National Aeronautics and
Space Administration

Budget Estimates

FISCAL YEAR 1983

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Washington, D.C. 20546

Volume I

Agency Summary

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

VOLUME I

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AGENCY
SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 BUDGET ESTIMATES

GENERAL STATEMENT

"he National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautics activities for peaceful purposes for the benefit of all. NASA's activities are designed to maintain United States leadership in aeronautical and space research and technology and its utilization. More specifically, the objectives of NASA activities are 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;

-- Disseminate pertinent findings to potential users; and

-- Promote international cooperation in peaceful activities in space.

"he NASA FY 1983 budget recommendation of $6,612.9 million provides for progress toward achievement of these objectives at a pace consistent with the constrained federal fiscal environment.

Space program elements in the budget provide for progress in development of the operational capability and use of the Space Shuttle and related systems; in technology development for application of space capabilities to remote sensing of the Earth's surface and atmospheric conditions, to materials processing, and to communications; in exploration of the solar system and expansion of our knowledge of the universe; and in advancing the technology necessary for United States leadership in space. Major areas of emphasis include:

o Design, development, test and evaluation of the Space Shuttle to be completed in FY 1982. The manufacture of orbiter vehicles will continue on a schedule consistent with the requirements of the Department of Defense and civil users. The Space Shuttle is progressing toward the initial

operational flight scheduled for early FY 1983. Two successful orbital flight tests have been completed, and two additional orbital flight tests are scheduled during FY 1982 leading to this operational capability. The Space Shuttle, the first reusable Earth-to-orbit transport vehicle, will be the key element in the space transportation system which will also include upper stages to provide high altitude orbit and planetary capability, and the Spacelab being developed by the European Space Agency to provide a new capability for conducting experiments in space. This space transportation system will provide the basic capability for a new era of operations in and utilization of space. The FY 1983 program continues development of improved Shuttle performance and preparation for the initial demonstration of the capability of the Space Shuttle to rendezvous with and repair spacecraft in orbit.

o Space science flight missions and research and analysis to expand human knowledge of the Earth's environment, the solar system, and the universe. Specifically, work will continue on the Galileo orbiter and probe mission to Jupiter as the next step after Voyager in exploration of the outer planets; on the Space Telescope to provide a quantum jump in our ability to observe the universe; on the Gamma Ray Observatory to study extremely high energy phenomena and on the refurbishment of the Solar Maximum Mission spacecraft and instruments to return this sytem to full operational status with the aid of the Shuttle.

o Space applications flight missions and ground-based activities to develop the technology to use space capabilities in meeting needs on Earth. For example, Landsat-D will be launched in FY 1982 and, in FY 1983, work will continue in preparation for launch of the Landsat-D′ spacecraft to extend and improve Earth resources observations from space; on the Earth Radiation Budget Satellite to measure the exchange of energy between the Earth and space; on the search and rescue locator system to be flown on weather satellites initially in 1982; and, on the Upper Atmospheric Research Satellite Experiments to monitor the upper atmosphere. Preparation for materials processing experiments taking advantage of the space environment, and technology development in advanced satellite communications are also part of the applications program. The FY 1983 budget reflects a deemphasis of Federal Government involvement in major space demonstration projects with greater reliance on industry to support development with commercial applications.

o Space research and technology activities emphasizing the longer range aspects of technology which are crucial to future United States leadership in space.

Aeronautical research and technology activities in the budget are necessary to advance the aeronautical technology base for safer, more economical, efficient and environmentally acceptable air

transportation systems which are responsive to current and projected national needs; to maintain the long-term competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft. The FY 1983 program continues emphasis on the fundamental research and technology base in all disciplines and speed regimes vital to aeronautics. Specific technology efforts will continue directed toward major improvements in low speed and high speed aircraft, with priority accorded to advancing national security objectives.

Resources Summary

The budget authority recommended for FY 1983 totals $6,612.9 million with estimated outlays of $6,582.0 million and a civil service staffing level of 21,219.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

RESEARCH AND DEVELOPMENT	Budget Plan FY 1981	FY 1982	FY 1983
Space Transportation Systems	2,728,600	3,090,100	3,467,800
Space Shuttle	1,995,000	2,163,000	1,718,000
Space flight operations	679,200	895,900	1,707,000
Expendable launch vehicles	54,400	31,200	42,800
Space Science	541,488	568,000	682,000
Physics and astronomy	323,700	323,500	471,700
Planetary exploration	175,600	205,000	154,600
Life sciences	42,188	39,500	55,700
Space and Terrestrial Applications	340,350	333,800	320,300
Space applications	331,550	325,800	316,300
Technology utilization	8,800	8,000	4,000
Aeronautics and Space Technology	384,000	344,000	355,000
Aeronautical research and technology	271,400	233,000	232,000
Space research and technology	110,700	111,000	123,000
Energy technology	1,900	---	---
Tracking and Data Acquisition	339,900 a/	402,100 a/	508,900
TOTAL RESEARCH AND DEVELOPMENT	4,334,338	4,738,000	5,334,000
CONSTRUCTION OF FACILITIES	116,950 a/	98,700 a/	100,000
RESEARCH AND PROGRAM MANAGEMENT	1,071,064	1,144,700 b/	1,178,900
TOTAL	5,522,352	5,981,400	6,612,900
OMAS	5,425,557	5,831,000	6,582,000

a/ Reflects reprogramming of R&D funds to CoF: 1981 program $1.2M, 1982 program $2.9M.
b/ Includes increased pay costs of $41.4M.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Proceed with development of a versatile space transportation system to provide for:

  -- Expanded capabilities employing the 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

- Conclude Shuttle orbital flight tests in FY **1982**

- Initiate operational flight missions in early FY **1983**

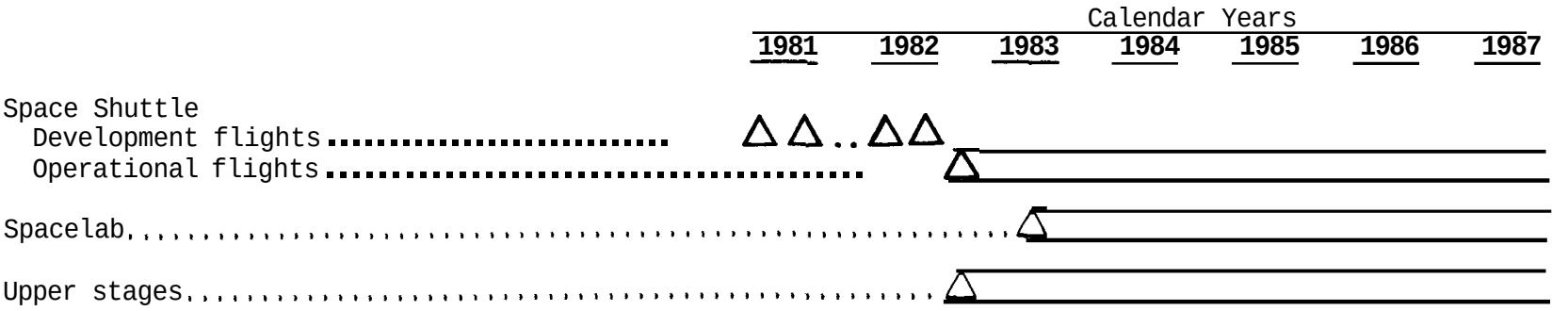
- Continue production to provide a national fleet of Space Shuttle orbiters

- Proceed with development of additional Shuttle performance capability

- Proceed with activities supporting early demonstration of Shuttle on-orbit retrieval and repair capability

- Provide expendable launch vehicle services as required by NASA and other users during transition to the space transportation system

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

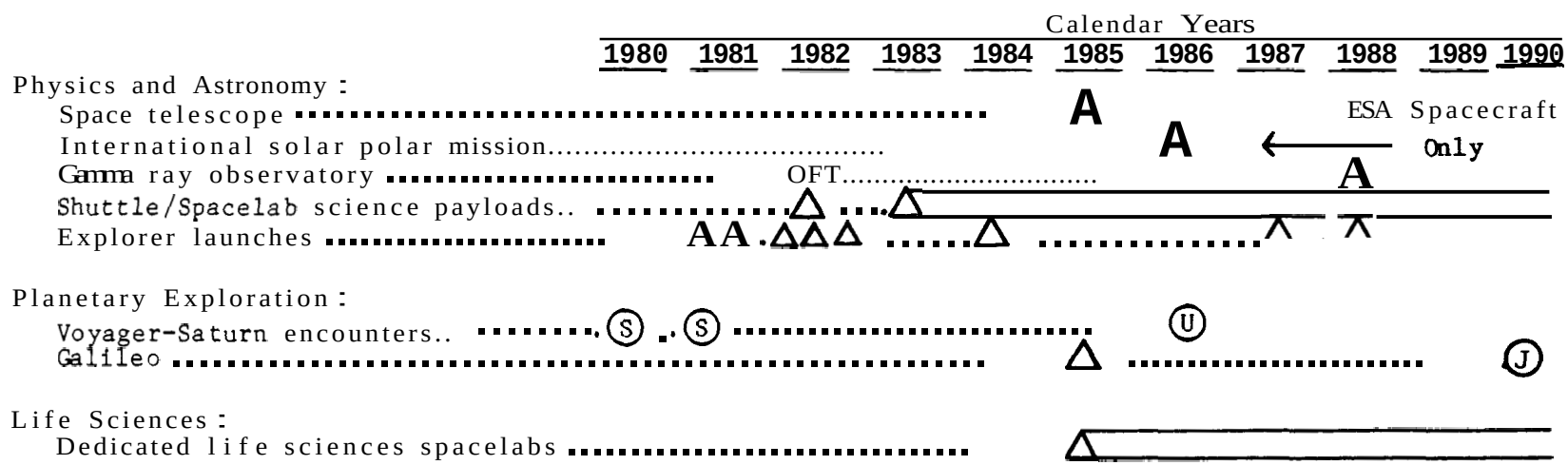
SPACE SCIENCE

- Increase our understanding of the evolution and nature of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations

- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained

- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields

MAJOR FLIGHT ACTIVITY

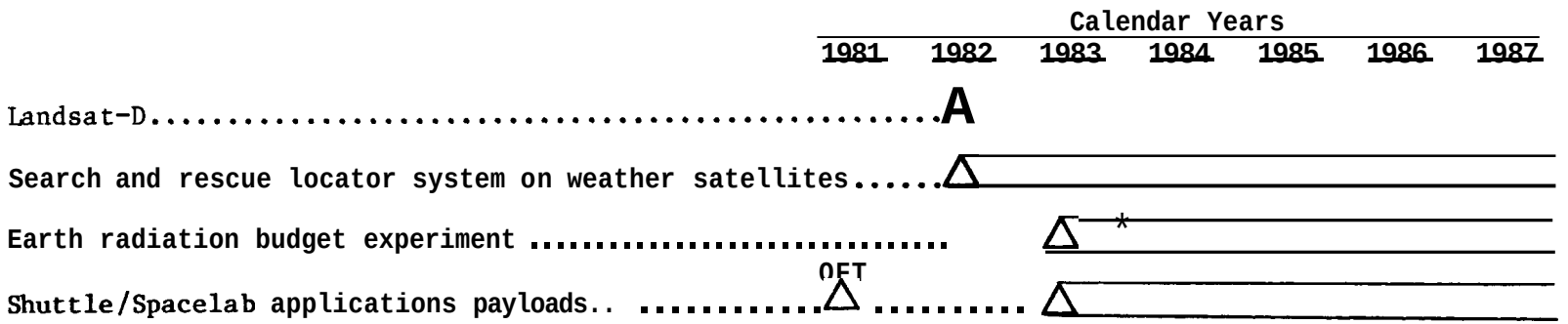


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE AND TERRESTRIAL APPLICATIONS

- Develop and demonstrate practical uses of space and space-derived technology
  - Remote sensing of Earth resources
  - Environmental observations from space
  - Materials processing in space
  - Space communications

MAJOR FLIGHT ACTIVITY



*currently under review

NATIONAL AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide the Nation with the fundamental research and technology in the aeronautical disciplines and speed regimes to:

  -- Improve performance
  -- Reduce costs
  -- Increase safety
  -- Reduce energy requirements
  -- Decrease environmental effects

- Accomplish these objectives by means of research and technology efforts in the aeronautical disciplines of:

  -- Aerodynamics
  -- Propulsion
  -- Materials and structures
  -- Aircraft controls and guidance
  -- Human factors

- Enhance and validate this disciplinary activity through ground- and flight-based multidisciplinary research and technology in all aeronautical speed regimes and flight modes:

  -- Low speed
  -- Subsonic
  -- Transonic
  -- Supersonic
  -- Hypersonic

NATIONAL AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base essential to future United States leadership in space by:

  -- Improving performance and effectiveness
  -- Reducing cost and risk
  -- Increasing reliability
  -- Developing technological options

- Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:

  -- Aerothermodynamics
  -- Materials and structures
  -- Electronics and automation
  -- Chemical and electric propulsion
  -- Space power systems
  -- Component standardization
  -- Spacecraft, transportation, and information systems

MAJOR FLIGHT ACTIVITY

	Calendar Years						
	1981	1982	1983	1984	1985	1986	1987
Space technology Shuttle/Spacelab payloads	.....	.....	.....	A			

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:

