being studied in detail with initiation of a program planned in FY 1978 directed to application of this technique to large aircraft components providing both weight reduction and manufacturing cost savings. Flutter analysis of all configurations will continue with emphasis on weight reduction and suppression by design techniques.

Electronic control technology is required for this class of aircraft and will be used in all flight regimes for control of systems, the aircraft, and as a means of reducing adverse loads on the aircraft structure. The YF-12 aircraft will be utilized in FY 1978 as a basis for design and flight testing of advanced titanium structures and for proof-of-concept demonstration and testing of integrated control techniques.

Tilt Rotor Research Aircraft

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,000	290	800	800	300

OBJECTIVES AND STATUS:

The objective of this joint NASA/Army program is to develop a research aircraft to perform proof-of-concept and advanced flight research investigations. 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 (TRRA) is currently under going ground tests at Bell Helicopter Textron in preparation for the start of contractor flight tests prior to delivery to the Ames Research Center.

BASIS OF FY 1978 ESTIMATE:

The Tilt Rotor Research Aircraft (TRRA) program was initiated at Ames Research Center in FY 1973. The first of two research aircraft is scheduled for delivery in FY 1978. During the joint NASA/Army proof-of-concept flight testing, NASA and Army project pilots will explore and expand all areas of the flight envelope including the conversion corridor between hover and forward flight operation. The investigation will also include evaluations of operational flight characteristics, limitations, environmental characteristics, gust sensitivity and safety aspects of Tilt Rotor Vertical/Short Takeoff and Landing (V/STOL) flight.

Rotor Systems Research Aircraft

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
3,100	100	300	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 first of the two aircraft began contractor flight tests in October 1976. The second aircraft is in the final assembly and instrumentation phase.

BASIS OF FY 1978 ESTIMATE:

The Rotor Systems Research Aircraft (RSRA) program was initiated at Langley Research Center in FY 1973. Following aircraft ground tests, flight substantiation tests of the basic aircraft and research subsystem will be conducted during the remainder of FY 1977 and in the first half of FY 1978. This will be followed by a series of research investigations to verify analytical prediction methods in the areas of rotor performance, stability and control, and dynamics.

Highly Maneuverable Aircraft Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)		
4,900	1,800	5,500	5,500	2,800

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 for the design of future vehicles. The program will provide two unmanned, subscale, remotely piloted low cost flight research vehicles which will be extensively flight tested. 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. The Preliminary Design Review was held in May 1976 and the Critical Design Review in December 1976. During FY 1977, the subscale flight research vehicle parts will be fabricated and assembly will commence.

BASIS OF FY 1978 ESTIMATE:

With the completion of assembly scheduled for early FY 1978, the vehicles will be delivered early in the second quarter of the Fiscal Year. After extensive ground checkout, the flight research activities will commence in mid-FY 1978.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Research and technology base	60,560	15,745	62,100	61,610	65,900
Systems studies	2,025	325	1,600	2,000	2,000
Systems technology programs	2,020	645	3,100	3,080	5,800
Experimental programs	4,195	1,085	6,900	7,010	15,000
Low cost systems program	6,100	1,500	8,300	8,300	9,000
Total	74,900	19,300	82,000	82,000	97,700
Distribution of Program Amount by Installation:					
Johnson Space Center	754	176	1,410	937	2,040
Marshall Space Flight Center	2,044	479	2,389	3,865	4,870
Goddard Space Flight Center	5,293	1,376	8,162	5,947	7,000
Jet Propulsion Laboratory	17,680	5,146	17,927	20,426	19,500
Wallops Flight Center	55	15	55	55	---
Ames Research Center	8,221	1,876	8,890	7,909	9,200
Dryden Flight Research Center	770	---	---	---	200
Langley Research Center	17,845	4,603	19,685	20,684	28,400
Lewis Research Center	18,785	4,874	20,493	18,786	23,400
Headquarters	3,453	755	2,989	3,391	3,090
Total	74,900	19,300	82,000	82,000	97,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

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 FY 1977 BUDGET ESTIMATE:

There were no changes from the FY 1977 budget estimate for the Space Research and Technology program as a whole. However, funding adjustments did occur between individual programs within the Space Research and Technology program. These adjustments were 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 changes are provided under each of the individual programs involved.

BASIS OF FY 1978 ESTIMATE:

A strong research and technology effort will be maintained in the disciplinary areas of materials, structures, fundamental electronics, guidance and control, information systems, chemical and electric propulsion, energy systems and aerothermodynamics to meet the needs of current and future space activities. Systems Studies will be pursued to investigate future space mission alternatives and to identify and evaluate the technology requirements of future missions. Systems Technology efforts will continue toward extending the temperature limits for composite materials to allow their use on advanced space transportation systems; providing a "no-moving-part" data storage system for aerospace vehicles; developing multipurpose user-oriented software technology to reduce future software development costs; and the demonstration of the technology readiness of an advanced planetary orbiter spacecraft propulsion system which utilizes high performance space-storable fluorine-hydrazine propellants. In Experimental Programs, under the Space Technology Shuttle/Spacelab Payloads program fabrication of the Long Duration Exposure Facility (LDEF) will be completed and experiment integration and acceptance testing initiated; development of experiments to be flown on early Space Shuttle and Spacelab missions will be continued; and development of experiments which will utilize the Shuttle orbiter as a research vehicle to advance multidisciplinary technology areas will be initiated. In the Low Cost Systems area, the FY 1978 emphasis will be to develop and improve various standard spacecraft components.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Materials research and technology	6,843	1,733	8,700	7,211	7,200
Structures research and technology	6,124	1,537	5,500	6,044	6,100
Fundamental electronics research and technology	4,535	1,155	5,000	4,427	4,500
Guidance and control research and technology	3,180	870	3,500	3,447	3,500
Information systems research and technology	5,306	1,440	5,200	5,564	6,200
Chemical propulsion research and technology	8,020	2,125	8,300	7,191	8,100
Electrical propulsion research and technology	5,445	1,510	5,200	5,694	6,300
Space energy systems research and technology	7,129	1,735	7,800	8,574	9,600
Nuclear energy research and technology	2,221	380	2,000	1,112	1,500
High power lasers and energetics research and technology	5,184	1,710	5,200	6,428	6,600
Entry research and technology	6,573	1,550	5,700	5,918	6,300
Total	60,560	15,745	62,100	61,610	65,900

Materials Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
6,843	1,733	8,700	7,211	7,200

OBJECTIVES AND STATUS:

The objective of this program is to provide basic materials science and advanced materials technology necessary for more efficient, lower cost spacecraft structures, thermal protection systems, and power systems for future Earth orbiting and planetary vehicles.

Thermal control studies in white paints, heat pipes, and second-surface mirrors are well advanced. Reentry thermal protection systems have reached a highly developed state.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $1,489 thousand reflects lower than anticipated costs of services in support of the in-house materials research efforts, as well as the balancing of program funding between the Materials and Structures and among the other disciplines within the Research and Technology Base.

BASIS OF FY 1978 ESTIMATE:

Research, basic to this program, will continue to emphasize thin radiation resistant metal oxide semiconductor (MOS) materials and high temperature superconductors. Basic studies on the nature of solids and their surfaces will be continued in order to increase the performance and efficiency of such materials as composites and high temperature alloys.

Applied materials studies will focus on metal matrix composites for use in lightweight space structures. The properties of advanced composites, such as aluminum or glass matrices containing glass coated fibers, will be explored. Studies on bearings, seals and lubricants will be continued. High pressure seals for liquid oxygen or hydrogen and solid lubricants which can withstand the rigors of orbital cruise and reentry heating will be developed.

Control of environmental effects will emphasize thermal control technology. A cryogenic diode heat pipe will be space flight tested. Development of advanced heat pipe concepts will be continued. Second-surface mirrors and thermal control coatings will be developed for flight testing on Shuttle-launched missions, including the long duration exposure facility (LDEF).

The technology of thermal protection materials for earth reentry and planetary entry of spacecraft will be continued. Evaluations of current reusable surface insulation and protective coatings stable up to 2800 degrees Fahrenheit (^{o}F) will be completed. In addition, studies of new systems, such as semirigidized alumina and mullite, and coatings stable to over 3000°F will be conducted.

Structures Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
6,124	1,537	5,500	6,044	6,100

OBJECTIVES AND STATUS:

The objective is to advance structures technology to facilitate the development of new or improved classes of space vehicles to meet future mission needs involving expanded orbital operations and more cost effective space transportation.

Current activities have produced a new concept for stackable tubes that would increase the packaging density for launch of large space structures components, promising high temperature sandwich panels for advanced space transportation systems, and technology for payload dynamic environments and test requirements.

CHANGES FROM 1977 BUDGET ESTIMATE:

The FY 1977 increase of $544 thousand reflects higher than anticipated costs of services in support of the in-house research efforts as well as the balancing of program funding between the Structures and Materials line items.

BASIS OF FY 1978 ESTIMATE:

The principal emphasis in the advanced space structures effort will be placed on concepts and materials applications for erecting very large structures in space. This activity will include evaluation of various combinations of materials and structural configurations which can provide dimensional accuracy and stability in the space environments and be compactly packaged for launch to orbit. Activities will continue in the investigation of lightweight composite pressure vessels and development of optimum composite structures for various propulsion applications.

In the area of vehicle design methods, research efforts will be continued in FY 1978 to improve structural analysis programs, entry thermal protection structures, design of composite space structures, and fracture control methods. The effort will include improvements for the NASA Structural Analysis (NASTRAN) program, evaluation of advanced high temperature structures in thermal/structures test facilities, and design and fracture control methods for lightweight composite and metallic structures.

The structural dynamics effort in FY 1978 will aim at improving the analytical prediction methods for the dynamic response of space transportation vehicles, payloads, and large space structures. Current activities in coupled body dynamics, payload environment simulation, and more cost-effective testing procedures development will continue. Effort will also be directed to the area of dynamic structure-control interaction methodology in support of large space structures technology activities.

Fundamental Electronics Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
4,535	1,155	5,000	4,427	4,500

OBJECTIVES AND STATUS:

The objective of the Fundamental Electronics program is to provide advanced high resolution sensors and detectors for increasing the efficiency of data acquisition, electronic components for advanced onboard data preprocessing and storage, and large-scale integrated microcircuit arrays for reliable operational low-cost electronic systems.

In FY 1977, the first 400 x 400 charge-coupled device (CCD) array was used to observe the planet Uranus and surface features were detected that have never been seen before. The first 128 kilobit CCD memory was fabricated and evaluated for future use on an orbiting telescope. A novel laser probe was tested for detecting faults in large-scale integrated circuits and remote sensing on oceanographic turbidity has been made feasible using laser methods.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $573 thousand reflects the net effect of a transfer of funds for development of onboard data processors and correlators using charge-coupled-device technology to the Information Systems line item, and lower than anticipated costs of in-house services in support of the fundamental electronics research and technology efforts.

BASIS OF FY 1978 ESTIMATE:

New technologies are being investigated to improve the efficiency of both terrestrial and extraterrestrial data acquisition systems. In FY 1978, millimeter and submillimeter wavelength technology will be developed for detecting and measuring low concentration stratospheric constituents and pollutants. Intensified charge-coupled device technology will be evaluated to optimize the observations of remote star fields. A tunable detection system for analyzing atmospheric constituents will be advanced as a potential experiment for a future Space Shuttle mission. In addition, an advanced 800 x 800 charge-coupled-device array camera system will be developed for higher resolution imaging.

Electronic devices to improve systems performance and reduce costs are being investigated for application to future aerospace missions. In order to reduce data acquisition costs by a factor of 10, cooled and uncooled infrared devices, detector arrays and improved multispectral detectors are being developed. Techniques for increasing the density of magnetic "bubble" devices will be investigated. Integrated optics technology is being advanced for low power, high speed, data processing with direct optical coupling from camera systems.

Solar cell research is designed to investigate high efficiency, radiation resistant, light weight, low cost solar cells. Research on superconducting devices will have as its main thrust the production of high speed, high sensitivity detectors and circuits.

Reproducible, long-life, economical, large-scaled integrated circuit arrays are being evolved by providing design and test software and procedures; proving process feasibility and demonstrating software and equipment; correlating yield, performance and process parameters; creating controlled processing equipment sources; implementing a controlled processing facility and demonstrating processing techniques; and conducting feasibility studies and engineering evaluations of hybrid techniques. Packaging integrity of microcircuits and inspection techniques are being investigated. Technology to circumvent failures in electronic

circuits and to maximize tolerance to radiation and other space environment factors is being developed, using chemical and electrical diagnostic measurements applied to test wafers or chips from selected wafer processing lines.

Guidance and Control Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,180	870	3,500	3,447	3,500

OBJECTIVES AND STATUS:

The purpose of this program is to develop components and techniques which will lower the life cycle costs and improve the performance of spacecraft attitude control systems, provide precise pointing of experiments, improve the accuracy of space navigation, and permit autonomous operation of spacecraft, robot vehicles and experiments in space.

BASIS OF 1978 ESTIMATE:

Guidance and control research emphasizes new concepts and components which promise reduced costs and increased mission capability. Development of long life attitude control system technology in FY 1978 will emphasize programmable attitude controllers with fault tolerant capability, and noncontacting signal and power transfer devices. Fabrication of an engineering model of a magnetically suspended high accuracy experiment pointing mount will be completed. An engineering model of the Long Life Reaction Wheel concept will be demonstrated and aircraft flight testing of a video-inertial pointing system for infrared telescopes will be completed.

Advanced navigation techniques are being developed to reduce costs and increase the scientific return from missions to outer planets. During FY 1978 optimized maneuver strategies will be implemented for planetary orbiters and multiple planet rendezvous. A prototype autonomous onboard navigation system software breadboard model will be completed. A high resolution laser gyro attitude sensor will undergo laboratory test and evaluation.

Work will begin on determining approaches for applying machine intelligence techniques to reduce costs and increase productivity of future NASA missions. The integrated robotic test facility at the Jet Propulsion Laboratory (JPL) will be used to test out promising automated approaches. University studies of automated problem systems and scene interpretation techniques will be continued in FY 1978.

Information Systems Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,306	1,440	5,200	5,564	6,200

OBJECTIVES AND STATUS:

The objective of the Space Information System program is to provide, through research, design, and experiment 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 FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $364 thousand reflects the transfer of funds for development of onboard data processors and correlators using charge-coupled-device technology from the Fundamental Electronics line item.

BASIS OF FY 1978 ESTIMATE:

The high capacity data systems efforts are aimed at providing design data and techniques which will permit construction of reliable, high speed, high capacity data processing systems. In FY 1978, construction of a ground-based Synthetic Aperture Radar (SAR) processor unit, using charge-coupled-device technology, will be initiated. A prototype version of a unified data system based on microprocessor technology will be constructed. This data system has application to planetary and earth observations missions. Fabrication of a parallel image processing system capable of processing all points of an image simultaneously at an effective bit rate of 10^{11} per second, will also be started. This system will be used to process data generated in earth resources and any other image sensing missions.

The microwave data transfer efforts are aimed at the design of increasingly reliable spacecraft communications systems and components for multimission use. In FY 1978, a new diagnostic technique will be developed for determining the group velocity, size, and spread (axial and radial component) of the electron beam in submillimeter and millimeter tubes. This information on electron velocity and size are essential if power amplifiers operating at 45 Gigahertz (GHz) and 85 GHz are to be developed. Work on Surface Acoustical Wave (SAW) S-band oscillators operating at 2.2 GHz and the development of the prototype Ku-band modulator exciter will be completed.

The high rate data transfer and tracking activity is focused on the development of laser technology. In FY 1978, an engineering model of a space-borne high precision laser receiver and short pulse laser transmitter will be completed. These two space qualified items are the key components in a 2-centimeter precision ranging system planned for the space shuttle in support of the Office of Applications, Earth and Ocean Physics Program.

Chemical Propulsion Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
8,020	2,125	8,300	7,191	8,100

OBJECTIVES AND STATUS:

The objective of this program is to advance the technology of high thrust chemical propulsion systems in order to significantly reduce the development, production and operations costs and improve the performance capability of future space vehicles.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $1,109 thousand results from a transfer of research tasks to the High Power Lasers and Energetics line item in the areas of atomic and metallic hydrogen research; generation and storage of excited states of matter; and in advanced energy conversion techniques. This transfer was made to place related areas of fundamental research in a single program.

BASIS OF FY 1978 ESTIMATE:

The advanced 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. Component technology for small oxygen-hydrogen propulsion systems designed for reusable orbital transfer vehicles has been completed and the work is now focused on the technology of mixed mode propulsion system concepts which have applicability to most future vehicles of interest. This effort is building on and making use of the component technology successfully completed under the reusable oxygen-hydrogen propulsion program. In FY 1978, work will continue in the general areas of high density propellant characterization, including slush and triple point cryogens, combustion, heat transfer and cooling studies for both bipropellant and tripropellant modes of operation; and expansion nozzle configurations designed to maximize specific inpulse over a variety of operating and environmental conditions.

The long life space storable propulsion technology program is directed towards component technology for a fluorine-hydrazine propulsion system that would provide a 25-percent increase in specific impulse performance over current state-of-the-art planetary spacecraft propulsion systems and an extended lifetime capability of five years or more. In FY 1978 this work will continue to focus on flight weight component 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 in NASA missions. During FY 1978, work will continue in the areas of heat sterilizable propellants; long term propellant storability; high performance, lightweight motors; and on an advanced detonation propulsion concept for use in dense planetary atmospheres.

Basic research will be continued to expand understanding of the chemical and physical processes that occur in rocket propulsion systems. Work in these areas in FY 1978 will include studies of combustion and expansion losses to improve efficiency; determination of physical, kinetic and transport properties of liquid propellants, fluid flow and film cooling in porous media, solid propellant polymers and viscoelastic properties; and behavior of fluids in a zero-gravity environment.

Electrical Propulsion Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,445	1,510	5,200	5,694	6,300

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 FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $494 thousand reflects higher than anticipated costs of services in support of in-house electrical propulsion research efforts.

BASIS OF FY 1978 ESTIMATE:

In the area of auxiliary electric propulsion, a 20,000-hour, 5,000-cycle endurance test of a one millipound engineering model thrust system initiated in FY 1977 will continue in FY 1978. This test simulates operation of the ion engine system in a representative type of satellite north-south station keeping application. In addition, modifications of this engine to accommodate both higher and lower thrust levels (0.5 and 2.0 millipounds) will be continued.

In the area of primary solar electric propulsion, the 15,000-hour endurance test of a 30-millipound engineering model ion engine will be continued. Performance evaluations and packaging studies of a functional model power processor will be completed in FY 1978 and the results incorporated into the engineering model power processor. In FY 1977, a root section of the Solar Electric Propulsion (SEP) solar array successfully completed a zero-gravity deployment and retraction test in a KC-135 aircraft. The design evaluation test program is scheduled to continue into FY 1978. The fabrication of the full-scale wing (12.5 kilowatts, 4 x 32 meters), started in FY 1977, is scheduled for delivery in FY 1978.

A continuing basic technology effort supports the auxiliary and primary electric propulsion efforts by providing a better understanding of the processes limiting life and efficiency. Work continues on exploring various potential applications of ion beam technology. Experiments in the areas of sputter deposition, milling, and texturing applications will continue.

Space Energy Systems Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
7,129	1,735	7,800	8,574	9,600

OBJECTIVES AND STATUS:

The objective of this program is to provide the technology for high power and long life space energy systems at reduced cost and improved energy and power densities.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $774 thousand reflects a transfer of technology tasks and funding from the Nuclear Energy line item in the area of thermionic energy conversion. This transfer was made to place related areas of energy conversion technology for space power in a single program.

BASIS OF FY 1978 ESTIMATE:

Work on solar cells and arrays will emphasize low-mass high end-of-life efficiency for the cells and high power density for arrays. The improved understanding of radiation damage and design features for high efficiency being achieved in current programs will continue to be advanced. In addition, initial fabrication of thin solar cells and other critical components necessary for the attainment of a 200-watt per kilogram solar array design in the 100-kilowatt range will be carried out.

Advanced battery component technology efforts aimed at light weight, low cost, nickel and cadmium electrodes, cases, and separators will be continued toward the goal of doubling life and power density of nickel cadmium batteries. An evaluation of cell protection electronics and pulse charging techniques to increase battery reliability and life will be completed in FY 1978. Fuel cell tests will continue to stress reliable operation with reactant-grade propellants at low pressure aimed at systems advantages of shared propellants.

Preliminary design of an automatically managed power system and evaluation of power system sensors will be completed by FY 1978. Analytical models developed for the spacecraft charging investigation, aimed at providing design criteria, techniques, and test methods to insure control of charging of spacecraft surfaces, will be correlated with test data from the Air Force Spacecraft Charging at the High Altitudes (SCATHA) satellite to be launched in CY 1978.

In the area of thermal-to-electric energy conversion, mini-Brayton (0.5-2.0 kilowatt) components delivered to the Energy Research and Development Administration will be ground tested with simulated electric heaters. The larger (2-15 kilowatt) Brayton rotating unit test will be continued towards the goal of 50,000 hours of operation. High efficiency thermoelectric materials for use in radioisotope thermoelectric generators will be evaluated. Efficient long life thermionic converters will continue to be evaluated during FY 1978.

Nuclear Energy Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,221	380	2,000	1,112	1,500

OBJECTIVES AND STATUS:

The objective of this program is to provide, through basic physics research on fission-heated gases and plasmas and through technological experimentation, the essential knowledge and information needed for the design on gaseous fuel nuclear reactors for major advances in space power and propulsion.

In FY 1977, reactor criticality experiments were completed with uranium hexafluoride for the establishment of reactor control capabilities.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 decrease of $888 thousand primarily reflects a transfer of technology tasks and funding to the Space Energy line item in the area of thermionic energy conversion. This transfer was made to place related areas of energy conversion technology for space power in a single program.