  -- Shuttle orbital flight tests and operational flights

  -- Automated Earth orbiting missions - approximately fifty applications and scientific spacecraft will be supported including the Nimbus, Landsat-D, International Ultraviolet Explorer, International Sun Earth Explorer, High Energy Astronomy Observatories, Applications Technology Satellites, Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and Solar Mesospheric Explorer

  -- Planetary missions - support will continue for Pioneers-10 and 11 and Voyagers-1 and 2, as well as limited support for Viking, Helios, and earlier Pioneer missions

  -- Sounding rockets

  -- Aeronautical flight research program

- The Tracking and Data Relay Satellite System (TDRSS) will eventually replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft will be launched in January 1984 and the second in July 1984.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR **1983 ESTIMATES**
SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	FY 1981	FY 1982	FY 1983
Research and Development	4,335,538	4,738,000	5,334,000
Basic appropriation..	4,396,200	4,973,100	5,334,000
Reduction (PL 96-526).	-55,412	---	---
Rescission (PL 97-12).	-4,500	---	---
Reduction (PL 97-101, Sec. 501 (41)	---	-232,200	---
Transferred to Construction of Facilities	-750	-2,900	---
Construction of Facilities	115,750	98,700	100,000
Basic appropriation.....	115,000	99,800	100,000
Reduction (PL 97-101, Sec. 501 (41)	---	-4,000	---
Transferred from Research and Development..	750	2,900	---
Research and Program Management	1,071,064	1,103,300	1,178,900
Basic appropriation	1,030,000	1,114,300	1,178,900
Unobligated balance lapsing	-336	---	---
Reduction (PL 97-101, Sec. 501 (41)	---	11,000	---
Supplemental appropriation (PL 97-12)	41,400	---	---
Total	5,522,352	5,940,000	6,612,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

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

Fiscal Year 1981	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 96-526	5,541,200	4,396,200	115,000	1,030,000
Reduction, General Provisions PL 96-526	-55,412	-55,412	---	---
Rescission, PL 97-12	-4,500	-4,500	---	---
Supplemental Appropriation, PL 97-12	41,400	---	---	41,400
Transfer between accounts	---	-750	+750	---
Unobligated balance lapsing	-336	---	---	-336
Total Budget Plan	5,522,352	4,335,538	115,750	1,071,064
Fiscal Year 1982				
Appropriation, PL 97-101	6,187,200	4,973,100	99,800	1,114,300
Reduction, PL 97-101, Sec. 501 (41)	-247,200	-232,200	-4,000	-11,000
Increased pay costs in FY 1982	41,400	---	---	41,400
Transfer between accounts	---	-2,900	+2,900	---
Total Budget Plan	5,981,400	4,738,000	98,700	1,144,700
Fiscal Year 1983				
Appropriation request/budget plan	6,612,900	5,334,000	100,000	1,178,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

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

	Total			Research and Development			Construction of Facilities			Research and Program Management		
	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983
Johnson Space Center.....	1,702.4	1,807.3	1,809.6	1,523.6	1,616.2	1,613.7	27	4.5	3.5	176.1	186.6	192.4
Kennedy Space Center.....	520.9	617.1	626.2	365.1	433.4	451.2	5.6	20.3	5.5	150.2	163.4	169.5
Marshall Space Flight Center.	1,176.2	1,377.6	1,723.5	995.9	1,197.9	1,521.2	15.3	8.9	24.6	165.0	170.8	177.7
National Space Technology Laboratories.....	15.2	17.1	16.2	8.5	9.1	7.6	1.2	1.9	2.3	5.5	6.1	6.3
Goddard Space Flight Center..	741.2	803.4	989.3	571.2	628.4	803.5	7.6	4.9	12.2	162.4	170.1	173.6
Jet Propulsion Laboratory. ...	268.3	321.5	330.3	258.7	317.1	326.3	9.6	4.4	4.0	---	---	---
hues Research Center.....	274.3	290.7	202.9	160.4	165.9	167.9	19.1	22.1	10.1	94.8	102.7	104.9
Langley Research Center..	288.4	256.4	266.7	142.9	122.1	115.5	24.7	6.3	19.9	120.8	128.0	131.3
Lewis Research Center..	277.4	209.5	205.4	163.5	98.4	87.7	14.0	4.1	7.1	99.9	107.0	110.6
Headquarters..... ...	240.9	259.5	352.0	144.5	149.5	239.4	---	---	---	96.4	110.0	112.6
lhdistributed Construction of Facilities:												
Various Locations..	7.2	11.3	2.5	---	---	---	7.2	11.3	2.5	---	---	---
Facility Planning and Design	10.0	10.0	8.3	---	---	---	10.0	10.0	8.3	---	---	---
Total Budget Plan	5.522.4	5.981.4	6.612.9	4.334.3	4.738.0	5.334.0	117.0	98.7	100.0	1.071.1	1.144.7*	1.178.9

* Includes $41,400,000 for increased pay cost

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

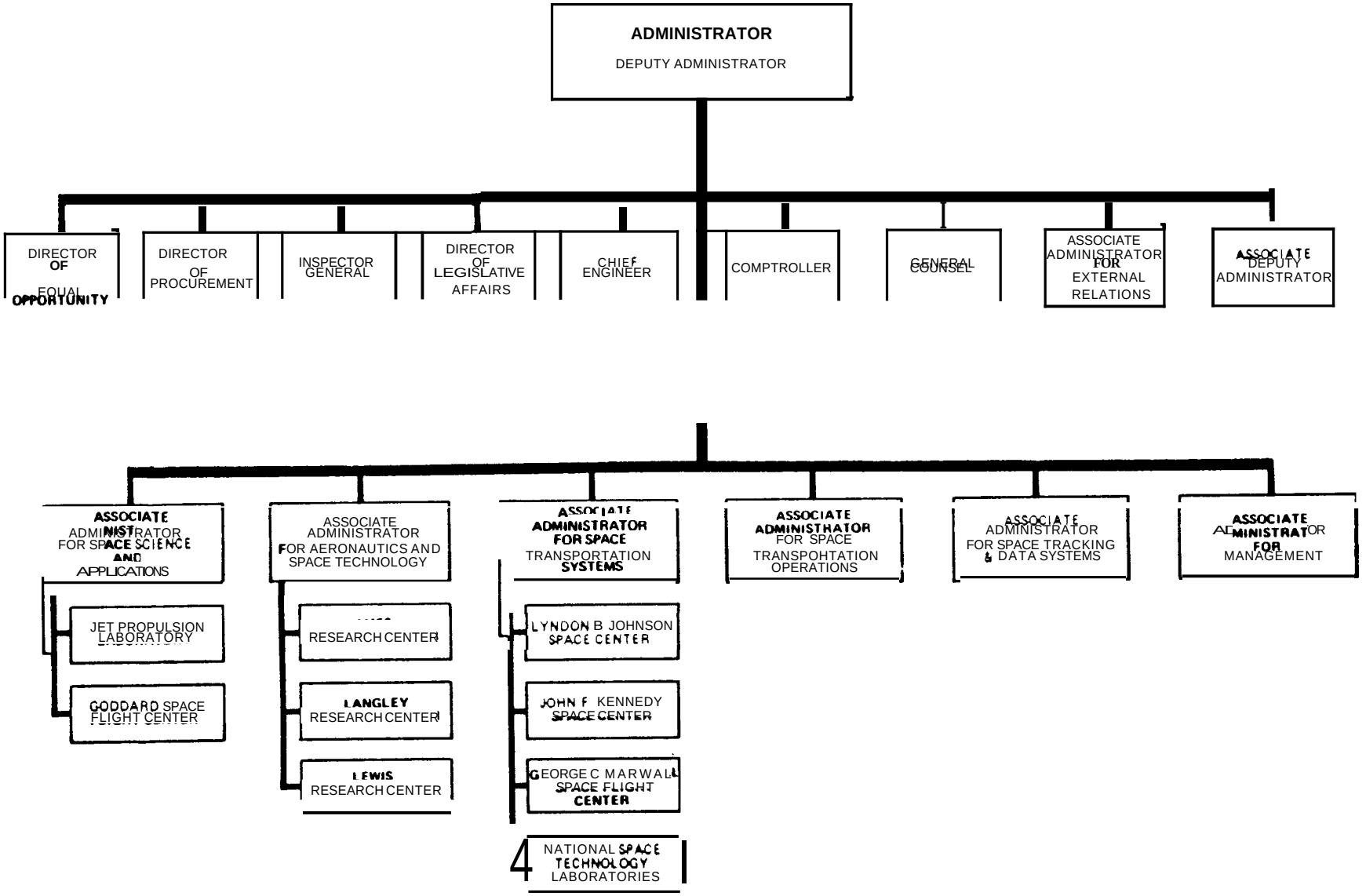
RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1983 ESTIMATES

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

Installation	FY 1981	FY 1982	FY 1983
Johnson Space Center	3.380	3.346	3.293
Kennedy Space Center	2.155	2.133	2.112
Marshall Space Flight Center	3.385	3.351	3.285
National Space Technology Laboratories	105	104	104
Goddard Space Flight Center	3,699	3.661	3.623
Ames Research Center	2.058	2.037	2.021
Langley Research Center	2.895	2.866	2.845
Lewis Research Center	2.690	2.663	2.479
Headquarters	1.506	1,491	1,457
Total. Permanent Positions	21.873	21,652	21.219


ADMINISTRATOR
DEPUTY ADMINISTRATOR
DIRECTOR OF EQUAL OPPORTUNITY
DIRECTOR OF PROCUREMENT
INSPECTOR GENERAL
DIRECTOR OF LEGISLATIVE AFFAIRS
CHIEF ENGINEER
COMPTROLLER
GENERAL COUNSEL
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE DEPUTY ADMINISTRATOR
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
LYNDON B JOHNSON SPACE CENTER
JOHN F KENNEDY SPACE CENTER
GEORGE C MARWALL SPACE FLIGHT CENTER
4 NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPOHTATION OPERATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

RESEARCH
AND DEVELOPMENT

SUMMARY
INFORMATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

GENERAL STATEMENT

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

SPACE TRANSPORTATION SYSTEMS: A program to provide the transportation and related capabilities required to conduct space operations. The major development objective is the reusable Space Shuttle and other elements of a versatile, economical space transportation system to provide round trip access to space and operational capabilities to meet civil and defense needs in the use of space.

SPACE SCIENCE: A program using space systems, supported by ground-based and airborne observations, to conduct a broad spectrum of scientific investigations. The objective is to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the other stars of our galaxy and the universe.

SPACE AND TERRESTRIAL APPLICATIONS: A program to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in solution of Earth resources and environmental problems. To accomplish these objectives, the program employs spacecraft, airborne systems, and ground-based research and data analysis activities. The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology and development programs.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental research and to develop the technology required to maintain the United States leadership in aeronautics and space.

TRACKING AND DATA ACQUISITION: A program utilizing a worldwide antenna network and a satellite system to support deep space, Earth orbital, suborbital and aeronautical activities.

SPACE TRANSPORTATION SYSTEMS

Space transportation system activities provide all of the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the development and flight testing of the Space Shuttle. The Space Shuttle, the first reusable Earth-to-orbit transport vehicle, will be the key element in the space transportation system which will also include upper stages to provide high altitude orbit and planetary capabilities, and the Spacelab being developed by the European Space Agency to provide a new capability for conducting experiments in space. The space transportation system will provide the basic capability for a new era of operations in and utilization of space.

The Space Shuttle's versatility and reusability are key elements in opening a new era of expanded use of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle consists 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 altitude and planetary missions. The advent of readily available, economical transportation to and from low Earth orbit for automated payloads, as well as for scientists and other personnel, will revolutionize our concepts of using space and will expand the returns from space operations. The Shuttle's unique capabilities will not only lower the cost of space operations but will also lead to savings in the costs of payloads. These anticipated savings will result from repair and reuse of payloads and relaxation of weight and size constraints. The advantages offered by the space transportation system over existing expendable launch systems will enhance both the flexibility and the productivity of space missions.

Completion of orbital flight testing and delivery of the second orbiter are scheduled for FY 1982. Initiation of operational flights are scheduled to begin in FY 1983. Production on the orbiter fleet will continue in FY 1983 with the third orbiter scheduled for delivery in September 1983 and the fourth orbiter to be delivered about fifteen months later.

Preparations are underway for the third (STS-3) of the four Space Shuttle flights in the orbital flight test program. Orbiter 102 (Columbia) is in the Kennedy Space Center's Orbiter Processing Facility (OPF) for checkout. It is scheduled to be moved from the OPF to the vehicle assembly building in February 1982, where it will be mated to the external tank (ET) and the two solid rocket boosters. Following integrated testing of these elements, the vehicle is scheduled to be moved to the launch pad for final launch preparations. The STS-3 launch is scheduled for late March 1982, and is to land at the Dryden Flight Research Facility - Edwards Air Force Base.

The second, third, and fourth flight orbiters are in various stages of manufacturing. Challenger, Orbiter 099, is scheduled for delivery in mid-1982. Substantial parts of its airframe were used during the development phase to test the structural dynamics of the vehicle under various load conditions; the modifications to convert it into a flight orbiter are nearly complete. Discovery, Orbiter 103, is well into the structural assembly phase at the Rockwell facility in Downey, California, and at the various subcontractor facilities around the country; OV-103 is planned for delivery in September 1983. Atlantis, Orbiter-104, is in the early stages of primary structural buildup; its delivery is scheduled to occur in December 1984. The highest priority has been assigned to maintaining the delivery schedule for Orbiter-099 and Orbiter-103, however, and within the resources available, certain Orbiter-104 activities scheduled for FY 1982 may have to be delayed. Procurement of the necessary supporting hardware, such as the remote manipulator system, is underway on a schedule which supports the above orbiter delivery dates.

The production main engines required to support the testing and flight program are currently being delivered. These engines are in the full power level configuration, providing thrust levels at 109% of the rated power level engines used for the first flights of Orbiter Vehicle-102, Columbia. Seven production engines are scheduled for delivery in FY 1982.

For FY 1982, the budget plan for design, development, test and evaluation covers the estimated cost for completing the development and flight test program. The FY 1982 and 1983 budget plan for production provides for progress on the second, third, and fourth orbiters based on the above delivery schedules and for production of main engines, for spares and equipment, and for second line ground support equipment at the Kennedy Space Center. The budget recommendation also provides a total of $72.5 million for changes and systems upgrading to meet additional requirements and improvements needed as a result of actual flight experience.

Because present projections show that some augmentation of ascent performance will be needed to support certain national security missions, funds have been included in the FY 1983 budget to develop filament wound motor cases to significantly reduce the weight of the solid rocket boosters. FY 1982 funding budgeted for performance augmentation studies will be applied to this project to help meet an October 1985 mission need date.

Progress on the Space Shuttle will be matched by other activities vital to the establishment of the space transportation system operational capability and to preparations for early operational missions. The Spacelab, a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the

unique environment of space. The Spacelab is being designed and built by the European Space Agency, with ten European nations participating in this development. Upper stages are required for use with the Shuttle for planetary missions and for Earth orbital missions such as geosynchronous missions, requiring altitudes beyond the basic Shuttle capability.

Space transportation system operational missions are scheduled to begin in early FY 1983. The FY 1983 budget provides for these missions through continued procurement, assembly, and checkout of the solid rocket booster, external tank and upper stages; and through flight planning, avionics software, mission integration activities, flight control systems, crew procedures, crew training, crew equipment, and other mission oriented activities.

Space transportation system activities during FY 1983 will also provide expendable launch vehicles and services, as well as engineering support, to meet the heavy demand during the period of transition to the space transportation system.

Included in this budget for FY 1982 and FY 1983 are activities to support a demonstration of the space transportation system's ability to support a mission to retrieve an operating spacecraft and repair it on orbit or return it to Earth for refurbishment. It has been determined that the Solar Maximum spacecraft, which is now partially disabled, will serve as the target for this demonstration. NASA plans to restore this spacecraft to full operational status for further important data gathering.

SPACE SCIENCE

The space science program uses space systems supported by airborne and ground-based observations to study the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, and the other stars of our galaxy and universe. Results from these investigations significantly contribute to our understanding of the universe, including the key questions of life, matter, energy, and the complex phenomena that have such a profound effect on life and environment on Earth.

The Sun exerts a primary influence on the Earth and its immediate environment. A series of orbiting solar observatory missions has been conducted to study solar pheonomena. The discoveries from these missions, from the experiments flown during the Skylab program, and from the Solar Maximum Mission launched in 1980 to study the Sun during the period of peak solar flare activity, are revolutionizing our understanding of the Sun. The International Solar Polar Mission, a joint NASA and European Space Agency mission, will provide information on the solar system from far above the plane in which the

planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions as a function of solar latitude, and may allow us to gain insight into the possible effects of solar activity on weather and climate trends on Earth.

Development of the Space Telescope will continue. This multiple purpose telescope will be launched by the Shuttle, and will serve as a highly versatile astronomy observatory in space for over a decade. The Space Telescope will greatly expand the volume of space accessible for observation, contributing significantly to our understanding of the origin and evolution of the universe and its energy-generating mechanisms.

The three High Energy Astronomy Observatory missions have been successfully launched and have yielded important scientific information. These missions explored the high energy phenomena observable with X-ray, gamma ray, and cosmic ray instruments. Work is also underway on explorer spacecraft to study ultraviolet and infrared astronomy and the Sun-Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab. The Gamma Ray Observatory, initiated in 1981, will take a significant next step in high energy astro-physics. This mission will conduct a comprehensive whole-sky survey in the highest energy region of the electromagnetic spectrum, which will advance knowledge of the nuclear processes occuring in the universe, and of the nature and dynamics of pulsars, galactic gamma ray processes, neutron stars, and black holes.

Orderly progress in the systematic exploration of the solar system is proceeding. The objectives of this effort are to understand the origin and evolution of the solar system and to better understand the Earth through comparative studies with other planets. Pioneer Venus provided basic information about the massive cloud covered atmosphere of Venus. The Voyager I and II spacecraft, after providing a wealth of new information about Jupiter and its moons, have made spectacular contributions to our knowledge of Saturn, its rings, and its satellites. Voyager II is now headed for an encounter with Uranus in 1986. The Voyager results have added to our confidence that the Galileo mission to Jupiter will also be a major milestone in planetary exploration. The major effort in FY 1983 will be continued development on the Galileo mission which will use a probe to make detailed measurements of the atmosphere of Jupiter and an orbiter to conduct extensive observations of the planet and its satellites.

SPACE AND TERRESTRIAL APPLICATIONS

The objective of the space applications program is to develop and transfer space technology, systems and related capabilities for practical benefits here on Earth. Space applications research and development covers the areas of resources observations, environmental observations, materials processing, and communications. Technology utilization activities are designed to accelerate and expand the availability and use of technology developed in all NASA programs into the private and public sectors of the economy.

Resource Observations - Principal activities include the identification of user information needs, development of remote sensing and information extraction techniques, and provision for the acquisition of space data leading eventually to the establishment and routine use of global data collection systems. Currently, Landsat-2 and -3 are providing a wide variety of useful data. Landsat-D, with improved sensing capabilities, is under development and will be launched in 1982. NASA will support the National Oceanic and Atmospheric Administration (NOAA) in its new responsibility for managing the operation of the Landsat-D system. Experiments designed to test the applicability of active microwave measurements were successfully conducted on the second Space Shuttle orbital test flight, and a large format camera to obtain high resolution imagery for mapping investigations is planned for flight on a subsequent Shuttle mission. Studies are also underway for development of advanced technology for improved remote sensors for multiple applications. Joint research, development, and testing activities with other Federal agencies are underway to advance our understanding of how to apply multiple data sources in improving agricultural early warning and crop commodity forecasting. Joint research activities are planned with other Federal agencies and coordinated with international organizations for advancing the scientific knowledge of the solid Earth.

Environmental Observations - This program aims at improving the understanding of processes in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional in extent, they can be most effectively, and sometimes solely, studied from space. NASA's program includes research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites give a special view of the radiative, chemical, and dynamic processes occuring in the atmosphere and oceans.

Studies of the upper atmosphere are producing an understanding of the distribution of ozone and other trace constitutents and predictions of how these will evolve. Localized field measurements are

determining the detailed processes involved. The upper atmospheric research satellite experiment program is developing a set of instruments to provide the needed global data for a comprehensive determination of the state of the upper atmosphere. We are continuing to assess the severity of the threat to the ozone layer due to chlorofluorocarbons. Our ability to make projections is being improved through laboratory measurements and the development of more realistic numerical models which make use of the data obtained from in situ and space observations.

Research on the dynamics and radiative properties of the atmosphere is showing that the improved global observations available only from space show promise of extending long range weather forecasts from the current four to five days to eight to ten days. Advanced numerical modeling techniques are being employed to improve our understanding of weather and severe storm phenomena. New remote sensing capabilities, such as the earth radiation budget experiment, are being developed to provide the data needed to test our theories and extend predictive abilities.

Data from the instruments carried on the NIMBUS, SAGE, and SEASAT satellites continue to prove valuable in understanding many aspects of the environment. Ocean observations have shown the potential for revolutionizing oceanography and providing useful new information. An effort is underway to determine the best approach to using satellite altimeters to measure the currents flowing in the global ocean. The perspective of ocean circulation offered by space has never been available to oceanographers. Quantitative measurements of the chlorophyll concentration in the ocean surface layer have been made using the coastal zone color scanner and are being used to determine the productivity of the ocean and the best places to fish. Measurements of sea surface winds have been shown to be useful in improving weather forecasts and will be essential to determining wind driven components of the ocean circulation.

Materials processing - Research activities are designed to exploit the unique capabilities of spaceborne facilities for materials processing in the space environment, and to provide opportunities for independently-funded users to exploit space flight for processing activities related to their own needs. These activities are intended to encourage early transfer of space activity in materials science to private sponsorship. Ground-based research in FY 1982 will accommodate new areas of interest in materials science and in physical and chemical sciences as well as advanced technology development to meet needs identified in the research program. The program's first space transportation system payload, the fluid experiments system/vapor crystal growth apparatus, will undergo ground tests in 1983, leading to flight in early 1984.

Communications and information systems - In FY 1982 and FY 1983 will focus on completion of generic proof-of-concept communications technology applicable to the Ka band (30/20 GHz), technical support to the United States government for the World Administrative Radio Conference/Regional Administrative Radio Conference planning efforts, and continued experiment support to the Applications Technology Satellites 1-3-5. Information systems support will continue to emphasize development and demonstration of advanced data facilities.

Technology utilization - Activities are designed to accelerate the transfer of new knowledge and innovative technology generated by NASA and NASA contractors to the nonaerospace industry, as well as to State and local governments. During FY 1983, NASA will continue its efforts to assure effective and widespread dissemination of new technology.

AERONAUTICAL RESEARCH AND TECHNOLOGY

The objective of the aeronautics program is to provide the technology base essential for continued United States leadership in aeronautics. This technology base is needed for the development of future aircraft with improved performance and underlies the strong competitive position of the United States in the world aviation marketplace and the continued superiority of the Nation's military aircraft. The recommended program for FY 1983 includes a strong research and technology base effort and continuation of low speed and high speed systems technology activities.

The FY 1983 budget includes the necessary activities to provide a strong research and technology base. These activities place emphasis on the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human-vehicle interaction, materials and structures; and on the conduct of focused technology activities relevant to rotorcraft and high performance aircraft.

SPACE RESEARCH AND TECHNOLOGY

The objectives of the space research and technology program are to provide a technology base which will adequately support current and future space activities and to implement approaches for further reducing the costs of future space activities through improvement of components. The FY 1983 budget provides a modest increase in fundamental disciplinary research and technology. Emphasis on the longer term aspects of space technology is critical to future United States leadership in space.

In FY 1983, activities will focus on maintaining a strong research and technology base in the discipline areas of aerothermodynamics, chemical propulsion, materials and structures, electronics and

automation, and space power and electric propulsion. These are the only NASA advanced research and technology programs designed to support and extend these critical aerospace disciplines. In addition, activities in the research and technology base in information, spacecraft, and transportation systems research and technology are designed to study the interrelationships of discipline technology from an integrated systems point of view and are critical to the successful transition of technology from the laboratory to useful application. The systems technology effort in FY 1983 will focus on launching the solar array flight experiment, the solar cell calibration facility, and the tribology experiment aboard the Space Shuttle.

TRACKING AND DATA ACQUISITION

This program provides the vital tracking and data support required by all NASA flight projects in accomplishing their mission objectives. This support is provided by a worldwide network of NASA electronic ground stations and transportable laser tracking facilities interconnected by a communications system using ground, undersea, and satellite circuits. Computation facilities also are provided to process into usable 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.

In FY 1983, operations funding will provide support to Space Shuttle flights and to some fifty individual spacecraft missions. Systems funding will sustain the existing facilities and systems at the lowest levels consistent with the support of the ongoing missions and provide the necessary modifications to meet the requirements of approved future flight missions including those of the operational space transportation system.

Beginning in FY 1983, a major aspect of the tracking and data acquisition program 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.