BASIS OF FY 1978 ESTIMATE:

The main thrust of plasma cure reactor research is directed toward a benchmark gaseous fuel nuclear reactor experiment, utilizing reactor components salvaged from the previous NASA nuclear rocket program. The principal objective of effort in FY 1978 is the demonstration of sustained nuclear chain reactions in the reactor with flowing gaseous uranium hexafluoride fuel.

High Power Lasers and Energetics Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
5,184	1,710	5,200	6,428	6,600

OBJECTIVES AND STATUS:

The objective of this program is to provide, through basic scientific research in plasmadynamics, magnetics and cryophysics, fundamental photonics, high power lasers and their applications, the knowledge needed for major advances in the generation, transmission, and utilization of energy in space.

In FY 1977 the volumetrical pumping of nuclear energized gas lasers was demonstrated using the fission of helium isotopes into energetic protons and tritons at interactions with neutrons.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $1,228 thousand stems from a transfer of tasks and funding from the Chemical Propulsion line item in the areas of atomic and metallic hydrogen research; generation and storage of excited states of matter; and advanced energy conversion techniques. This transfer was made to place related areas of fundamental research in a single program.

BASIS OF FY 1978 ESTIMATE:

The area of plasmadynamic energy systems includes research on the heating of plasmas to millions of degrees Kelvin and investigation of advanced forms of energy conversion including magnetohydrodynamic (MHD) generators. The techniques of using superconducting magnets will be investigated.

In magnetics and cryophysics, superconductive materials and magnets are under development for uses in space energy systems. Cryogenic cooling by means of magnetic heat pumping will remain a continued research effort as well as the development of a large 30-Tesla cryogenic magnet. Research on methods to use ultracold superfluid helium in spacecraft is included, as is the investigation of atomic and metallic hydrogen.

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. Among other fundamental investigations, the direct conversion of fission fragment energy into coherent light in fissioning uranium hexaflouride will be attempted and the coupling of electron beams with laser beams.

In high power laser systems technology research, the study of a continuously operating closed-loop laser will be expanded 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, and the conversion of laser energy to electrical energy or directly to propulsive forces will be studied.

Entry Research and Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
6,573	1,550	5,700	5,918	6,300

OBJECTIVES AND STATUS:

The objective of this program is to provide an understanding of entry aerothermodynamic problems associated with earth orbital and planetary atmospheric vehicles in order to improve the operational efficiency and reliability of these vehicles.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $218 thousand supports expanded in-house efforts to establish research and technology for shuttleborne aerothermodynamic experiments.

BASIS OF FY 1978 ESTIMATE:

In the area of advanced Earth-orbital transportation aerothermodynamics, analytical and experimental studies will be made of configuration concepts that utilize technologies advanced beyond the base being established by the space shuttle. Specific studies will be directed toward solution of the aerothermodynamic problems associated with these concepts in such areas as aerodynamic performance, viscous interaction and real gas effects, vortex interaction, heat transfer, basic configuration shaping and optimization. Computational flow field methods will be developed with emphasis on realistic configurations, and technique for configurational design and analysis will be upgraded as required.

The planetary probe design effort supports NASA scientific missions to study the atmospheres of Mars, Venus, the outer planets and certain natural satellites such as Titan. 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. In this program new turbulence models appropriate for high speed flight will be developed; the effect of moderate to massive ablation rates on heat transfer and transition will be investigated; the effect of radiative cooling, equilibrium and nonequilibrium radiation on the flow field will be investigated; and the real gas aerodynamics and ablative products radiative properties will be defined.

As in previous years, the Space Shuttle aerothermodynamics effort will support the space shuttle by providing extensive use of NASA ground-based facilities and expertise and by continued in-house shuttle technology and development studies as required by the Office of Space Flight.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SYSTEMS STUDIES

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,025	325	1,600	2,000	2,000

OBJECTIVES AND STATUS:

The objectives of 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 FY 1977 BUDGET ESTIMATE:

The FY 1977 increase of $400 thousand reflects additional efforts on studies of technology relevant to possible future global service space systems and industrialization in space.

BASIS OF FY 1978 ESTIMATE:

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; the process of ordering and prioritizing these options; and the potential opportunities for major new initiatives from the Research and Technology Base activity providing systems technology and flight experiments.

The FY 1978 program will continue to develop the technology themes of exploration, global service, industrialization and space transportation. Of these, the OAST approach to industrialization technology through lunar resource utilization will be expanded beyond the limited studies initiated in 1977. Global services technology will proceed with continuing emphasis on geosynchronous platforms with added consideration to payload elements. Transportation studies will move from survey and requirements of orbital transfer systems to evaulation of selected configurations. The exploration technologies theme will continue the FY 1977 study efforts such as space-based extrasolar planetary search; space-based antenna systems for the Deep Space Network; radio astronomy uses, including search for extraterrestial intelligence; and further study of lunar and planetary sample characterization and/or recovery. Advanced concept development studies are intended to continue serving as a basis for modeling future technology needs and requirements.

Technology-specific studies will seek to further complete the cataloguing of technology available, planned and forecast both within and external to the NASA. Continuing studies of technology seek to rank options and to develop strategies for the attainment of long range goals through application to near-term missions. Special study emphasis will be given to key technology issues (e.g., automation, large structures, cryogenic systems, dual fuel propulsion, end-to-end data management and kilowatt/megawatt power sources) to evolve or further develop system technology programs.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Materials and structures systems technology	550	330	1,500	1,510	4,000
Guidance, control and information systems technology	700	315	900	870	1,000
Propulsion and power systems technology	---	---	700	700	800
Entry systems technology	770	---	---	---	---
Total	2,020	645	3,100	3,080	5,800
Materials and Structures Systems Technology					
	550	330	1,500	1,510	4,000

OBJECTIVES AND STATUS:

The objective is to demonstrate the validity of advanced materials and structures technologies to facilitate early transfer to application in space systems design. Critical system applications are selected for design, fabrication, and laboratory testing. Space flight experiments are considered if necessary and appropriate.

The Composites for Advanced Transportation Systems (CASTS) program, initiated in FY 1976, has progressed to the selection of two polyimide composite systems and initiation of the first fabrication technology study for evaluation of the techniques required to produce reliable 600-degrees Fahrenheit structures. The Shuttle component to be fabricated and tested later in the program has been selected.

BASIS OF FY 1978 ESTIMATE:

In the system technology studies area, the technology for advanced space structures will be explored.

The CASTS program is underway to develop a practical polyimide resin composite airframe with a capability for operating at 600°F. In FY 1978, the major emphasis will be on thermal/structural tests of elements to develop preliminary design allowables and preliminary design and analysis of the full-scale component for laboratory test and on development and evaluation of reliable graphite/polyimide fabrication techniques.

Guidance, Control and Information Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
700	315	900	870	1,000

OBJECTIVES AND STATUS:

The objective of this program is to integrate advanced electronic devices or system concepts with appropriate supporting technology and demonstrate improved performance, increased reliability and reduction in cost of spacecraft guidance, control and information systems.

Development of a solid-state data storage system using magnetic "bubble" domains as the storage media was initiated in FY 1976. Fabrication of an engineering model 10^8 bit recorder will be completed in July 1977.

BASIS OF FY 1978 ESTIMATE:

In the Solid-State Data Recorder area, test and evaluation of the engineering model solid-state recorder will be completed in the first quarter of FY 1978. Development of a fully operational recorder will follow, leading to completion of testing and qualification to flight standards by the end of FY 1978.

Software support tools identified in the FY 1977 software technology program will be developed during FY 1978 under the Multipurpose User-Oriented Software Technology program. Emphasis will be placed on automated verification and validation techniques and a generalized compiler writing system capable of automatic conversion of user-specific software into the particular assembly language of designated flight computers.

Propulsion and Power Systems Technology

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
---	---	700	700	800

OBJECTIVES AND STATUS:

The objective of this program is to demonstrate technology readiness of advanced space propulsion and power systems by conducting tests of complete systems assembled from advanced technology components already demonstrated under the Research and Technology Base 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 1978 ESTIMATE:

The goal of the Long Life Chemical Propulsion program is to design, fabricate, assemble and test a near flight weight advanced planetary orbiter spacecraft propulsion system, utilizing high performance space storable fluorine-hydrazine propellants under simulated space vacuum conditions by FY 1980. The objective is to demonstrate overall propulsion system performance and operation, and establish handling, safety and launch operation procedures. The FY 1978 work will include completion of preliminary design and analysis efforts to define the propulsion system configuration and to establish component operational requirements; the initiation of component procurement; and the establishment of a test plan and test procedures. Final systems design and component fabrication will be completed in FY 1978 and verification testing in FY 1979.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

EXPERIMENTAL PROGRAMS

Space technology shuttle/spacelab payloads.....	4,195	1,085	6,900	7,010	15,000

OBJECTIVES AND STATUS:

The objective of this program is to provide the capability to extend Research and Technology programs into space when that unique environment is essential to a continuing investigation, when in-space experimentation is cost-effective, when a space demonstration will accelerate the utilization of advanced technology, or when the opportunity to exploit the routine operation of a space system for research arises. The program provides for the definition, development, and management of experiments, payloads, and facilities which capitalize on the capabilities of the Shuttle and Spacelab.

BASIS OF FY 1978 ESTIMATE:

The Long Duration Exposure Facility (LDEF), the passive, free-flying satellite designed to accommodate a large number of exposure type experiments, is under fabrication, and will be a major element of one of the Shuttle orbital flight test missions. Seven experiments have been selected for development and additional experiments will be selected as a result of the first LDEF Announcement of Opportunity issued in late FY 1976. These experiments will be selected for development in FY 1977, with experiment integration and acceptance testing initiated in FY 1978 and completed in mid-CY 1979. Fabrication and assembly of the LDEF will be completed in early FY 1978 and installation of the experiment trays is scheduled for completion in early CY 1979. Mission analysis and flight operation procedures will be established in FY 1978 in preparation for a CY 1979/80 flight on an orbital flight test.

The system design study for a potential Advanced Technology Laboratory experiments and equipment to demonstrate technology in space is near completion. The payload concepts are being utilized as the basis for the development of mission management and operations precepts. This program also supports the development of flight experiments which are candidates for Shuttle orbital flight test missions and the early Spacelab missions. Several such experiments were selected as a result of the Spacelab-1 Announcement of Opportunity, including two lubrication experiments, and a zero-g spherical fluid flow experiment. The Drop Dynamics Module previously selected is also a candidate for this and subsequent Spacelab missions. A contamination monitor is being developed to verify the environment near the Orbiter vehicle and this hardware is being provided for flight on the Spacelab-1 mission.

A Technology Workshop was held in April 1976 to identify opportunities to advance technology in several disciplines using the Shuttle Orbiter as a research vehicle during routine launch and entry operations. As a result of this workshop, over 100 experiments were identified. Definition studies of some of the more promising of these experiments will be completed in FY 1977, and development will be initiated in FY 1978. Two experiments which are compatible with this method of research were identified at the Technology Workshop in August 1975 and are currently under development. These experiments will measure lee-side flow fields and heating, and free stream flow fields during Shuttle reentry.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

LOW COST SYSTEMS PROGRAM

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Low cost systems program.....	6,100	1,500	8,300	8,300	9,000

OBJECTIVES AND STATUS:

The Low Cost Systems Program was established to prescribe approaches toward further 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 further reducing the cost of space systems 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 six subcategories: Electrical Power; Auxiliary Propulsion; Stabilization, Guidance and Control; Communications and Data Handling; Payload Instrumentation; and Ground Support Equipment.