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; 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 [; and including not to exceed (1) $75,000,000 for Space Transportation Systems Upper Stages. (2) **$40,000,000** for Space Transportation Systems Operations—Upper Stages. **(3) $119,500,000** for the Space Telescope, (4) $10,000,000 for Venus Oribiting Imaging Radar, (5) $8,000,000 for the Gamma Ray Observatory, **(6) $108,000,000** for Project Galileo, **(7) $83,900,000** for Landsat D, **(8) $2,194,000,000** for the Space Shuttle, and **(9) $110,700,000** for Spacelab, without the approval of the Committees on Appropriations, **$4,973,100,000]** ***$5,334,000,000,*** to remain available until September **30, [1983]** *1984 (42 U.S.C. 2451, et. seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1982; 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 programmed)			Costs and obligations		
	1981 actual	1982 est.	1983 est.	1981 actual	1982 est.	1983 est.
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Space Shuttle	1.995.000	2.163.000	1.718.000	2.047.559	2.186.600	1.756.100
(b) Space flight operations	679.200	895.900	1.707.000	626.090	888.500	1.539,000
(c) Expendable launch vehicle development	41.800	15.700	30.900	39.465	27.100	31.400
2. Scientific investigations in space:						
(a) Physics and astronomy	330.600	329.700	479.400	328.982	332.000	435.600
(b) Planetary exploration	175.600	205.000	154.600	203.165	187.400	169.600
(c) Life sciences	42.188	39.500	55.700	42.953	42.300	46.700
3. Space and terrestrial applications:						
(a) Space applications	337.250	335.100	320.500	344.262	341.000	324.000
(b) Technology utilization	8.800	8.000	4.000	11.597	9.500	5.900
4. Space research and technology	110.700	111.000	123.000	116.291	116.900	120.300
5. Aeronautical research and technology	271.400	233.000	232.000	286.363	281.300	242.100
6. Energy technology	1.900	---	---	2.208	400	100
7. Supporting activity:						
(a) Tracking and data acquisition	339.900	402.100	508.900	363.303	360.400	532.200
Total direct program	4.334.338	4.738.000	5.334.000	4.412.238	4.773.400	5.203.000
Reimbursable program:						
1. Space transportation systems:						
(a) Space Shuttle	56.105	681.000	171.000	53.205	615.870	243.770
(b) Space flight operations	92.108	179.200	357.200	81.139	162.710	312.560
2. Scientific investigations in space:						
(a) Physics and astronomy	2.216	2.670	2.670	777	4.200	2.550
(b) Planetary exploration	169	180	180	80	170	180
(c) Life sciences	145	250	250	58	320	240
3. Space and terrestrial applications:						
(a) Space applications	284.673	334.500	347.700	271.936	343.980	329.570
(b) Technology utilization	21.171	19.700	24.500	18.898	27.280	22.610
4. Space research and technology	1.865	1.200	1.400	1.305	2.160	1.310
5. Aeronautical research and technology	23.659	22.600	20.700	22.049	27.990	20.040
6. Energy technology	196.406	84.200	99.600	163.481	138.880	92.570
7. Supporting activity:						
(a) Tracking and data acquisition	11.483	9.300	8.200	8.653	11.240	8.000
Total reimbursable program	690.000	1,334,800	1.033.400	621.581	1.334.800	1,033,400
Total program costs. funded	5.024.338	6.072.800	6.367.400	5.033.819	6.108.200	6.236.400
Change in selected resources (undelivered orders and stores)	---	---	---	36.361	393.579	131.000
10.00 Total	5.024.338	6.072.800	6.367.400	5.070.180	6.501.779	6.367.400

PROGRAM AND FINANCING (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programmed) 1981 actual	1982 est.	1983 est.	Costs and obligations 1981 actual	1982 est.	1983 est.
Financing:						
Offsetting collections from:						
11.00 Federal funds	-441,807	-1,099,437	-666,370	-408,238	-1,009,437	-666,370
14.00 Non-Federal sources	-248,193	-325,363	-367,030	-169,500	-325,363	-367,030
Unobligated balance available, start of year: For completion of prior year budget plans:						
21.40 Direct	---	---	---	-368,724	-282,483	---
21.40 Reimbursable	---	---	---	-218,479	-147,696	---
23.40 Unobligated balance transferred to other accounts	1,200	---	---	---	1,200	---
Unobligated balance available, end of year: For completion of piror year budget plans:						
24.40 Direct	---	---	---	282,483	---	---
24.40 Reimbursable	---	---	---	147,696	---	---
25.00 Unobligated balance lapsing	---	---	---	120	---	---
39.00 Budget authority	4,335,538	4,738,000	5,334,000	4,335,538	4,738,000	5,334,000
Budget authority:						
40.00 Appropriation	4,396,200	4,973,100	5,334,000	4,396,200	4,973,100	5,334,000
40.00 Reduction pursuant to Public Law 96-526	-55,412	---	---	-55,412	---	---
40.00 Reduction pursuant to Public Law 97-101, see. 501 (41)	---	-232,200	---	---	-232,200	---
40.01 Appropriation rescinded (Public Law 97-12)	-4,500	---	---	-4,500	---	---
41.00 Transferred to other accounts	-750	-2,900	---	-750	-2,900	---
43.00 Appropriation (adjusted)	4,335,538	4,738,000	5,334,000	4,335,538	4,738,000	5,334,000
Relation of obligations to outlays:						
71.00 Obligations incurred, net				4,492,442	5,166,979	5,334,000
72.40 Obligated balance, start of year				1,008,505	1,267,945	1,842,124
74.40 Obligated balance, end of year				-1,267,945	-1,842,124	-1,890,924
77.00 Adjustments in expired accounts				-4,634	---	---
90.00 Outlays				4,228,368	4,592,800	5,285,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET PLAN SUMMARY

Code		FY 1981	FY 1982	FY 1983
		(Thousands of Dollars)		
	SPACE TRANSPORTATION	2,728,600	3,090,100	3,467,800
253	Space Shuttle	1,995,000	2,163,000	1,718,000
253	Space flight operations	679,200	895,900	1,707,000
253	Expendable launch vehicles	54,400	31,200	42,800
	SPACE SCIENCE AND APPLICATIONS	881,838	901,800	1,002,300
254	Physics and astronomy	323,700	323,500	471,700
254	Planetary exploration	175,600	205,000	154,600
254	Life sciences	42,188	39,500	55,700
254	Space applications	331,550	325,800	316,300
254	Technology utilization	8,800	8,000	4,000
	AERONAUTICS AND SPACE TECHNOLOGY	384,000	344,000	355,000
402	Aeronautical research and technology	271,400	233,000	232,000
254	Space research and technology	110,700	111,100	123,000
254	Energy technology	1,900	---	---
255	TRACKING AND DATA ACQUISITION	339,900	402,100	508,900
	Total	4,334,338	4,738,000	5,334,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code		FY 1981	FY 1982	FY 1983
253	Space Flight	2,728,600	3,090,100	3,467,800
254	Space Science, Applications and Technology	994,438	1,012,800	1,125,300
255	Supporting Space Activities	339,900	402,100	508,900
(250)	Subtotal, General Science, Space and Technology	4,062,938	4,505,000	5,102,000
402	Air Transportation	271,400	233,000	232,000
	Total	4,334,338	4,738,000	5,334,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR J3 ESTIMATES

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

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
SPACE TRANSPORTATION PROGRAMS	1981	2,728,600	1,464,500	361.300	808,700	5,600	47,100	100	1,663	1,647	25,300	12,690
	1982	3,090,100	1,566,900	431.300	1,001,900	5,900	32,400	200	2,617	889	600	47,394
	1983	3,467,800	1,554,600	448,000	1,265,000	4,800	48,100	200	1,800	---	5,000	140,300
Space Shuttle	1981	1,995,000	1,298,700	248,500	438,600	300	---	---	1,663	747	---	6,490
	1982	2,163,000	1,328,900	324,200	473,000	---	---	---	2,617	89	---	34,194
	1983	1,718,000	1,034,400	69,000	495,800	---	---	---	---	---	---	118,800
Space flight operations	1981	679,200	165,800	110,500	370,100	5.300	1,900	100	---	---	19,700	5.800
	1982	895,900	238,000	104,900	528,900	5,900	4,800	Z00	---	---	600	12,600
	1983	1,707,000	520,200	377,200	769,200	4,800	7,400	200	1,800	---	5,000	21,200
Exoendable launch vehicles	1981	54,400	---	2,300	---	---	45,200	---	---	900	5,600	400
	1982	31,200	---	2,200	---	---	27.600	---	---	800	---	600
	1983	42.800	---	1,800	---	---	40,700	---	---	---	---	300
SPACE SCIENCE AND APPLICATIONS PROGRAMS	1981	881,838	51.169	3,819	176,706	2,948	264,551	164,459	74,061	13,914	19,459	110,752
	1982	901,800	41,167	2,136	185,009	3,225	304.996	199,750	69,393	12,708	8,940	74,476
	1983	1,002,300	49,274	3,225	240,524	2,800	364,066	195,497	56,468	11,173	6.050	73,223
Physics and astronomy	1981	323,700	2,001	3.146	159.468	---	79.980	36,626	10,969	37	---	31,473
	1982	323,500	1,485	1,215	165,184	---	104,431	21,766	4,717	18	---	24,684
	1983	471,700	4,360	1,700	221,779	---	170,226	36,871	6,617	18	---	30,129
Planetary exploration	1981	175,600	8,397	---	30	---	3,943	99,471	27,194	7	---	36,558
	1982	205,000	11,400	---	---	---	3,900	146,500	30,650	---	---	12,550
	1983	154,600	8,900	---	---	---	3,500	120,200	12,000	---	---	10,000
Life sciences	1981	42,188	14,104	390	8	---	---	1,234	17,190	176	---	9,086
	1982	39,500	13,120	871	259	---	---	1,704	17,071	170	---	6,305
	1983	55,700	20,964	1.525	350	---	---	2,732	21,351	170	---	8,608
Space applications	1981	331,550	26,667	255	16,948	2,814	179,666	25,305	18,155	12,835	19,301	29,604
	1982	325.800	15,062	---	19,166	3,225	195,800	29,480	16,755	12,070	8,740	25,502
	1983	316,300	15,050	---	18,200	2,800	189.950	35.644	16,450	10,750	6,050	21,406
Technology utilization	1981	8,800	---	28	252	134	962	1,823	553	859	158	4,031
	1982	8,000	100	50	400	---	865	300	200	450	200	5,435
	1983	4,000	---	---	195	---	390	50	50	235	---	3,080
AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS	1981	384.000	7.940	4	10.295	---	9,490	21,529	81,612	127,355	118,689	7,086
	1982	344,000	8,150	---	10,300	---	9,500	20,500	91,000	108,500	88,850	7,200
	1983	355,000	9,850	---	15,150	---	11,100	23,500	105,700	104,300	76,700	8,700
Aeronautical research and technology	1981	271,400	190	---	675	---	590	780	71,462	100,155	93,389	4,159
	1982	233,000	150	---	800	---	500	500	80,750	80,500	65,300	4,500
	1983	232,000	150	---	750	---	500	500	95,000	76,000	54,600	4,500
Space research and technology	1981	110,700	7,600	---	9.450	---	8,900	19,600	10,150	27,200	24,900	2,900
	1982	111,000	8,000	---	9,500	---	9,000	20,000	10,250	28,000	23,550	2,700
	1983	123.000	9,700	---	14,400	---	10,600	23,000	10.700	28,300	22,100	4.200
Energy technology	1981	1,900	150	4	170	---	---	1,149	---	---	400	27
	1982	---	---	---	---	---	---	---	---	---	---	---
	1983	---	---	---	---	---	---	---	---	---	---	---
TRACKING AND DATA ACQUISITION PROGRAM	1981	339,900	---	---	Z00	---	250,080	72,598	3,070	---	---	13,952
	1982	402,100	---	---	700	---	281,500	96,600	2,900	---	---	20,400
	1983	508,900	---	---	500	---	380,200	107,100	3,900	---	---	17,200
TOTAL BUDGET PLAN	1981	4,334,336	1,523,609	365,123	995,901	8,548	571,221	258,686	160,406	142,916	163,448	144,480
	1982	4,738,000	1,616,217	433,436	1,197,909	9,125	628,396	317,050	165,910	122,097	98,390	149,470
	1983	5,334,000	1,613,724	451,225	1,521,174	7,600	803,466	326,297	167,868	115,473	87,750	239,423

SPACE
TRANSPORTATION
PROGRAMS

SPACE
SHUTTLE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE TRANSPORTATION SYSTEMS

Programs	Budget Plan			
	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Space Shuttle	1,995,000	2,194,000	2,163,000	1,718,000
Space flight operations	679,200	910,900	895,900	1,707,000
Expendable launch vehicles	54,400	31,200	31,200	42,800
Total	2,728,600	3,136,100	3,090,100	3,467,800

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS | **SPACE SHUTTLE PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
	(Thousands of Dollars)				
Design. Development. Test and Evaluation	973.000	740.000	898.000	---	
Orbiter	510.500	372.000	422.000	---	RD 1-7
Main engine	134.000	127.000	130.000	---	RD 1-9
External tank	63.500	25.000	56.000	---	RD 1-10
Solid rocket booster	50.500	17.000	30.000	---	RD 1-12
Launch and landing	214.500	199.000	260.000	---	RD 1-13
Production	1.022.000	1.154.000	1.260.000	1.585.500	
Orbiter	779.000	837.000	860.000	933.500	RD 1-16
Main engine	112.000	105.000	144.000	262.000	RD 1-19
Launch and landing	33.000	57.000	63.000	67.000	RD 1-20
Spares and equipment	98.000	155.000	193.000	323.000	RD 1-23
Changes/Systems Upgrading	---	300,000	---	72.500	RD 1-25
Performance Augmentation	---	(5,000)	5.000	60.000	RD 1-27
Total	1.995.000	2.194.000	2.163.000	1.718.000	

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation:				
Johnson Space Center	1,298,700	1,232,400	1,328,900	1,034,400
Kennedy Space Center	248,500	256,800	324,200	69,000
Marshall Space Flight Center	438,600	389,800	473,000	495,800
National Space Technology Laboratories	303	---	---	---
Ames Research Center	1,663	1,600	2,617	---
Langley Research Center	747	100	89	---
Headquarters	6,490	313,300	34,194	118,800
Total	1,995,000	2,194,000	2,163,000	1,718,000

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 Space Shuttle is the first reusable space vehicle, and is 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 Space 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 equipments to orbit; and to perform rescue missions. These capabilities will greatly enhance Elexibility and productivity, and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements -- the orbiter, the main engines, an expendable external propellant tank (ET), and twin solid rocket boosters (SRB) -- plus launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads into orbit to perform their assigned tasks and return them to Earth. The orbiter is roughly the size of a DC-9 aircraft and contains three liquid fueled reusable main engines. It also provides a habitable environment for a crew which will include scientists and engineers.

MISSION PROFILE:

The Space Shuttle is launched into space by the thrust of its three 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 (24 nautical miles), the solid rocket boosters burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) downrange. They then

are recovered for refurbishment and reuse. The three main engines continue to burn for another six and one-half minutes. Just before orbital insertion, the engines are shut down and the external tank jettisoned. Following a ballistic trajectory, the empty tank reenters, tumbles, and breaks up over a remote ocean area about 18,500 kilometers (10,000 nautical miles) downrange. The orbiter, aided by its orbital maneuvering engines, enters Earth orbit to perform its mission. After completing the mission, the orbiter again fires its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will usually have a crew of three: the commander, the pilot, and the mission specialist. On some missions, up to four more mission or payload specialists may be added. The crew will experience forces not greater than three times that of gravity during launch and landing, and is able to perform their work in a shirt-sleeve environment.

STATUS:

Prelaunch preparations are underway for the third (STS-3) of the four Space Shuttle flights in the development orbital flight test program. Orbiter 102 (Columbia) is currently in the Kennedy Space Center's Orbiter Processing Facility (OPF) undergoing checkout. It is scheduled to be moved from the OPF to the vehicle assembly building in early February 1982, where it will be mated to the ET and the two SRB's. Following integrated testing of these elements, the vehicle is scheduled to be moved to the launch pad in late February 1982, for final launch preparations. The STS-3 launch is scheduled for late March 1982, and is scheduled to land at the Dryden Flight Research Facility - Edwards Air Force Base.

Main engine activities have consisted principally of single engine testing culminating in the completion in FY 1981 of the preliminary flight certification program which qualified the engines for the first orbital flight. The engines performed flawlessly during first flight of the Columbia, requiring only inspections and minor maintenance to prepare them for the second flight. Testing was initiated on the full power level (FPL) version of the main engine during FY 1981. The technical problems which were discovered in this early development testing (two main injector liquid oxygen post failures, a fuel preburner liquid oxygen post failure, and a fuel turbopump turbine failure) have been corrected. Testing is continuing in support of the FPL certification program which was initiated early in FY 1982.

The third flight external tank has been delivered to the Kennedy Space Center (KSC). The fourth external tank is in final checkout for delivery in January 1982. The two remaining tanks of the

heavyweight configuration, along with the first six lightweight tanks, are in various stages of manufacture at the Michoud Assembly Facility.

In 1981, SRB subsystem component qualification tests were completed to support the STS–1 flight and to qualify components for reuse capability. The flight hardware was assembled for the second orbital flight test. Repair of the aft skirts damaged during water impact on **STS-1** was started and should be completed early in 1982.

At the Kennedy Space Center, the first line of Space Shuttle processing facilities and ground support equipment are fully activated and have successfully supported the vehicle assembly, tests, servicing, checkout and launches for STS–1 and STS–2. The processing activities also included the replacement of defective vehicle parts, changeout of payloads, orbiter deservicing and ferrying from the Dryden Flight Research Facility landing site to the Kennedy Space Center, and retrieval of SRB's from the Atlantic Ocean and subsequent disassembly. The processing procedures, software, and launch processing system are functioning well and the workforce is supporting critical path processing on a schedule of three shifts a day, six days per week. Assembly of the SRB and ET elements and premate testing of the orbiter is underway in preparation for launching STS–3 in March 1982.

The second, third, and fourth flight orbiters are in various stages of manufacturing. Challenger, Orbiter 099, is scheduled for delivery in mid–1982. Substantial parts of its airframe were used during the development phase to test the structural dynamics of the vehicle under various load conditions; the modifications to convert it into a flight orbiter are nearly complete. Discovery, Orbiter 103, is well into the structural assembly phase at the Rockwell facility in Downey, California, and at the various subcontractor facilities around the country; OV–103 is planned for delivery in September 1983. Atlantis, Orbiter 104, is in the early stages of primary structure build–up; its delivery is scheduled to occur in December 1984. However, within the available funding for FY 1982, the highest priority has been assigned to maintaining the delivery schedule for Orbiter–099 and Orbiter–103; certain Orbiter–104 activities scheduled for FY 1982 may have to be rephased. Procurement of the necessary supporting hardware, such as the remote manipulator system and television cameras, is underway on a schedule which supports the above orbiter delivery dates.

The production main engines required to support the testing and flight program are currently being delivered. These engines are in the full power level configuration, providing thrust levels at 109% of the rated power level engines used for the first flights of Orbiter Vehicle–102, Columbia. Seven production engines are scheduled for delivery in FY 1982.

At the Kennedy Space Center, a number of the second line of processing facilities are nearing completion. Activation of the second bay of the Orbiter Processing Facility, the second SRB and ET checkout bay and second vehicle assembly bay in the Vehicle Assembly Building, and the second mobile launcher platform has been accelerated to receive and process Challenger independently of Columbia when Challenger is delivered in mid-1982. The readiness date for the software development facility in the launch control center firing room is also being accelerated to support this independent second line. Work on the second firing room, second launch pad, and increased rate capability in other work stations is underway, with activation planned for subsequent years.

Spares and equipment funds provide for the initial operational inventory of crew equipment, necessary spares for flight hardware and ground support equipment, plus ET and SRB production rate tooling. This includes orbiter flight spares, orbiter and launch site ground support equipment spares, the extravehicular mobility units (each comprised of a space suit assembly, a primary life support system, and a portable oxygen system), main engine spares, and ET and SRB production tooling to support the operational flight rate buildup.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

DESIGN, DEVELOPMENT, TEST, AND EVALUATION

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Orbiter.....	510,500	372,000	422,000	---

OBJECTIVES AND STATUS:

The orbiter is a reusable vehicle which serves as the orbiting spacecraft to deploy and retrieve payloads in low Earth orbit and provides living quarters for personnel in orbit. The orbiter reenters the atmosphere and lands as an unpowered aircraft, returning crew and payloads. A payload of up to 29,500 kilograms (65,000 pounds) can be placed in low Earth orbit at an altitude of 185 kilometers (100 nautical miles). The payload bay is 4.6 meters (15 feet) wide by 18.3 meters (60 feet) long.

Columbia (Orbiter 102)--the DDT&E flight vehicle--has flown two very successful flights: STS-1 in April 1981 and STS-2 in November 1981. STS-1 was the first flight in the four-flight orbital flight test program. The orbiter systems performed almost flawlessly on the first flight. Some minor thermal protection system (TPS) damage was noted, with one whole tile and pieces of 15 other tiles missing. This minor tile damage caused no mission problems. All flight objectives were achieved and the landing took place as planned at Edwards Air Force Base (EAFB).

Following the landing at EAFB, Columbia was checked, deserviced, and placed atop the 747 carrier aircraft for transport back to the Kennedy Space Center (KSC). Upon arrival at KSC, Columbia was towed to the Orbiter Processing Facility (OPF) where it was prepared for the second flight. While in the OPF, modifications and repairs were made to the orbiter and for the first time, a payload was installed in the payload bay. This payload, OSTA-1, was a multiobjective experiment mounted to a Spacelab pallet. Also, for the first time, the remote manipulator system (RMS) was installed in the payload bay. This arm was developed by Canada and the first flight unit was provided by the Canadian government at no cost to the United States.

After processing in the OPF, Columbia was moved to the Vehicle Assembly Building (VAB) for mating with the external tank/solid rocket booster; a few weeks later, the stacked vehicle was moved to the launch pad. A fluid spill during fuel loading of the forward reaction control system caused damage to thermal protection system tiles and resulted in about a one month delay in launch. A further one week delay was required when the auxiliary power unit filters were found to be clogged; they were subsequently cleaned, lines were flushed, and the STS-2 launch took place on November 12, 1982.

This flight lasted approximately 54 hours, shortened from the planned 124 hours due to a problem with one of the fuel cells. However, despite the shortened mission, nearly 90% of the high priority mission objectives were attained and the flight has been classified as very successful. All systems worked well and only minor anomalies were reported. Tile damage was limited to small nicks with no missing tiles. Most of the damage was caused by launch and ascent debris. The remote manipulator system's overall performance was excellent. The general status of the vehicle is better than after STS-1. Once again, the crew commented on the precise handling characteristics of the orbiter.

Columbia is now back at KSC undergoing preparations for the third flight now scheduled for March 1982. Flight software verification and mission support for STS-3 and STS-4 will be provided by the Space Shuttle avionics integration laboratory (SAIL) at the Johnson Space Center and the flight system laboratory (FSL) at Rockwell in Downey, California. The fourth and final flight in the orbital flight test program is scheduled for July 1982, after which the orbiter will be readied for its first operational flight--now planned for November 1982.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The orbiter estimate has increased by $50.8 million. Orbiter prime contractor increases have been experienced due to the delay in completion of life qualification of subsystems, and the implementation of changes such as the trans-Atlantic abort capability and redesign of the motor control assembly. Other increases have been experienced for external tank reentry tracking, continued mission control capability development, support and data reduction activities associated with the orbital flight tests, and the continued development of the manned maneuvering unit.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of	Dollars)	
Main engine.....	134,000	127,000	130,000	---

OBJECTIVES AND STATUS:

The highlight of 1981 for the Space Shuttle main engine program was the flawless performance of the three engines installed in Columbia during the first two orbiter flight tests. Their performance during flight was the culmination of many years of testing and continuing engineering analyses to develop a reliable and reusable rocket engine having the highest thrust to engine weight relationship of any engine yet developed. At rated power levels, these engines develop 470,000 pounds of thrust in the vacuum of space. Through December 1981, the main engine program had accumulated a total of over 800 tests and more than 135,000 seconds of operations.

The development effort to increase the main engine's performance to full power level (109% of rated power level) is the current principal program focus. Sixty-four tests and 13,574 seconds of operations at the full power level have been run through December 1981. During 1981, several engine problems at the full power level were discovered during development testing. On July 15, 1981 and on September 3, 1981, two main injector liquid oxygen posts failed during testing, resulting in substantial injector damage on two test engines. Also, on July 14, 1981, a fuel preburner liquid oxygen post failed, resulting in preburner face plate errosion. After substantial analyses, fixes were designed to preclude further problems of these types.

In FY 1982, testing activities will be concentrated on demonstrating that the full power level engine design will result in a reliable engine suitable for flight use. Flight certification of the full power level engines began in FY 1982 and should be completed in early FY 1983. Full power level certification testing and the initiation of life demonstration testing activities in FY 1983 are funded under the main engine production program.

In addition to the development and test work by Rocketdyne and its subcontractors, there are a number of necessary project support efforts. These include engineering analyses, propellant procurement, maintenance of the engine systems hardware simulation laboratory, logistics support, and materials and processes evaluation.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The 1982 estimate for the Space Shuttle main engine has been increased by $3.0 million. A substantial part of this increase was utilized to cover unit cost growth in propellants. In addition to this, research and development funds were required to repair the bearing test facility at the Marshall Space Flight Center which will be utilized for testing hydrogen turbopump bearings. The remainder of the increase was due to the added hardware requirement to support schedule adjustments in the full power level development and certification testing programs.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
External tank.....	63,500	25,000	56,000	---

OBJECTIVES AND STATUS:

The external tank (ET) contains all the propellants for the orbiter's three main engines - liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the orbiter's main engines from main engine start to engine cutoff, which occurs just before orbital insertion. Following the main engine cutoff, the ET separates from the orbiter and falls through a ballistic trajectory to break up over a designated remote ocean area. The ET is a single assembly approximately 8.5 meters (27.5 feet) in diameter and 47 meters (154 feet) long. It contains approximately 700,000 kilograms (1.55 million pounds) of propellant at liftoff. The liquid hydrogen volume is 1,530 cubic meters (54,000 cubic feet) and the liquid oxygen volume is approximately 565 cubic meters (20,000 cubic feet).

The second flight tank was delivered to the Kennedy Space Center on April 21, 1981, and was mated with the solid rocket boosters, and launched on STS-2, November 12, 1981. The performance of the first and second flight tanks was generally superior, although there were minor anomalies such as the failure of the tumble valve on the first flight. Prelaunch processing problems associated with the debonding of the insulation required extensive repair efforts and the institution of cryogenic tanking tests to verify the adequacy of the insulation prior to committing to flight.

The third flight tank was delivered to Kennedy Space Center on October 5, 1981. Final assembly operations are proceeding on schedule to support a January 1982 completion date for the fourth flight tank.

The development of a lighter-weight (by about 6,000 pounds) external tank is nearing completion. The first lightweight tank delivery is presently scheduled for September 1982. This effort has involved a significant number of changes to the initial, heavyweight configuration, including changing the dimensions of structural members and altering the tooling to be compatible with the changes. The development effort has been responsible for the lightweight tank design and testing; the necessary tooling modifications have been undertaken under production spares and equipment.