To date, 17 components have been declared standard. These have concentrated on the spacecraft maintenance functions. Included are tape recorders, hydrazine thrusters and valve assemblies, solar cells specification, Nickel-Cadmium (NiCd) battery and cell specification, power regulator, spacecraft computer, dry gyro inertial reference unit, pyrotechnic initiator, transponders, star tracker, reaction wheel, telemetry and command components and a pyrogen igniter. Currently under evaluation are 24 additional standards. These include not only components for spacecraft maintenance functions, but also apply the standard equipment concept to the experiment and instrument interface support equipment and ground support equipment areas. Items under

evaluation are in areas such as solar cell panel, central power regulator, sun sensors, solid state star tracker, magnetometer, universal articulation system, magnetic bubble memory, phased array antenna, instrumentation modular electronics, common sensor subsystem, test sets, spacecraft checkout system, and spacecraft simulator.

As standard hardware becomes available, flight projects are able to obtain flight qualified hardware which is significantly less expensive than in the past. Standard hardware is now being utilized in the Mariner Jupiter/Saturn 1977, TIROS-N, Nimbus-G, Seasat, Stratospheric Aerosol Gas Experiment, and Solar Maximum Mission projects.

BASIS OF FY 1978 ESTIMATE:

In FY 1978, 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 will include: solar array panels, power processing components, universal articulation system, data storage and communication components, modular electronics for payload instrumentation, and ground test and checkout equipment.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF ENERGY PROGRAMS

ENERGY TECHNOLOGY APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Energy Technology Applications...	5,900	1,500	---	6,000	4,500
Distribution of Program Amount by Installation:					
Johnson Space Center.....	404	225	---	1,300	500
Marshall Space Flight Center.....	902	122	---	1,400	600
Goddard Space Flight Center.....	340	---	---	---	---
Jet Propulsion Laboratory.....	2,732	619	---	1,155	800
Ames Research Center.....	75	239	---	100	100
Dryden Flight Research Center....	20	---	---	---	---
Lewis Research Center.....	1,383	269	---	2,000	2,500
Headquarters.....	44	26	---	45	---
Total.....	5,900	1,500	---	6,000	4,500

OFFICE OF ENERGY PROGRAMS

ENERGY TECHNOLOGY APPLICATIONS

PROGRAM OBJECTIVES AND JUSTIFICATION:

The technology developed in the Aeronautics and Space programs conducted by NASA holds potential for significant contributions to the solution of energy problems on Earth. The Energy Technology Applications program provides an effective method of using the capabilities of NASA as it carries out its primary responsibilities.

The program has two primary thrusts: (1) Energy Technology, specifically designed to use NASA-developed aerospace technologies, experience and facilities to support the energy program needs of the Energy Research and Development Administration (ERDA) and other government agencies; and (2) Energy Systems (Use of Space), designed as a joint study effort with ERDA to fully understand how the unique characteristics of the space environment and our ability to operate successfully in space may be used to help solve energy needs on Earth and in space.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

Direct R&D funding for these activities was not requested in NASA's FY 1977 budget submission to the Congress. NASA planned to continue to apply its expertise and capabilities in these areas by conducting research and development projects as requested and funded by the Energy Research and Development Administration and other agencies. Subsequent Congressional action on the Agency's FY 1977 budget provided direct funding to NASA for both technology identification and verification "seed money" activities and a joint ERDA/NASA Solar Satellite Power Systems definition effort.

BASIS OF FY 1978 ESTIMATE:

During FY 1978, NASA's Energy Technology efforts will continue to focus on those selected areas of emphasis which show the most potential for technology advancement. For example, NASA will maintain its program responsibilities to ERDA in the areas of solar heating and cooling, wind energy, and photovoltaics (solar cells). Negotiations are in process for major activity in advanced ground propulsion. Efforts are also continuing in the areas of gas turbines, energy conversion, fuel cell systems, energy storage systems, and advanced coal extraction techniques. The primary emphasis in Energy Systems will be to complete an initial technical systems definition activity.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Operations	192,536	50,400	206,800	203,600	229,900
Systems Implementation	39,043	10,700	42,500	42,700	42,500
Advanced Systems	9,221	2,300	8,700	8,700	9,300
Total	240,800	63,400	258,000	255,000	281,700
Distribution of Program Amounts by Installation:					
Marshall Space Flight Center	---	9	---	---	---
Goddard Space Flight Center	168,279	43,909	181,900	177,300	199,700
Jet Propulsion Laboratory	52,489	14,641	54,800	55,300	57,200
Wallops Flight Center	4,700	1,023	4,800	5,000	5,200
Dryden Flight Research Center	2,267	831	2,500	3,000	3,300
Headquarters	13,065	2,987	14,000	14,400	16,300
Total	240,800	63,400	258,000	255,000	281,700

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 conditions; (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 (as shown in Figure 1), 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.

To meet the support requirements levied by the wide variety and number of flight projects, NASA has established two types of facilities to meet the needs of the two basic classes of NASA flight missions. These two types of facilities include the Spaceflight Tracking and Data Network (STDN), which supports

NASA TRACKING AND DATA ACQUISITION NETWORK

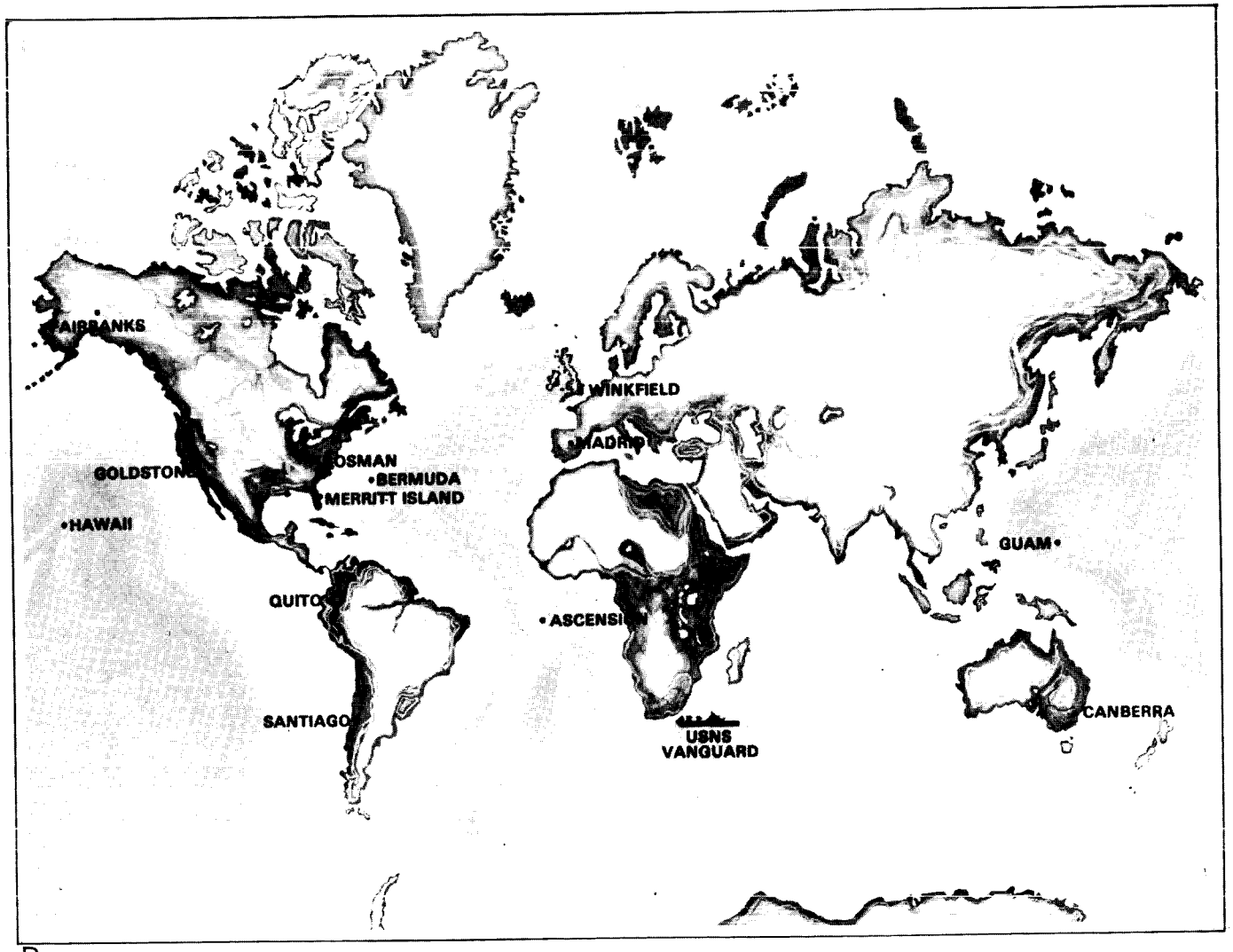


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FIGURE 1

earth orbital scientific and applications programs, and the Deep Space Network (DSN), which supports planetary and interplanetary flight missions.

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 FY 1977 BUDGET ESTIMATE:

The decrease in the FY 1977 budget estimate reflects congressional authorization action reducing the tracking and data acquisition budget request by $3.0 million. The impact of this reduction was moderated by foreign currency devaluations in Australia and Spain. Program support adjustments were also made, which permitted the temporary deactivation (wet storage) of the instrumented tracking ship, USNS Vanguard, and staffing decreases at the Alaska tracking station.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

OPERATIONS

The FY 1978 funding requirements are based upon a continuing support workload for an average of approximately 60 automated earth-orbiting and planetary missions. The operations funding will also provide for the pre-launch support activity required for upcoming approved missions. The increase in the FY 1978 funding request for Operations is due to the reactivation of the USNS Vanguard for critical mission support, the operation of the five new laser systems in support of NASA's Earth and Ocean Dynamics Program, control center operations for upcoming approved missions, and the continuing effect of escalation in all areas of operations.

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
		(Thousands of Dollars)			
Spaceflight tracking and data network.....	98,189	25,600	108,800	105,500	122,300
Deep space network.....	40,309	11,000	43,000	41,800	46,800
Aeronautics and sounding rocket support.....	3,865	1,000	4,200	4,500	4,600
Communications.....	26,535	6,400	26,000	26,000	28,300
Data processing.....	23,638	6,400	24,800	25,800	27,900
Total.....	192,536	50,400	206,800	203,600	229,900

Spaceflight Tracking and Data Network Operations

	98,189	25,600	108,800	105,500	122,300

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 network provides launch support to NASA's automated planetary missions, as well as the spaceflight missions of other nations, commercial firms, the Department of Defense, and other 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 Earth and Ocean Dynamics Programs. Figure 2 shows a mobile laser station of the STDN.

The thirteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; Quito, Ecuador; Winkfield, England; and Madrid, Spain. A transportable station, which was previously located near St. John's, Newfoundland, for Skylab and Apollo Soyuz Test Project support, has been refurbished and relocated at NASA's Dryden Flight Research Center (DFRC), Edwards, California, for support of the Shuttle Approach and Landing Tests scheduled to begin in 1977.

The Spaceflight Tracking and Data Network is currently providing support for an average of nearly 50 automated applications and space science spacecraft. Examples of the more significant missions being supported include two Earth Resources Technology Satellites (Landsat 1 & 2), four Applications Technology Satellites (ATS 1, 3, 5, & 6), two Interplanetary Monitoring Platform Satellites (IMP 7 & 8), the Orbiting Solar Observatory (OSO-8), Orbiting Astronomical Observatory (OAO-3), Radio Astronomy Explorer (RAE-2), Atmosphere Explorers (AE 3 & 5), Nimbus 4, 5, & 6, and Geodynamics Experimental Ocean Satellites (GEOS 2 & 3). The network is also continuing to receive valuable scientific data from the five Apollo Lunar Surface Experiment Packages (ALSEP) placed on the Moon's surface during the Apollo program.

Upcoming missions to be supported by the network include the High Energy Astronomical Observatories (HEAO), the International Ultraviolet Explorer (IUE), the Heat Capacity Mapping Mission (HCMM), the International Sun Earth Explorers (ISEE), Seasat-A, and Landsat-C. The overall workload of the Spaceflight Tracking and Data Network is projected at an average of approximately 50 spacecraft during FY 1978.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The downward adjustment of $3.3 million in FY 1977 results from the placing of the USNS Vanguard in wet storage, support reductions at the Alaska station, and foreign currency fluctuations and devaluations in Australia and Spain. The support reductions (USNS Vanguard and Alaska) are temporary in nature due to the increased risk to and potential loss of data from both upcoming missions and the general support workload.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 funding requirements for the Spaceflight Tracking and Data Network operations provide for the maintenance and operation of the network and mission control 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 1977 to FY 1978 is due in part to significant escalation in both labor and logistics costs throughout the network.

MOBILE LASER STATION

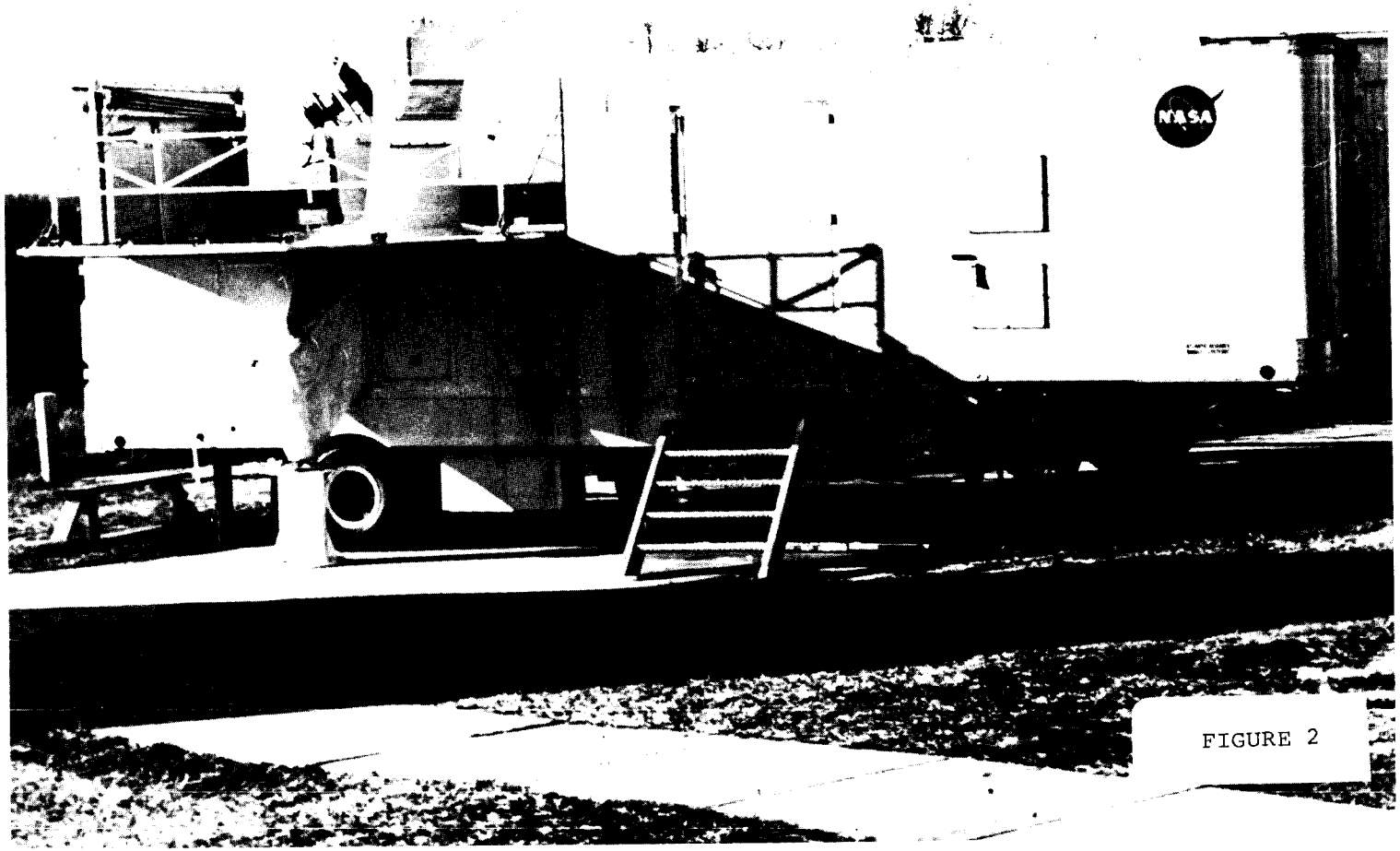

FIGURE 2

Additional costs will be incurred because of reactivation of the USNS Vanguard for critical launch support in FY 1978 and the staffing and operation of five additional laser systems for NASA's Earth and Ocean Dynamics Programs. Cost increases are also being experienced in the control center complex at GSFC where software preparation and staffing buildups are underway to support the upcoming International Ultraviolet Explorer (IUE), International Sun Earth Explorers (ISEE), and Seasat-A mission.

Deep Space Network Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
40,309	11,000	43,000	41,800	46,800

OBJECTIVES AND STATUS:

The primary function of the Deep Space Network (DSN) is to support planetary and interplanetary space flight missions. The Deep Space Network provides the vital two-way communication link by which the distant spacecraft are controlled and scientific data are acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems, software programs, and operational techniques that push the state of the art in telecommunications.

The Deep Space Network stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The stations consist of one 64-meter and two 26-meter diameter antennas at each location. 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. Figure 3 shows the 64-meter facility at Goldstone.

The current workload in the DSN consists of the six ongoing Pioneer spacecraft (Pioneer 6-11), the four Viking spacecraft, (two orbiters and two landers), and the two Helios missions. Support of these missions will continue during FY 1978.

Of the Pioneer spacecraft, Pioneer 10 is already over 1.7 billion kilometers from Earth and is proceeding on a path that will take it beyond 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, some 600 million kilometers from Earth, is also being tracked during its journey to the planet

64 METER DIAMETER ANTENNA

GOLDSTONE, CALIFORNIA

FIGURE 3

Saturn which it is scheduled to fly by during the third quarter of 1979. The Pioneer 6-9 spacecraft are provided support for coverage of special events such as solar conjunction. The two Helios missions are continuing their orbit about the Sun as they gather data on the solar plasma.

During the prime mission phase of Viking, the DSN supplied the most complex, intensive and successful support ever provided to a planetary mission. Working with the two Viking orbiters and two landers at a distance of approximately 350 million kilometers from earth, and with a round trip signal time of some 40 minutes, the DSN provided continuous support for approximately four months sending tens of thousands of commands and receiving imaging data at rates of up to 16,000 bits per second for extended periods of time. Having completed the prime mission phase, the two Viking missions are now in an extended mission phase requiring less intensive support by the DSN.

Taking advantage of a rare alignment of the outer planets Jupiter and Saturn, two Mariner-class spacecraft are scheduled for launch in 1977 and preparations are underway in the DSN to provide the necessary support. These support preparations require thorough and complex planning, since the implementation and operations for the Mariner Jupiter/Saturn mission (MJS 1977) must be carried out at the same time that the network must support the extensive ongoing workload described above. Also, as is typical of planetary missions, the two Mariner spacecraft will require support for several years during their flight to Jupiter and Saturn.

The Deep Space Network facilities are also used for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The 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 1978, support of these radio astronomy experiments will continue on a noninterference basis to the flight missions.

In addition to Mariner Jupiter/Saturn 1977 missions, the upcoming DSN workload also includes preparation for support of the two Pioneer Venus missions, scheduled for launch in 1978. Pioneer Venus will consist of an orbiting spacecraft around Venus and a second spacecraft carrying four separate probes which will descend into the Venusian atmosphere to collect data. These missions will require intensive support during the planetary encounter phase, particularly as the probes penetrate into the Venusian atmosphere.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The decrease of $1.2 million from the budget estimate to the current FY 1977 funding level is due to foreign currency fluctuations and devaluations in Spain and Australia.

BASIS OF FY 1978 ESTIMATE:

Deep Space Network operations funds provide for the contractor maintenance and operation of the network facilities, logistics costs, and network support and engineering costs associated with the operation of the network. The funds requested for FY 1978 are based upon the ongoing workload, including the Pioneer spacecraft, the Viking and Helios extended missions, and the Mariner Jupiter/Saturn 1977 missions. The two Pioneer Venus missions to be launched in 1978 will require extensive prelaunch engineering support, especially in preparation for the precision tracking of the entry probes during their descent through the dense Venusian atmosphere. This intensive workload, along with continuing escalation, is the basis for the increased funding level in FY 1978.

Aeronautics and Sounding Rocket Support Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,865	1,000	4,200	4,500	4,600

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 Dryden Flight Research Center. These instrumentation systems include general purpose tracking, telemetry, data handling, and communications systems, as well as special purpose optical equipment. Figure 4 graphically shows an aerial view of the Wallops support complex.

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 1978. 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 Dryden Flight Research Center (DFRC) operates the Aerodynamic Test Range, consisting of facilities at DFRC 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

WALLOPS FLIGHT CENTER
INSTRUMENTATION FACILITIES

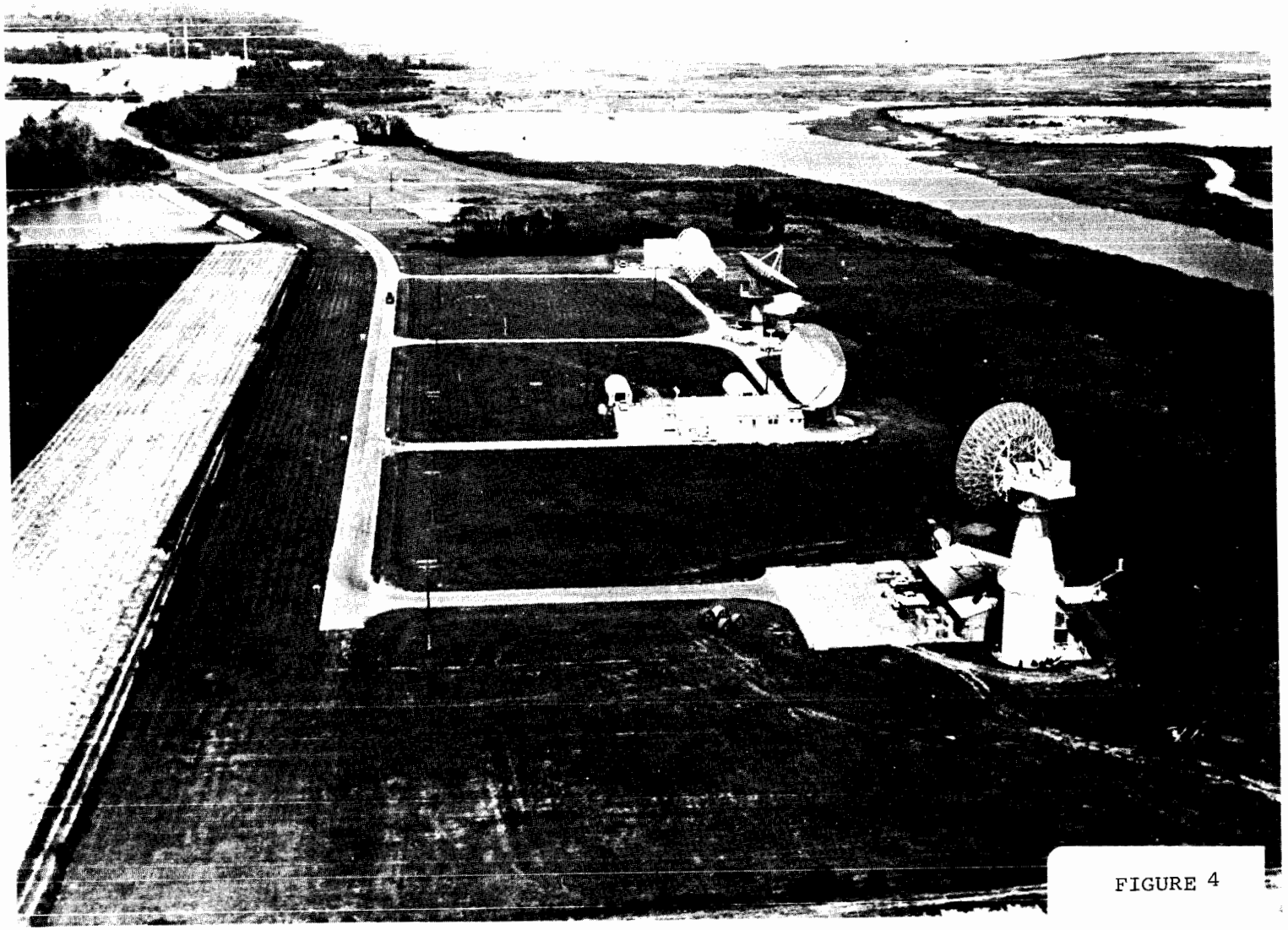

FIGURE 4

and development programs of both NASA and the Air Force. Various aircraft 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 Approach and Landing Tests which will be initiated at the Dryden Flight Research Center in 1977.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The $300 thousand increase from the budget estimate to the current FY 1977 funding level is due primarily to an increase in operations requirements for support of the Space Shuttle Approach and Landing Tests.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 budget request covers the funding requirements for support of the sounding rocket launches and the Aerodynamic Test Range activities. The request also includes the anticipated effect of escalation and the necessary resources to support the Shuttle Approach and Landing Tests at the Dryden Flight Research Center.

Communications Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
26,535	6,400	26,000	26,000	28,300

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM) interconnects by means of leased voice and data circuits the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the 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. Figure 5 is a pictorial representation of the NASCOM.

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 onboard experiments. In addition, there is a requirement to provide increasing amounts of experiment data more quickly to the users for analysis.

NASA TRACKING, DATA ACQUISITION, AND COMMUNICATIONS NETWORK

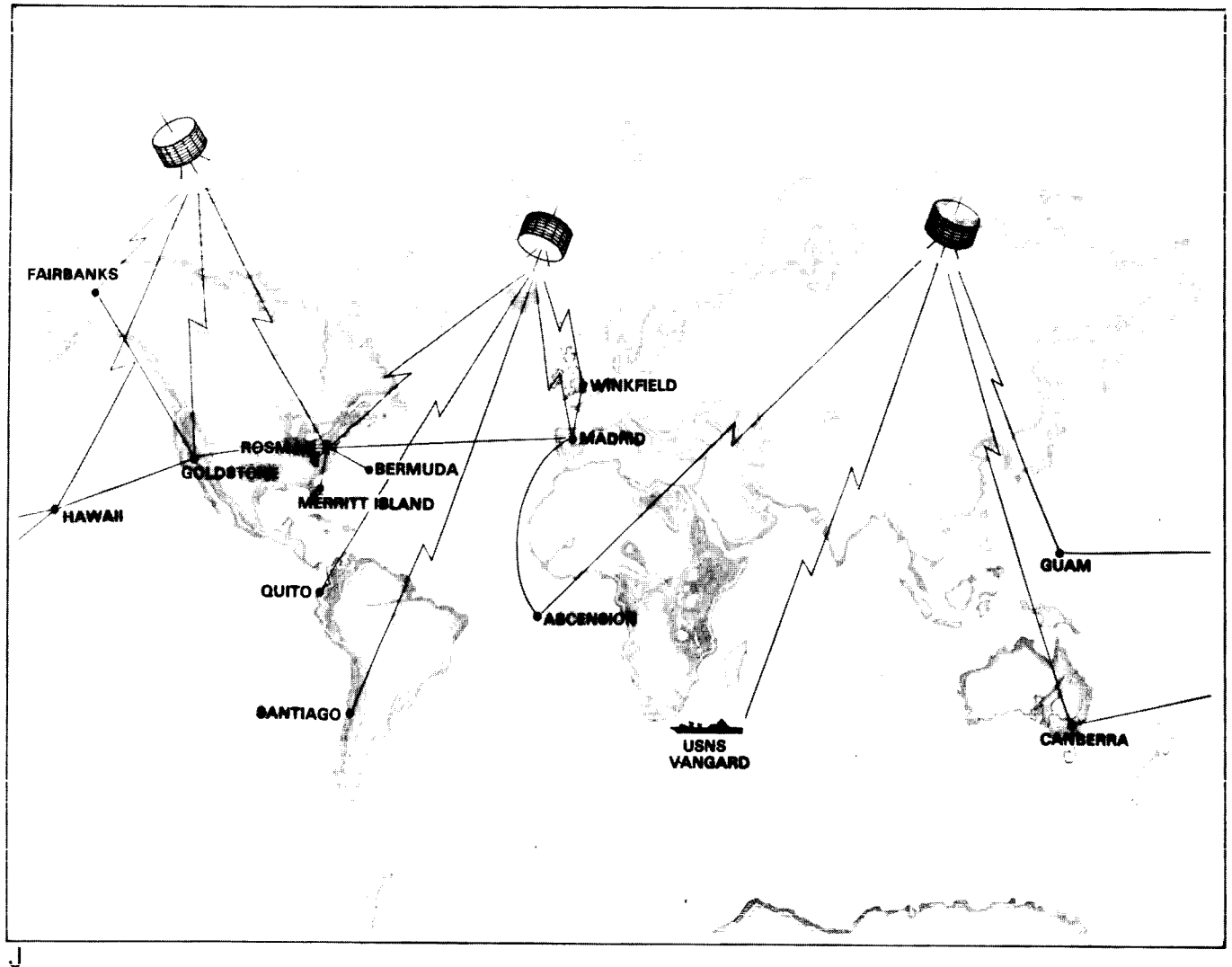

FIGURE 5

In order to meet these higher data transfer rate requirements, new communications technology using digital techniques is being implemented into the NASCOM. Such innovations allow for a greater amount of data to be sent over typical communications circuits. In addition, new services becoming available from the common carriers allow for the transmission of higher data rates at reasonable cost. As a result, the technique of sending data directly from a spacecraft, through a tracking station without manipulation to a mission or project control center, is becoming increasingly attractive. This approach, referred to in the communications field as a "bent pipe" mode, simplifies the systems needed at a tracking station, thereby reducing the operations and maintenance costs. As a result, the trend will continue toward the direct transfer of data from the spacecraft to the control center via high speed communications links.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 budget request for communications operations will provide the necessary funding for the circuits and services required to operate and maintain the NASCOM. International communications satellites will permit the expansion of digital wideband service to all overseas tracking stations. This service will provide for the near real time transfer of data for all ongoing flight programs.

The Shuttle Approach and Landing Tests and the Mariner Jupiter/Saturn (MJS 1977) missions will require additional wideband communications support. Also, an increased bandwidth service using domestic satellites will be required in support of the Nimbus-G and Seasat-A programs. The use of this service permits a "bent pipe" mode of operation that will help reduce the number of operating personnel at the high cost Alaska tracking station.

The operation of the switching centers and technical control facilities are a continuing function assuring high reliability and efficiency in the use of the various types of communications services available to NASCOM from the common carriers. Funds are included in the FY 1978 request to operate and maintain these facilities.

Data Processing Operations

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
23,638	6,400	24,800	25,800	27,900

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form for the day-to-day spacecraft operations and for analyzing the experiment data acquired by the spacecraft. This data processing function is performed for a wide variety of programs, which range from the small Explorer satellites to large and complex Solar and Astronomical Observatories and the Landsat Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to compute spacecraft positions. These functions are essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information from each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data are the primary product of the spacecraft missions, and it is through reductions and analyses of these data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, the upcoming projects require extensive premission orbit studies, including spacecraft position and attitude predictions. Studies are also required to develop operational sequences and procedures to be used during the actual mission operations of these complex spacecraft.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

The increase of $1.0 million in the FY 1977 funding level resulted from extension of support for the GEOS-C mission and greater than expected cost escalation in the operations and programming contracts due to legally required salary and wage redeterminations.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 budget requirements include 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.

Software procurement activities have been initiated for support of upcoming space science and applications spacecraft such as the Solar Maximum Mission (SMM), the Heat Capacity Mapping Mission (HCMM), the International Sun-Earth Explorers (ISEE), Nimbus-G, and Seasat-A. The activities cover spacecraft orbit and attitude control and related data processing requirements which require additional funding for FY 1978.

The Image Data Processing Facility, initially established for the support of the first Earth Resources Technology Satellite (Landsat-1) to handle imagery data, now also supports the second Landsat spacecraft, which was successfully launched in January 1975. Landsat-C will be launched in the first half of FY 1978 and supported with a new all digital system to reduce the time required to provide data to users. The operational requirement for this facility is expected to continue through the next several years for support of the currently approved earth resources programs.