Increased emphasis is being applied to assuring production readiness and to efforts to improve the producibility of tanks during FY 1982. The basic producibility objective is to develop new techniques and processes which are more efficient and thereby reduce the time and cost of building the tanks. Areas of activity include improved welding techniques, automated inspection systems, alternate insulation foam materials, etc. The objective of the production readiness effort is to accomplish the transition in the management and control of operations from a development to a production orientation. This includes analyzing the flow of hardware through the plant to identify possible "choke points"; refinement of production work standards, and automation of cost/schedule, inventory control, labor reporting, and discrepancy processing systems.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

A number of problems were encountered during the preparation and checkout of the first two flight tanks which required the redirection of effort planned during FY 1981 for the fourth tank, lightweight development, and producibility program. The diversion of this planned effort during FY 1981 required rescheduling activities for performance during FY 1982. In addition, the scope of the transition from a development phase to an operational production program was underestimated; review teams consisting of NASA, DOD, and industry personnel recommended that the production readiness program be given a high priority and sufficient funding to assure that the management and control systems required for higher production rates were implemented.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Solid rocket booster.....	50,500	17,000	30,000	---

OBJECTIVES AND STATUS:

The Space Shuttle propulsion system includes two reusable solid rocket boosters which burn in parallel with the orbiter main engines at launch to provide the necessary thrust from liftoff to booster staging. Each solid rocket booster weighs approximately 583,600 kilograms (1.29 million pounds) and delivers approximately 11.6 million newtons (2.6 million pounds) average vacuum thrust. The solid rocket boosters are approximately 3.6 meters (12.2 feet) in diameter, 45.5 meters (149 feet) long, and are attached to the external tank. After burnout, at an altitude of about 45 kilometers (150,000 feet), the boosters separate from the external tank. The solid rocket boosters descend by parachute and land in the ocean about 260 kilometers (140 nautical miles) from the launch site. They are recovered by ship and returned for refurbishment and reuse.

The main element in the solid rocket booster system is the solid rocket motor, which is being developed by Thiokol, Wasatch Division, in Utah. Other booster system elements such as the recovery system, thrust vector control, attach structures, forward and aft skirt, and separation motors are being procured separately. The Marshall Space Flight Center has the responsibility for total systems integration of the solid rocket booster effort.

The performance of the solid rocket boosters during the STS-1 Space Shuttle launch was excellent. The solid rocket motor performance characteristics were well within the predicted range. There were, however, some anomalies during reentry. These resulted in some damage to the aft skirts and the hydraulic power unit. Modifications are planned to minimize damage during subsequent reentries.

The performance characteristics of the boosters during the STS-2 flight were within specification and both boosters were successfully retrieved. There were some anomalies during reentry as well as water impact which resulted in damage to the aft skirt and motor nozzle. Preparations for the third launch (STS-3) are well underway with the SRB's already stacked on the mobile launch platform. Work has also been started on the assembly of the hardware for STS-4. The solid rocket motor segments for STS-4 have completed casting.

In addition to supporting the orbital flight test programs in FY 1982, the solid rocket booster project will support the continuation of development of the high performance motor; the expected payload performance gain from this development is approximately 3,000 pounds. During FY 1982, one of the two scheduled qualification test firings will be completed.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

It has been necessary to increase funding for the solid rocket booster due to the modifications needed to correct the problems experienced during the first two flights, the delay of materials procurement from FY 1981 to FY 1982 for the high performance qualification motor, and increases in the cost of labor.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Launch and landing	214,500	199,000	260,000	---

OBJECTIVES AND STATUS:

The launch and landing project provides for the preparation and operations through FY 1982 in support of the orbital flight tests of the first line of Space Shuttle landing, ground processing, and launch processing facilities and equipment at the Kennedy Space Center (KSC) and landing systems at the Dryden Flight Research Facility (DFRF) and the White Sands Missile Range, New Mexico. The station equipment sets include handling, testing, and servicing systems, and ground support equipment. The launch control center at KSC contains the heart of the computerized automated launch processing system, which connects to many of the station sets for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing. The processing hardware is operated with carefully prepared procedures and software to receive the flight vehicle elements (solid rocket boosters, external tanks, orbiters); test and repair or reconfigure them; assemble the Space Shuttle vehicle; install payloads; check out, service and launch the vehicle; deservice the orbiter after landing and mate and demate it with the carrier aircraft which ferries it back to KSC; and retrieve the solid rocket boosters from the Atlantic Ocean and disassemble them for refurbishment.

In addition to supporting the orbital flight test programs in FY 1982, the solid rocket booster project will support the continuation of development of the high performance motor; the expected payload performance gain from this development is approximately 3,000 pounds. During FY 1982, one of the two scheduled qualification test firings will be completed.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

It has been necessary to increase funding for the solid rocket booster due to the modifications needed to correct the problems experienced during the first two flights, the delay of materials procurement from FY 1981 to FY 1982 for the high performance qualification motor, and increases in the cost of labor.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Launch and landing....	214,500	199,000	260,000	---

OBJECTIVES AND STATUS:

The launch and landing project provides for the preparation and operations through FY 1982 in support of the orbital flight tests of the first line of Space Shuttle landing, ground processing, and launch processing facilities and equipment at the Kennedy Space Center (KSC) and landing systems at the Dryden Flight Research Facility (DFRF) and the White Sands Missile Range, New Mexico. The station equipment sets include handling, testing, and servicing systems, and ground support equipment. The launch control center at KSC contains the heart of the computerized automated launch processing system, which connects to many of the station sets for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing. The processing hardware is operated with carefully prepared procedures and software to receive the flight vehicle elements (solid rocket boosters, external tanks, orbiters); test and repair or reconfigure them; assemble the Space Shuttle vehicle; install payloads; check out, service and launch the vehicle; deservice the orbiter after landing and mate and demate it with the carrier aircraft which ferries it back to KSC; and retrieve the solid rocket boosters from the Atlantic Ocean and disassemble them for refurbishment.

Activation of the various launch and landing station sets was paced to match the flight hardware development, certification, and readiness for the first Shuttle flight. The all important processing procedures and launch processing system control software were developed, verified, and ready to support each sequence as the STS-1 vehicle was processed and launched on April 12, 1981. Improvements have been made to the procedures, software, and station set equipment with further experience through STS-2 and to date.

The vehicle processing effort prior to FY 1981 was devoted to preparing the orbiter, external tank and solid rocket booster elements for assembly into the integrated STS-1 vehicle. The STS-1 vehicle was assembled in November and December 1980 and the Shuttle interface tests were performed in the vehicle assembly building. The vehicle was moved to the launch pad in December 1980 and a cryogenic tanking test was performed. The cryogenic temperatures caused debonding of a large area of super light ablator type insulation from the external tank, which had to be repaired. These repairs required the construction of extensive additional access platforms on the rotating service structure, approximately a month of effort to make the repairs, and a subsequent cryogenic tanking test which used additional propellants and gasses. However, a flight readiness firing was successfully completed before the insulation repairs in addition to the finishing of an additional tanking tests. These three tests also revealed that the recently installed gaseous oxygen vent collector and swing arm required rework. The remainder of the mission tests, vehicle servicing, and countdown were completed satisfactorily and STS-1 was launched on April 12, 1981.

The STS-1 launch produced some launch pad damage which was considered minor for a first launch with a new vehicle/pad configuration (i.e., about one tenth of that resulting from the Apollo first launch). Analysis of launch revealed how some pad hardening could be accomplished to reduce the damage from subsequent launches and that the launch pad and associated structures should be washed down immediately after each launch to remove the rocket exhaust residue. There was also an over-pressure wave from the solid rocket booster's ignition and thrust build-up sequence, which had the potential of damaging the flight vehicle or payload. This led to a significant modification to the launch pad, using water sprays and water blankets to break up the overpressure wave.

The STS-1 flight concluded with the landing of the orbiter at Edwards Air Force Base on April 14, 1981. It was weighed, deserviced, mated with the carrier aircraft and ferried back to KSC for refurbishment and processing for STS-2. The solid rocket boosters from STS-1 were retrieved from the Atlantic Ocean with the loss of only one main parachute, which lost its flotation and sank, and were disassembled for refurbishment for a subsequent flight.

The STS-2 vehicle processing included the replacement of over 1,500 orbiter thermal protection system tiles, several items of hardware such as fuel cells and an auxiliary power unit, and repair of damaged thermal protection system areas on the aft orbital maneuvering system pods. The new solid rocket booster and external tank were processed without difficulty. After the STS-2 vehicle was assembled, tested and moved to the launch pad, some forward reaction control system nitrogen tetroxide was spilled on the right forward quadrant of the orbiter, due to a ground support equipment quick disconnect valve sticking and not closing properly on command. This required the installation of access platforms and replacement of 379 thermal protection system tiles which resulted in a three-week schedule impact. There was also an eight-day delay in the launch to change the lubricating oil and filters in two orbiter auxiliary power units. STS-2 was launched on November 12, 1981. The STS-2 pad damage was less than for STS-1 and the overpressure effects were reduced to an acceptable level of about one fourth of the level experienced on STS-1.

Columbia landed at Edwards on November 14, 1981, and was weighed, deserviced, mated with the carrier aircraft and ferried back to KSC. The STS-2 SRB's were retrieved from the Atlantic Ocean, during which one parachute was damaged (by a retrieval ship's propeller), and disassembled for refurbishment and reuse.

Effort is currently underway in processing the vehicle in preparation for launching STS-3 in late March 1982. After STS-3, vehicle processing will be accomplished for STS-4 and initiated for STS-5 before the end of FY 1982.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The launch and landing estimate has increased $61.0 million. The causes for this growth in requirements are related to the support for launch processing operations and for facility and equipment modifications needed to resolve problems experienced during the first two Shuttle launches. Operations support increases included additional manpower needed for critical path vehicle processing schedules, realignment of responsibilities for Shuttle support operations to Shuttle DDT&E from development, test and mission support (DTMS), and provision for launch scrubs and cryogen tanking tests. Facility and equipment modifications have included: the extension into FY 1982 of the gaseous oxygen vent collector and swing arm rework; SRB ignition overpressure modifications; and, changes to access platforms on the pad for the repairs required by the orbiter forward reaction control system nitrogen tetroxide spill before the STS-2 launch.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

PRODUCTION

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Orbiter.....	779,000	837,000	860,000	933,500

OBJECTIVES AND STATUS:

The Space Shuttle production program is based on a national fleet of vehicles currently approved as four orbiters. Three orbiter vehicles are now being procured in the production phase: Challenger, Discovery, and Atlantis. Challenger (Orbiter 099), used in the Design, Development, Test, and Evaluation (DDT&E) program as the structural test article, is being modified to an operational vehicle while Discovery (Orbiter 103), and Atlantis (Orbiter 104) are being manufactured as new vehicles. Columbia (Orbiter 102 -- the DDT&E vehicle) will be modified to an operational configuration after completion of the orbital flight test program. The prime contractor for the production orbiters is Rockwell International, Shuttle Orbiter Division. The planned delivery schedule for the production orbiters is: Orbiter 099 -- June 1982; Orbiter 103 -- September 1983; and Orbiter 104 -- December 1984. However, within the available funding for FY 1982, maintaining the delivery schedule for Orbiter 099 and Orbiter 103 has been assigned the highest priority; certain Orbiter 104 activities scheduled €or FY 1982 may have to be rephased if necessary.

With the exception of the forward reaction control system and the orbital maneuvering system pods, all major components for Orbiter 099 have been shipped to the Palmdale final assembly facility. These major components have been assembled and final systems installation is underway. There are over 20,000 thermal protection system tiles installed with approximately 10,000 tile installations remaining. Integrated systems testing was initiated in early November 1981 and is proceeding satisfactorily; delivery of the vehicle by Rockwell to NASA is anticipated to occur in late June 1982.

Orbiter 103's manufacturing is well underway. Early CY 1982 deliveries to Palmdale from the major subcontractors and Rockwell include the mid-fuselage, the wings, the payload bay doors, and the upper and lower forward fuselages. This will be the first time two flight vehicles will be at Palmdale

simultaneously. During the remainder of FY 1982, the vertical stabilizer will be shipped, the major components will be assembled, and the thermal protection system and secondary structure installations will begin. The major subcontract effort on Orbiter *104* has been initiated and Rockwell has started assembly of the aft fuselage at the Downey, California facility.

The follow-on remote manipulator system production contract with SPAR Ltd. in Toronto, Canada is on schedule. The first production unit is scheduled for delivery to the Kennedy Space Center in the third quarter of FY 1982. The supporting systems integration, procurement of ancillary hardware (such as the closed circuit television cameras used on the orbiters), upgrading of the Johnson Space Center software production facility, post-OFT test program, and increased flight simulation capability are also included in this program element. In addition, the modifications to the manned maneuvering unit and related crew equipment to support the retrieval/repair demonstration using the Solar Maximum Mission (SMM) spacecraft are provided for, as well as the procurement of the manned maneuvering unit hardware. The present orbiter program objectives do not include provisions for the modifications to the production orbiters and the related system integration analyses required to support the use of the Centaur as a Shuttle upper stage.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The net increase in FY 1982 funding requirements of $23.0 million is attributable to the implementation of required design improvements in the orbiter--such as the redesigned fuel cell for longer life, reaction control system tank redesign, and implementation of the advanced FRCI-12 tile; the provision for implementing the OV-102 modifications at KSC between STS-4 and STS-5 and subsequently at Palmdale after STS-5; the development of the orbital maneuvering system (OMS) payload bay kit for the demonstration of on-orbit rendezvous, retrieval, and repair capabilities using the SMM spacecraft; the provision for modifications to the manned maneuvering unit and related mission support hardware to conduct the retrieval/repair demonstration; and, the decrease in funding for procurement of long-lead hardware Eor OV-105 due to the deferral of the decision to proceed.