The telemetry processing facility which has handled the conventional, nonimagery data will be reconfigured in FY 1978 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. Concurrent operation of the present system with TELOPS requires additional funding until the new system is checked out and accepted.

As in the other areas of operations, escalation is a significant factor contributing to the increased funding level requested for FY 1978 over FY 1977.

BASIS OF FY 1978 FUNDING 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 large module spares, and associated services such as acceptance testing, integration and checkout of subsystems and systems.

Funds are necessary to maintain the required level of operational proficiency and reliability of network systems through the replacement of obsolete and wornout equipment, the modification and augmentation of existing systems to maintain compatibility with changes in associated onboard spacecraft communications systems and to improve the utilization and efficiency of network systems.

Fiscal year 1978 funds are required to continue the implementation of new capabilities for upcoming approved missions including the Mariner Jupiter/Saturn 1977, Pioneer Venus and Shuttle programs. Funds are also required for augmenting the data processing and control center facilities to handle the higher data rates associated with the increasing availability of wideband communication circuits for transmitting data from the stations to the control centers; i.e., the "bent pipe" approach.

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Spaceflight tracking and data network.....	19,150	5,200	19,000	19,000	20,000
Deep space network.....	10,886	3,200	14,000	14,000	12,700
Aeronautics and sounding rocket support.....	2,523	800	2,600	2,800	3,000
Communications.....	3,284	900	3,900	3,900	3,500
Data processing.....	3,200	600	3,000	3,000	3,300
Total.....	39,043	10,700	42,500	42,700	42,500
Spaceflight Tracking and Data Network Systems Implementation					
	19,150	5,200	19,000	19,000	20,000

OBJECTIVES AND STATUS:

During FY 1978, the network will continue to support approximately fifty spacecraft on an around-the-clock basis. These include many ongoing missions with highly complex requirements for tracking, dat acquisition, and command. Among these are the Space Shuttle Approach and Landing Tests, Landsats 1 and 2, the Laser Geodynamic Satellite (LAGEOS), Applications Technology Satellite (ATS 6), the Geodynamic Experimental Ocean Satellite (GEOS 3). In addition to the ongoing missions, the network will provide support to a number of new missions including the High Energy Astronomy Observatory Landsat-C, the International Sun-Earth Explorers (ISEE A, B, and C), the International Ultraviolet Explorer (IUE), the Heat Capacity Mapping Mission (HCMM), Seasat-A, and the launches of various foreign, commercial, and other U.S. Government agency spacecraft.

The Spaceflight Tracking and Data Network systems implementation program encompasses the procurement and implementation of systems and services necessary to sustain the network's continuing capability for reliable support to these ongoing scientific and applications satellite missions, to provide network capabilities to assure efficient and multipurpose tracking, command, and data acquisition support for all manned and unmanned earth orbital missions, and to meet new support requirements for spacecraft to be launched in the near future.

BASIS OF FY 1978 ESTIMATE:

Equipment modifications are required in the network in FY 1978 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 and to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

The network systems modifications required for support of the Space Shuttle Orbital Flight Tests were initiated in FY 1976 and FY 1977 and installation of the equipment will be completed in FY 1978 to assure the network's readiness to support the first manned orbital flight. Additionally, procurements were initiated in FY 1977 to provide necessary systems for prelaunch verification of the ampoatibility between Space Shuttle payloads and data formats to be used in communications between the payloads and the Tracking and Data Relay Satellite System (TDRSS). These modifications will be continued in FY 1978.

Several significant control center augmentations at the Goddard Space Flight Center (GSFC) are also planned in FY 1978, in order to meet the requirements of upcoming missions. Modifications to the existing Meteorological Data Handling System (MDHS) will be completed in time to support the launch of the Nimbus-G spacecraft. A telemetry input processor will be purchased to accommodate high data rates which will be received from future spacecraft via wide bandwidth "bent pipe" communication circuits. This single processor will perform the necessary data identification functions which are now being done at each of the individual network stations.

To meet the mission control workload in the 1980's a new approach to control center design will be initiated in FY 1978. This approach will involve techniques to rapidly configure control center equipment to meet the requirements of a particular mission. The overall objective of the new design is to permit the sharing of resources to improve equipment utilization and to decrease the number of software and operations personnel.

A new control center is planned for implementation for support of the Landsat-D mission. The Landsat-D spacecraft is significantly different from the Landsat 1, 2 and C spacecraft and cannot be adequately supported by the existing control center. Because of the long term and continuous support requirements for the approved Landsat program it is not possible to make major modifications to the existing control center while at the same time supporting current Landsat operations. Consequently, a new control center is required.

Deep Space Network Systems Implementation

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
10,886	3,200	14,000	14,000	12,700

OBJECTIVES AND STATUS:

Spacecraft control and science data recovery from distant planetary and interplanetary spacecraft are accomplished through highly specialized ground capabilities in the Deep Space Network. These capabilities include high power transmitters, ultra sensitive receivers and antenna components, and advanced data handling systems used with the strategically located 64-meter and 26-meter antennas around the world.

The Deep Space Network systems implementation program provides for the procurement of equipment and related services to be used in this network to assure that its capabilities keep pace with ongoing and upcoming approved planetary mission support requirements. The increased complexity of planetary missions associated with advancements in spacecraft technology and a greater understanding of planets' characteristics has resulted in evolving demands being placed on the Deep Space Network.

Due to the long communication distances involved, long flight durations, and the need for dedicated network support during critical mission events, the support requirements of approved programs push the state of the art in ground communication and spacecraft navigation technology. This requires a continuing effort to extend the capabilities and improve the performance and reliability of the network.

A major time-phased equipment modification program, initiated in prior years, is continuing throughout the network to support the upcoming Mariner Jupiter/Saturn 1977 missions (MJS 1977). The capabilities being implemented under this program will have a multimission configuration that permits concurrent support of

the MJS 1977 and the ongoing Viking, Pioneer, and Helios extended missions. Design and early hardware fabrication has also commenced on special equipment to recover data from the multiple Pioneer Venus Probes during their critical entry phase into the atmosphere of Venus.

BASIS OF FY 1978 ESTIMATE:

Funds requested in FY 1978 will be used to provide an increased command capability required by the MJS 1977 spacecraft onboard computer systems. Continual updating of onboard stored programs, as recently done with the Viking spacecraft on Mars, has demonstrated the importance of being able to adapt to changing mission modes to maximize flight project objectives. The high data rate command system for MJS 1977 is intended to provide similar flexibility in working with the onboard computer to control the numerous spacecraft functions as variations in the mission profile occur.

Other modifications in the network planned for completion in FY 1978 include new higher frequency (X-band) telemetry decoding equipment. This telemetry capability is required for the retrieval of general science and imagery data as the MJS 1977 spacecraft swing by the planet Jupiter and its satellites, Io, Ganymede, and Callisto. These flybys, occurring over a billion kilometers from Earth, will be as close as twenty-five thousand kilometers from the surface of these satellites and will provide valuable data on the composition of their surfaces and atmospheres.

In order to navigate the spacecraft in close proximity to the planets and, to achieve the critical swingby trajectory necessary to travel on to Saturn, an improved and more accurate tracking, data handling, and timing capability is required. FY 1978 funding is necessary to continue development of this very precise system which uses the new technique of very long baseline interferometry. This technique employs the use of tracking stations at two widely separated locations. The data obtained by these stations permits accurate determination of the station locations and also the spacecraft position. From this information, improved spacecraft navigation accuracy is possible. Navigation support by these same techniques will be even more critical for the Saturn encounter phase of the MJS 1977 mission, which occurs some one and one-half billion kilometers from Earth, and the later numerous satellite flybys of the Jupiter Orbiter/Probe mission.

Special equipment and modifications are required to support the Pioneer Venus orbiter and multiprobe mission. Simultaneous recovery of data from the multiple probes entering the Venusian atmosphere requires additional receiving, recording, and data handling capabilities in the network. Initiated in prior years, this effort will be completed with FY 1978 funds.

To meet the substantial Venus and Jupiter encounter workload that will occur in 1978, the modification of a Goldstone, California, 26-meter station has been initiated. This modification will enable the station to receive the higher performance X-band frequencies being used by Pioneer Venus and MJS 1977 missions as well

as future planetary missions. In FY 1978 similar modifications will be initiated at two overseas 26-meter stations. The additional X-band reception capability in the network is needed to support the cruise navigation requirements for MJS 1977 and to allow the more sensitive 64-meter stations to support other interplanetary missions such as the Pioneer 10, which at that time will be well beyond the range of the 26-meter antenna capabilities.

The necessity to cover critical one-time mission events requires an extremely high level of network reliability. FY 1978 funds are needed to maintain this high level of reliability through a continuing program of spares provisioning and replacement of failure prone and obsolete components. Additionally, minor adaptations and modifications are needed to interface new equipments with the existing complement.

Aeronautics and Sounding Rocket Support Systems Implementation

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
2,523	800	2,600	2,800	3,000

OBJECTIVES AND STATUS:

The aeronautics and sounding rocket programs are supported at the Wallops Flight Center in Virginia and the Dryden Flight Research Center in California.

The aeronautics program support at Wallops consists of space component tests utilizing helicopter or aircraft drops, aircraft noise abatement projects, slow speed landing techniques for jet aircraft, antiskid tests on grooved runways, vertical/short takeoff and landing (V/STOL) terminal area research, microwave landing system development tests, collision avoidance programs and remote (airborne) sensing developments in support of the earth resources programs.

The sounding rocket programs supported at Wallops cover all 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 annually 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 onboard antennas and transponders. To meet specific test requirements, modifications and augmentations of selected telemetry, communications, tracking, command, and data handling systems are required. In addition, the mobile equipment must be periodically refurbished and modified to meet remote site requirements such as the ongoing meteorological program in cooperation with several nations, including Argentina, Brazil, and Spain.

The aeronautical research and technology programs supported by the Dryden Flight Research Center (DFRC) consist of high altitude and terminal area tests involving high performance aircraft such as the F-111, YF-12, 747 Shuttle carrier aircraft, and various other aircraft and helicopters. Dryden 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 FY 1977 BUDGET ESTIMATE:

The increase of $200 thousand in the FY 1977 funding level resulted from the requirement for additions to the range communication system in support of the Shuttle Approach and Landing Tests.

BASIS OF FY 1978 ESTIMATE:

Funds are requested in FY 1978 to provide the sustaining equipment and modifications to support the sounding rocket and aeronautics program as described above.

Communications Systems Implementation

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,284	900	3,900	3,900	3,500

OBJECTIVES AND STATUS:

The objective of the Communications System Implementation Program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to sustain NASCOM at a high level of reliability in the transmission of data.

NASCOM interconnects the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers.

BASIS OF FY 1978 ESTIMATE:

Funds requested in FY 1978 will provide for the continuing procurement of systems to improve the data transmission capability of the network. As discussed in the communications operations area, the NASCOM is using digital techniques to handle the higher data rates of the flight projects. The use of digital techniques requires specialized equipment to transmit the data over the leased communications circuits.

Along with digital techniques, it is becoming increasingly cost effective to use wideband circuits in NASCOM to "bent pipe" data from the stations to control centers. Wideband terminal and interface equipment will be procured in FY 1978 as the common carriers make available a greater variety of wideband communication services

To maintain system reliability, a continuing program to procure replacement parts, spares, test, and monitoring equipment is necessary. Funds for this purpose are included in the FY 1978 request.

Data Processing Systems Implementation

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
(Thousands of Dollars)				
3,200	600	3,000	3,000	3,300

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. The operational capability of these complexes

are used to determine spacecraft attitude and orbit, to generate commands to the spacecraft, and to provide the status of onboard subsystems. In support of spacecraft payloads, these complexes process the data from science and applications experiments for subsequent transfer to the experiments.

Several significant activities in this program 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 FY 1978. A second major activity underway is a modification to the Image Processing Facility to provide for higher resolution and greater accuracy in the handling of imagery data. Also, equipment is being procured to interface between the NASCOM terminal and the existing data processing facility to accommodate the wide-band data transmission mode currently being implemented in the NASCOM network.

BASIS OF FY 1978 ESTIMATE:

The FY 1978 estimate includes funds to augment and complete the interface of the existing Univac 1108 multiprocessor used in data processing with the new Telemetry On-Line Processing System (TELOPS). Equipment to be procured includes high density recorders, front-end processors and large disc storage for the 1108.

Funds are also included in the FY 1978 request to provide the TELOPS with a data capture capability for handling and identifying data from multiple NASCOM circuits including TDRSS wideband transmissions. This wideband data capture capability will also provide an interim solution for data processing of Spacelabs 1 and 2 payloads.

For later Spacelab missions much higher data rates are expected, which may require additional expansion of the data processing capability.

The FY 1978 estimate also includes funds to complete the conversion of the existing NASA Image Data Processing Facility to a general purpose system, and to complete the sensor peculiar preprocessing and product generation subsystems for supporting upcoming missions such as HCMM and Nimbus-G. Funds are also required to demonstrate on a limited scale a capability to preprocess sensor data at rates ten times greater than the present capability. Application preprocessors and related software are planned for procurement in FY 1978 as part of this effort.

BASIS OF FY 1978 FUNDING REQUIREMENTS:

ADVANCED SYSTEMS

1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)			
9,221	2,300	8,700	8,700	9,300

OBJECTIVES AND STATUS:

The objectives of the Tracking and Data Acquisition Advanced Systems Program is to accomplish studies and developments which provide a sound basis for cost-effective support of the total mix of space flight missions. These studies and developments focus on new and improved network and data processing capabilities to meet upcoming mission requirements. Included are such efforts as optimizing space-to-ground telecommunications links and the development of techniques for planning economical and reliable operational support.

BASIS OF FY 1978 ESTIMATE:

Capabilities to telemeter, acquire, and process image type data are being developed which provide for a level of picture detail greater than that of a quality TV channel. Future spacecraft with instruments that can collect a whole new spectrum of information about land, sea and environmental conditions require data rate handling capabilities many times greater than now possible. In FY 1978 work will be pursued on millimeter-wave, radio frequency (R-F) systems and automated digital processing techniques needed to meet tracking and data acquisition support requirements for missions with higher data rates. These requirements cannot be met with current capabilities.

Some of the most impressive improvements in tracking and data acquisition capabilities have been in planetary mission telecommunications. Through improvements on antennas and feeds, low noise receivers, spacecraft R-F systems, in signal coding and related efforts we have extended planetary telecommunications capabilities from approximately 8 bits per second in 1965 at the distance of Mars to approximately 16,000 bits per second at the distance of Jupiter. This is an improvement factor of 5,000 in the data rate at approximately 6 times the distance. Work will continue in FY 1978 in this area to meet future requirements. Future spacecraft command and data acquisition requirements are expected to exceed 40,000 bits per second at distances of Saturn, approximately 1.5 billion kilometers from Earth.

Similarly impressive improvements have been made in the area of ground monitored and directed spacecraft navigation. Work will continue on ground tracking systems and techniques aimed at meeting the extreme accuracies needed for the outer planet missions to accomplish, for example, precision "sling shot" swing bys and to obtain planetary satellite pictures. Such techniques include two-station tracking, Very Long Baseline Interferometry (VLBI), atomic frequency standards, and precise station-to-station timing synchronization.

Tracking and data acquisition support operations are becoming more efficient and effective because of the development of computer assisted operating techniques which permit greater centralized control and monitoring of both the network stations and their control centers. Work continues on efforts to further reduce recurring operations costs and will focus on the "bent pipe" approach for transmitting data. Under this approach a station acquires and relays, via NASCOM, all spacecraft data in real time without manipulation at the station. This effort will include a consolidation of station functions with automated operation in those functional areas where overall cost effectiveness can be shown. The studies will consider the use of minicomputers and microprocessors along with the development of a common aoftware and hardware interfaces for use in the various functional areas.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1978 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1976 Actual	Transition Quarter Actual	1977 Budget Estimate	1977 Current Estimate	1978 Budget Estimate
	(Thousands of Dollars)				
Industrial applications	3,145	1,013	3,245	3,445	3,445
Technology applications	3,500	812	3,640	3,640	3,640
Program control and evaluation	855	175	1,015	1,015	1,015
Total	7,500	2,000	7,900	8,100	8,100
Distribution of Program Amount by Installation:					
Johnson Space Center	435	100	450	450	450
Kennedy Space Center	110	---	100	100	100
Marshall Space Flight Center	422	10	600	600	600
National Space Technology Laboratories	53	10	50	50	50
Goddard Space Flight Center	391	128	500	500	500
Jet Propulsion Laboratory	630	134	650	650	650
Wallops Flight Center	15	---	15	15	15
Ames Research Center	800	206	800	800	800
Dryden Flight Research Center	---	---	35	35	35
Langley Research Center	900	151	700	700	700
Lewis Research Center	55	5	250	250	250
Headquarters	3,689	1,256	3,750	3,950	3,950
Total	7,500	2,000	7,900	8,100	8,100

OFFICE OF INDUSTRY AFFAIRS
AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The overall objective of the NASA Technology Utilization Program is to enhance National economic growth through the transfer of new technology resulting from aeronautical and space research and development efforts to the non-aerospace segments of the economy. Developing secondary uses for aerospace technology assures added return on the National investment in aerospace research and development.

The specific objectives of the program are to:

(1) Expedite the application of new technology by compressing the time required from generation of technology to its use in the economy;

(2) Encourage the use of aerospace technology in non-aerospace segments of the economy having problems amenable to technological solutions; and

(3) Understand more fully the technology transfer process and its impact and systematically manage and optimize the process.

Over the past 15 years, thousands of aerospace-derived technologies have spun off to the public and private sectors of the economy. A steady stream of technological innovations and advances has affected nearly every facet of our lives--home and automotive designs; fire prevention techniques and protection for firefighters; medical diagnostic instrumentation; bridge construction; food processing equipment; farm machinery; computerized banking; traffic controls and highway safety; microelectronic products; energy systems; and industrial processes of almost every description. Many of these advances have values measured in millions of dollars. In aggregate, spin-offs of aerospace technology have provided significant benefits to the general welfare and to the national economy.

During FY 1977 and FY 1978, NASA will continue its efforts to convey new aerospace knowledge and innovative technologies to a wide variety of users in the public and private sectors of the economy. Representative

examples of these activities include:

Publications: Announcement and dissemination of available aerospace technologies (e.g., NASA Tech Briefs). Nearly 50,000 specific requests for additional technical information result each year from this effort.

Industrial Applications Centers: Six regional computerized NASA technical information centers serving industry nationwide on a fee-paying basis. Nearly 80,000 client interactions occurred in 1976.

Computer Software Management and Information Center (COSMIC): One of the Nation's largest libraries of computer programs, containing over 1,600 programs, for dissemination to industrial users.

State and local technical assistance activities: An experimental effort begun in FY 1977, in conjunction with the Universities of Florida and Kentucky, to facilitate the provision of technical assistance and technology transfer at state and local levels.

Applications teams: Multidisciplinary groups of technologists to assist organizations in selected public sector areas, such as medicine and transportation, in problem-definition and solution. In 1976, for example, nearly 90 different medical institutions across the Nation were served through application team efforts.

Applications engineering projects: Projects for adapting existing aerospace technology for use in other public sector agencies. Among the nearly 60 currently active projects are: Project FIRES - NASA, in cooperation with the National Fire Prevention and Control Administration, is investigating the use and applicablity of new materials developed for aerospace programs to improve firefighters' equipment, including protective garments and firefighting implements and tools; and Tissue Stimulator - Extension of successful rechargeable cardiac pacemaker technology and telemetry techniques to the development of a fully implantable human tissue stimulator to reduce pain in patients with nerve and muscle problems. This project is jointly sponsored by the Johns Hopkins University Hospital.

CHANGES FROM FY 1977 BUDGET ESTIMATE:

Additional funds in the amount of $200,000 were made available in FY 1977 as a result of Congressional authorization action. This increase made possible the initiation of an experimental technical assistance activity in conjunction with the University of Kentucky to facilitate the transfer of aerospace technology to state, local and industrial needs of that area.

BASIS OF FY 1978 ESTIMATE:

Industrial Applications

In FY 1978, NASA plans to continue its efforts to improve the distribution of new technology to a broader industrial community. Additional attention will be focused on small business firms through cooperative efforts with the Small Business Administration and extension of an experimental effort begun in FY 1977 for small businesses located in southern California.

In addition, NASA will continue to increase its efforts to encourage industrial and professional journal publishers to reflect information on aerospace technology advances of interest to their readers. Such efforts will create increased awareness in the business community of available aerospace technologies which, when applied, may favorably affect industrial productivity.

The experimental technical assistance activities in Florida and Kentucky will continue to seek meaningful and productive ways in which NASA can work with state and local governments in applying aerospace technology to identified governmental and industrial needs of these regions. The results of these two activities, which are being jointly funded with these states, may lead to a more systematic and effective means for intergovernmental technology transfer than has been available before.

Technology Applications

In FY 1978, the Technology Utilization Program will continue to pursue technological solutions for identified public sector problems in such areas as medicine, transportation, and public safety. Existing aerospace technologies are adapted to solve problems specified in cooperation with other mission-oriented agencies at the Federal, state and local levels. Approximately two-thirds of the funds requested for technology applications will be used to continue multi-year projects (e.g., Project FIRES) and to initiate new efforts.

In addition, continued support will be provided to the application teams, which identify and assess problem-solution opportunities, generally defined in conjunction with other governmental organizations. Particular emphasis will be placed on the manufacturing processes team and their efforts to increase industrial productivity through the application of advanced aerospace technology and fabrication techniques.

Program Control and Evaluation

In FY 1978, NASA plans to continue to build on the FY 1977 analyses of technological, societal and economic impacts of aerospace-developed techniques. Recent analyses by the Department of Commerce show that advances

in technology are the single most important factors in the improvement of productivity. In addition, NASA plans to continue and improve its efforts to document specific evidence of technology transfer, and convey such information to the general public. Creating awareness of successful uses of aerospace knowledge and innovative technologies further stimulates the technology transfer process and broadens the spectrum of use in the public and private sectors of the economy.