BASIS FOR PY 1983 ESTIMATE:

During FY 1983, the Orbiter-103 crew module, aft fuselage, forward reaction control system, and orbital maneuvering system pods will be shipped to Palmdale. Thermal protection system installation will be started on these items and will continue on the components that were delivered in FY 1982. The systems installations will be completed, and the vehicle will undergo integrated acceptance testing and checkout. As part of the weight reduction program, the new lighter weight tile FRCI-12 will be used in place of the LI-2200 tiles on the Orbiter 103 vehicle.

During FY 1983, work will proceed at the major subcontractors on the Orbiter-104 mid-fuselage, wing, and vertical stabilizer. The aft fuselage and the crew module will be in work at the Downey facility.

Orbiter-102, after completing STS-5, currently scheduled for November 1982, will be modified to full operational status based on the latest design and design, development, test and evaluation flight test requirements. This will be a considerable effort at Palmdale and will be accomplished entirely in FY 1983.

The FY 1983 estimate incorporates the initiation and completion of factory checkout of Orbiter-103 at Palmdale, prior to its delivery to KSC, utilizing the automatic checkout equipment; continuation of software development for later flights in FY 1983 which includes the changes resulting from orbital flight tests and other operational mission unique payloads; and the continuation of the acquisition and use of the software production facility in FY 1983. The software production facility is required to support the operational software activities and mission unique operational flight packages. The acquisition phases of the software production facility are scheduled to be completed in FY 1987. The amount requested also includes provisions for continuing support for preflight preparation and post-flight analysis of: (1) defined flight test requirements deferred or not accomplished during orbital flight test; (2) additional requirements based upon flight results; and (3) vehicle design changes not yet identified. In addition, FY 1983 funds will be used to support continuing development of the Shuttle mission simulator mission-to-mission reconfiguration effort to augment the existing Shuttle mission simulator's capacity and provide additional part-task training capability.

Other activities to be pursued include crew training loads standardization, procurement of additional closed circuit television equipment for Orbiter 103 and Orbiter 104, and continued engineering support in the key disciplines of flight performance, aerodynamics, flight techniques, orbiter development, and flight design. Further, provision has been made for the support of the Solar Maximum retrieval/repair mission and the completion of the second manned maneuvering unit.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1983:

- modification of Orbiter-102 to an operational vehicle
- manufacture of Orbiters-103 and -104 resulting in delivery of Orbiter-103 at the end of FY 1983
- shipment of Orbiter 103 crew module aft fuselage, forward reaction control system, and orbiter maneuvering system pods to Palmdale for thermal protection system installation
- work will proceed at the major subcontractor level on the mid-fuselage, wing, and vertical stabilizer of Orbiter-104

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Main engine.....	12,000	105,000	144,000	262,000

OBJECTIVES AND STATUS:

The production budget provides the material procurement, fabrication, and assembly operation necessary to support the orbiter fleet with full power level (FPL) engines. The first production (FPL configuration) engine was assembled in early FY 1982. From materials procurement to final main engine assembly covers a time span of about 42 months. Then another few months are required for shipping to the National Space Technology Laboratories (NSTL), test stand installation, acceptance testing, final checkouts, and inspections before delivery to KSC. In FY 1983, the materials procurement, fabrication, and assembly operations necessary to support the orbiter production and flight schedule will continue.

Residual development activity will also be pursued starting in FY 1983 within the production program. This includes single FPL engine testing, culminating in certification during FY 1983. Subsequent testing will be focused on demonstrating the life capability of the main engine; this effort will demonstrate appropriate maintenance intervals for flight program use, identify components which should be redesigned for longer life, and continue the expansion of the engine certification program to certify the engine for an increased number of missions. Eventually, the main engine is planned to be certified for 55 missions.

CHANGES FROM FY 1982 BUDGET ESTIMATES:

The increase of $39.0 million in FY 1982 funding requirements is primarily due to design changes which have been necessary to implement fixes to problems encountered during recent FPL tests and the need to rephase and reallocate production engines as a result of the engine test failures. In addition, material cost increases have been greater than anticipated and the fabrication of certain critical components have been accelerated to ensure parts are available to support the program.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds are required to continue the fabrication and assembly of FPL configuration flight engines. Component deliveries such as main injector, turbopumps, main combustion chamber parts, etc., will be phased to support the fabrication and assembly operations. Fabrication, assembly and acceptance testing of engines for installation into Orbiter-103 will be completed. The fabrication of components for the completion of engines for the orbiter fleet will be phased throughout FY 1983 to meet the assembly requirements and planned delivery dates in succeeeding fiscal years. After assembly, each engine is transported to NSTL for acceptance testing. This effort requires logistics, evaluation, and analysis support. In addition, FPL certification testing will be supported, resulting in certification of the FPL engines in FY 1983 for ten missions. Life/maintenance demonstration testing will be initiated at the completion of the FPL certification testing.

MAJOR PROJECT ACTIVITIES PLANNED FOR PY 1983:

- o fabrication, assembly, and acceptance testing of engines to outfit Orbiter-103
- o continuation of fabrication and assembly of FPL configuration flight engines
- o phasing of fabrication of components for the completion of engines for orbiters to meet assembly requirements and delivery dates in upcoming fiscal years.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Launch and landing	33,000	57,000	63,000	67,000

OBJECTIVES AND STATUS:

The launch and landing project provides for the production and activation of a second line of vehicle processing stations at the Kennedy Space Center (KSC) to support the processing of two or more Space Shuttle vehicles simultaneously. Included in the second line facilities are a second high bay in the Orbiter Processing Facility (OPF), a second set of high bays in the Vehicle Assembly Building (VAB), a second mobile launch platform (MLP), a second launch pad, a third firing room in the launch control center (LCC), and a solid rocket motor (SRM) processing facility. In addition, temporary office

housing is required for the non-hands-on launch support personnel overflowing the LCC and VAB as more space in these facilities is being activated for vehicle processing and as safety considerations require people to move out of the VAB. System engineering effort is required to ensure the orderly activation of facilities and implementation of changes to specifications, drawings, and documentation that have occurred during first line activation efforts.

The basic facilities exist for the second line high bays in the OPF and VAB, and for the second MLP, second launch pad and third firing room in the LCC. Ground support equipment is being procured and installed in all of these second line processing stations; the OPF, MLP, and VAB second line facilities will all be activated during FY 1982. The firing room is to be activated in FY 1983 and the launch pad is to be activated at the end of FY 1986. Construction of the solid rocket booster processing facility is scheduled to be initiated in FY 1982 and activation is scheduled in FY 1984. The temporary office housing will consist of railroad boxcars and leased trailers which will be obtained, sited, and activated in FY 1982. All of these second line facilities are on schedule to meet the activation dates stated.

CHANGES FROM PY 1982 BUDGET ESTIMATES:

The launch and landing estimate for FY 1982 has increased $6.0 million due primarily to design changes in launch support systems and ground support equipment, which must be incorporated into the second line of processing stations, and changes in the operational readiness dates for several facilities. Examples of design changes which must be incorporated into the second line processing stations include the gaseous oxygen vent collector and swing arm at Pad B and the solid rocket booster overpressure water spray and water blanket modifications for the mobile launch platform. In order to support the independent processing of STS-6 using Orbiter-099 in parallel with STS-5 processing using Orbiter OV-102, the operational readiness dates were advanced two months (to June 1982) for the second OPF high bay, one month (to August 1982) for the second MLP, and ten months (to August 1982) for the second high bay set in the VAB. The software development center in firing room 2 is scheduled to be equipped and reconfigured early to support Orbiter-099 processing in the OPF by July 1982 and integrated vehicle testing in the VAB by September 1982. The temporary office housing required for non-hands-on personnel at launch complex 39 is included in the budget estimate increase for FY 1982. These costs are partially offset by deferring the readiness date of the second launch pad one year to September 1986 commensurate with changes in the flight manifest.

BASIS OF FY 1983 ESTIMATE:

The thrust of the FY 1983 effort will be to design, install, checkout, and validate the second line of facilities and ground support equipment for the DOD-secure third firing room, the solid rocket motor processing station set and Launch Pad B.

Firing room 3 in the Launch Control Center will be modified and activated for DOD-secure missions requiring secure launch operations. This effort will be in process in FY 1982 and completed in FY 1983 to support required launch dates and DOD launch schedules.

Work on the solid rocket motor processing station will be initiated in FY 1982, continue throughout FY 1983, and be completed in FY 1984. This facility will support the receiving, inspecting, rotating, testing, storing, and aft segment buildup prior to stacking in a VAB assembly station.

Although the operational readiness date for Launch Pad B is in FY 1986, intensive effort must begin in FY 1982 and continue through FY 1983 to develop installation plans and initiate long-lead procurements for ground support equipment (GSE). A major effort will be to update the design for Pad B. Design work will be done under the installation contract to lay out the procedures for installing the ground support equipment at the pad. Among the many items of ground support equipment to be procured and fabricated, some major ground support equipment procurements for the pad will be the gaseous oxygen vent arm, the ET vent arm, the orbiter access arm, and initial procurement for the payload ground handling mechanism (PGHM).

MAJOR PROJECT ACTIVITIES PLANNED IN PY 1983:

- o complete activation of the DOD-secure firing room in the launch control center
- o continue construction and outfitting the of solid rocket motor processing facility to meet the FY 1984 operational readiness dates
- o continue modification and outfitting of Pad B to meet the FY 1986 operational readiness date

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spares and equipment....	98,000	155,000	193,000	323,000

OBJECTIVES AND STATUS:

This program element provides for the initial lay-in of spares adequate for replacement of Shuttle components, the tooling requirements for higher external tank and solid rocket booster production rates and the procurement of adequate levels of flight crew equipment.

Initial spares include primarily line replaceable units, or those items for which the optimum maintenance action is removal from the vehicle and replacement. In some cases, economic analysis supports providing initial spares at the shop replaceable unit level as well. The initial spares funding line includes costs of flight spares, ground support equipment spares, and the logistics support analysis to properly estimate and procure these spares. Failure rate for each item and the turnaround time for item repair are two significant factors in determining the quantity of initial spares to be procured. Initial spares are considered to be an investment in the program capability to reach the flight rates and processing times required by the operational mission model.

Tooling modifications required to accommodate the external tank (ET) lightweight configuration continue both at the Michoud Assembly Facility (MAF) and at the subsystem hardware vendor facilities. *Also*, a number of major weld and thermal protection system tooling procurements required to achieve higher ET build rates are continuing in work. Tooling additions and modifications to accommodate higher build rates are also continuing at the solid rocket booster subcontractor facilities and at the Kennedy Space Center for the solid rocket booster subsystem hardware.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

Additional initial spares were found to be needed in the areas of the orbital maneuvering system, orbiter avionics, leading edge subsystem, reaction control system, and life support systems. Spares price increases have been experienced across the board, notably in the main propulsion system and avionics areas. External tank rate tooling costs to achieve a 24-per year production rate have grown as a consequence of recognizing the need to improve the rate capability of tools used for applying

insulation to the tank. Solid rocket booster tooling requirements decreased due to flight schedule adjustments. In order to support the flight rate and training schedule for flight crew equipment, it was necessary to increase the funding for spacesuit procurement.

BASIS OF PY 1983 ESTIMATE:

Sufficient initial spares are being procured to provide support for a flight rate of 13 flights in 1985, with the provision to procure at least one of every functional line replaceable units by that time. Test and turnaround support will also be commensurate with that rate. External tank producibility efforts initiated under the design, development, test and evaluation program in prior years will be pursued in the production program; the goal of this activity is to reduce future external tank costs by identifying producibility improvements in assembly and manufacturing operations. Tooling modifications and additional tools to accommodate higher hardware build rates will continue at both external tank and solid rocket booster prime contractor and subcontractor facilities. The production of crew items will result in a space suit inventory of thirteen training and nineteen flight suits at the end of FY 1983, with all five sizings available. This inventory plus the life support system and related spares will support flight and backup crew needs for training through STS-15 and for flights through STS-14.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1983:

- o procurement of adequate initial spares to support flight rate of 13 flights in 1985
- o pursuance of ET producibility efforts in production program to reduce future ET costs
- o accommodation of higher hardware build rates by tooling modifications and procurement of additional tools
- o support of flight and backup crew spacesuit and related equipment needs for flights through STS-14 and training through STS-15

BASIS OF FY 1983 FUNDING REQUIREMENTS:

CHANGES AND SYSTEMS UPGRADING

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Changes and systems upgrading.....	---	300,000	---	72,500

OBJECTIVES AND STATUS:

Management, technical flight experience, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the budget estimates for development and production. Such funds are necessary to provide for programmatic and technical changes which result from Space Shuttle development ground and flight testing, and experience in the production phase. Those changes include modification to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, funds are allocated to the appropriate budget account.

CHANGES FROM FY 1982 BUDGDET ESTIMATE:

The changes and systems upgrading funds identified in the FY 1982 budget have been reallocated to Shuttle design, development, test and evaluation (DDT&E) and production to help offset the cost of changes and increased development requirements identified in the individual program element justifications of changes from the FY 1982 budget estimates. The amounts reallocated to DDT&E and production are $158 million and $106 million, respectively. The residual amount of $36 million was

part of the Agency's overall response to the reductions in the NASA FY 1982 appropriations. Of this amount, a specific reduction of $25 million was possible due to the discontinuation of the NASA development of the Centaur as a Shuttle upper stage.

BASIS FOR FY 1983 ESTIMATE:

The funding requested for FY 1983 represents the amount required to initiate the modifications under consideration which have been identified to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, facilitating improved mission-to-mission turnaround time, and achieving improved mission performance margins. Specific changes and system upgrading enhancement candidates include reaction control system changes to improve reliability and redundancy; a redesigned auxiliary power unit; landing gear improvements; minor modifications to the main engines; tape recorder upgrading for increased storage and reliability; increased orbiter autonomy for onboard checkout and control; and, procedure and hardware changes which would reduce turnaround times, enhance operational capability, and reduce cost-per-flight.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

PERFORMANCE AUGMENTATION

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Performance augmentation.....	---	(5,000)*	5,000	60,000

*Requested for performance augmentation studies in the FY 1982 budget under Space Flight Operations.

OBJECTIVES AND STATUS:

As Space Shuttle development has progressed, some erosion in payload capability and performance margins occurred, primarily as a result of growth in system inert weight, particularly in the orbiter. Present projections show that even if planned orbiter weight reduction measures and other system improvements are fully successful, some augmentation of ascent performance will be needed to support certain national security missions. This additional capability will be required to support a scheduled launch from the Western Space and Missile Center in October 1985.

Based upon comprehensive assessments of mission requirements and detailed systems engineering and tradeoff studies of several performance augmentation options, NASA has decided to reduce the inert weight of the solid rocket boosters by using filament wound motor case segments to replace the heavier steel cases. This augmentation in performance would be available for missions launched from both the east coast and the west coast launch sites. In addition to satisfying the performance requirements of certain national security missions, the availability of the lighter weight filament wound motor case segments for other missions--where performance margins would otherwise require higher performance levels from the main engine and fine tuning of mission plans--is expected to lower the operating and maintenance costs.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

FY 1982 funding was originally requested and authorized for the completion of performance augmentation studies. Due to the completion of the necessary trade-off analyses and the requirement

to initiate development as soon as possible to meet the October 1985 mission need date, NASA has submitted a formal reprogramming request to the Congress. This request explains NASA's current program plans to proceed with development in FY 1982 and identifies the funding previously provided for studies within Space Flight Operations as the source of funds to be transferred to the Space Shuttle program to initiate development.

BASIS FOR FY 1983 ESTIMATE:

In order to meet the October 1985 flight availability date, filament wound case design and overall space transportation system integration activities are being initiated in FY 1982. Fabrication of development segments will start early in FY 1983 to support hydro-proof tests and structural tests during the last half of the fiscal year.

Two development motor test firings are planned in FY 1984 and one qualification motor firing in FY 1985 to support the October 1985 need date. Fabrication of flight sets will begin in the fourth quarter of FY 1984.

The filament wound case segments will be obtained through competitive bid from qualified vendors in the industry. Thiokol will continue as integration contractor for the solid rocket motor using the filament wound motor case segments and Rockwell International will be tasked with the overall integration analyses for the Shuttle system.

SPACE FLIGHT
OPERATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS/OPERATIONS — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REOUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space transportation systems operations capability development.	81,700	143,200	79,300	85,400	RD 2-5
Development, test and mission support/ Engineering and technical base.....	183,500	184,000	184,000	82,400	RD 2-14
Advanced programs.....	11,800	8,800	8,800	11,900	RD 2-18
Spacelab.	138,800	110,700	100,800	113,200	RD 2-20
Space transportation system operations..	263,400	464,200	523,000	1,414,100	RD 2-23
Total.....	679,200	910,900	895,900	1,707,000	

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation:				
Johnson Space Center	165.800	218.300	238.000	520.200
Kennedy Space Center	110.500	104.200	104.900	377.200
Marshall Space Flight Center	370.100	543.000	528.900	769.200
National Space Technology Laboratories	5.300	5.300	5.900	4.800
Goddard Space Flight Center	1.900	3.800	4.800	7.400
Jet Propulsion Laboratory	L00	---	200	200
Ames Research Center	---	---	---	1.800
Lewis Research Center	19.700	15.000	600	5.000
Headquarters	5.800	21.300	12.600	21.200
Total	679.200	910.900	895.900	1.707.000

OFFICE OF SPACE TRANSPORTATION SYSTEMS/OPERATIONS **SPACE FLIGHT OPERATIONS PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes space transportation systems operations capability development; the common support activites conducted under development, test and mission support (engineering and technical base); advanced programs, Spacelab; and space transportation system operations.

Space transportation system (STS) operations capability development provides for space transportation system development activities other than the Space Shuttle. These development and support activities are necessary for the orderly transition to STS operations. Principal areas of activity include the STS upper stages, multimission and payload support equipment, Mission Control Center upgrading (Level IT), payload and operations support, and STS operations effectiveness.

Development, test and mission support/engineering and technical base provides the common engineering, scientific, and technical support required at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratpries for space transportation systems research and development activities.

The advanced program effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions and systems. In support of this effort, advanced development activities are conducted to provide a basis for obtaining significant performance reliability improvements and reducing future program risks and development costs through the effective use of new technology.

The Spacelab is a major element of the space transportation system. The program is being carried out jointly by NASA and the Eurpoean Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes development of support equipment not provided by ESA. Other activities include procurement of flight hardware and system activation activities which assure Spacelab compatibility with the orbiter leading to an operational capability.

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

BASIS OF FY 1983 FUNDING REOUIREMENTS:

SPACE TRANSPORTATION SYSTEMS (STS) OPERATIONS CAPABILITY DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space transportation system upper stages	38,300	75,000	23,200	32,000	RD 2-7
Multimission and payload support equipment	15,500	17,700	14,600	16,900	RD 2-8
Mission control center (MCC) upgrading (Level II)	15,600	24,800	24,800	22,500	RD 2-10
Payload and operations support	9,300	10,700	13,700	10,000	RD 2-11
Space transportation system operations effectiveness	---	10,000	3,000	4,000	RD 2-13
Performance augmentation studies	3,000	5,000	(5,000)*	---	RD 1-27
Total	81,700	143,200	79,300	85,400	

*transferred to Space Shuttle budget line item

OBJECTIVES AND STATUS:

The space transportation systems operations capability development activity includes several major areas of effort. The STS upper stages currently under development consist of the inertial upper stage (IUS) and the spinning solid upper stage (SSUS). They are expendable, propulsive stages required to provide the capability to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone.

Multimission and payload support equipment consists of ground and flight hardware used for interfaces between the payloads and the space transportation system, as well as test equipment to

verify payload integration compatibility. This class of hardware will be developed into a standard, reusable inventory to support a variety of payloads.

The Mission Control Center (MCC) upgrading (Level 11) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level II will provide additional hardware, equipment, and software to upgrade the MCC to provide the capability to support three simultaneous orbiter operations.

The payload and operations support activity consists of two major efforts; orbital flight test (OFT) payload integration and the Payload Operations Control Center (POCC). The orbital flight test payload integration provides for the integration of payloads on the OFT flights. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads.

STS operations effectiveness involves developing ways to improve the operational effectiveness and performance of the STS in the following areas: vehicle hardware, vehicle turnaround/cargo processing, system software automation, mission operations, and management procedures.

Performance augmentation will be initiated to improve Shuttle performance capability. Improved performance is necessary for certain missions launched from Vandenberg Air Force Base (VAFB) and to accommodate new payloads and new space utilization concepts.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The STS operations capability development estimate changes are explained within each project.

BASIS FOR FY 1983 ESTIMATES:

FY **1983** funding for the multimission and payload support equipment is required for development, testing, and orbiter installation of mixed cargo hardware, and transportation multimission support equipment.

Upgrading the Mission Control Center (Level 11) will continue during FY **1983,** completing elements of the basic upgrade, including the POCC interface in support of Spacelab.

FY 1983 funds will be used to continue to work toward the completion of the checkout and testing of the POCC in order to meet the readiness data required to support the operational flight schedule requirements. Orbital flight test payload integration funding in FY 1983 is required for OFT post flight activities.

FY 1983 funding will be used to initiate design and development of improvements to the space transportation system to achieve operational effectiveness. Areas currently identified include changes to reduce vehicle turnaround times, simplification of cargo processing, and flight mission operations and improved risk management.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Space transportation systems (STS) upper stages.....	38,300	75,000	23,200	32,000

OBJECTIVES AND STATUS:

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These stages are the inertial upper stage (IUS) and the spinning solid upper stages (SSUS).

The IUS is being developed under a Department of Defense contract, to meet upper stage requirements for heavy payloads to be placed in high Earth orbit (up to 5,000 pounds in geosynchronous). Plans for development of a NASA three-stage IUS were cancelled during FY 1981 due to schedule problems, a lack of confidence in performance estimates, and a significant cost increase. Study and definition efforts began in FY 1981 for use of the Centaur as an upper stage in time for the planned Galileo launch in 1985 and the International Solar Polar Mission in 1986. Development of Centaur/STS was not provided in the FY 1983 budget because of the early year funding requirements. NASA is currently planning to modify the two-stage IUS for the Galileo and International Solar Polar Mission.

The IUS payload capability exceeds the capability needed by many geosynchronous payloads using currently available expendable launch vehicles. The SSUS is being developed commercially for these

smaller payloads in two weight classes. The Delta class, SSUS–D, will be capable of injecting up to 2,750–pound payloads into geosynchronous transfer orbit. The Atlas–Centaur class, SSUS–A, will be capable of injecting 4,400–pound payloads into the same orbit. Spacecraft apogee motors place the spacecraft (1,400 and 2,250 pounds respectively for SSUS–D and SSUS–A) into final geosynchronous orbit. The SSUS–A and SSUS–D offer launch economies to the user community. These relatively low cost upper stages have simple physical and functional interfaces for payloads, and facilitate an early and orderly transition from the current expendable launch vehicles to the operational STS. Two SSUS–A's or four SSUS–D's with their spacecraft can be flown on a single Shuttle flight. The primary thrust of the SSUS program is to emphasize servicing the commercial spacecraft user's requirements.

The commercial development of the SSUS–A and SSUS–D by the McDonnell Douglas Corporation is proceeding on a schedule to meet anticipated launch requirements. Designs are being refined and system level and component level qualifications are being completed. Hardware is being manufactured and assembled for first flights. Three SSUS–D's have been successfully launched on the Delta expendable launch vehicle.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease in the FY 1982 budget estimate of $51.8 million is based on the requirement €or continuing the two–stage IUS development and modifying the two–stage IUS for NASA's planetary missions.

BASIS OF FY 1983 ESTIMATE:

FY 1983 STS upper stages funding is required to complete the NASA portion of the two–stage IUS development and for modification for those NASA–unique planetary development activities.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Multimission and payload support equipment.....	15,500	17,700	14,600	16,900

OBJECTIVES AND STATUS:

Multimission and payload support equipment consists of equipment required to integrate arid check out payload elements, and a class of ground and flight hardware that will provide an interface between payloads and elements of the space transportation system (STS). These requirements can be satisfied more economically from a standard equipment inventory than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads.

Examples of this type of standardized equipment are:

(1) Payload Transportation Equipment: Intrasite payload equipment is being developed for use at the launch site to transport cargoes to and from the Shuttle orbiter. Ground and flight transportation equipment will also be used for cross-country transportation of payloads (regular and outsized) to and from the Kennedy Space Center and the Western Space and Missile Center.

(2) Payload Specialist Station Equipment: This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command and display requirements, as well as mixed cargo integration and operations on early STS missions. This approach will minimize the need for payload-unique equipment and operational changeout time.

(3) Mixed Cargo Support Equipment: This equipment will provide maximum flexibility for mixing cargoes in the orbiter bay, as well as decreasing installation and checkout time. The use of identical equipment for different payload configurations will allow simple crew interface and training. Examples of this equipment include standard cable harnesses which will allow command and data feedback simultaneously for up to four payloads in the orbiter cargo bay; and timing buffers which will provide various time signals to the Shuttleattached payloads while they are active.

(4) Cargo Integration and Test Equipment (CITE): This equipment is used to integrate and checkout payload elements as they are assembled into a complete cargo to be flown on the space transportation system. CITE will verify the compatibility of the cargo to Shuttle interfaces, and assure that cargo elements do not interfere with each other.

(5) Trace Gas Analyzer: The trace gas analyzer system will perform in-flight monitoring of the aggregate "outgassing" constituents from payloads and metabolic sources in the Spacelab pressurized

module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of contaminants in the Spacelab.

(6) Mission Kits: The mission kits consist of standard and optional flight hardware designed to extend the capabilities of the payload and orbiter to support the mission as dictated by the payload requirements. Examples of these items are self-contained payload containers and nitrogen tanks.

In 1982, development will continue for mixed cargo hardware, cargo integration and test equipment, and transportation multimission support equipment. Initial testing and orbiter installation of multimission and payload support equipment such as the self-contained payload containers, mission kits, and payload specialist station will be completed, as will testing of the trace gas analyzer and the cargo integration and test equipment in the Vertical Processing Facility.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $3.1 million from the budget estimate is the result of adjustments to funding requirements to reflect equipment demands in support of the current mission model.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds are required for the development, testing, and installation of the mixed cargo hardware and transportation multimission support equipment.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Mission control center (MCC) upgrading (Level II)...	15,600	24,800	24,800	22,500

OBJECTIVES AND STATUS:

Mission Control Center (MCC) upgrading (Level II) is the reconfiguration of the Johnson Space Center (JSC) Mission Control Center to support the STS operational flight schedule requirements. Flight-to-

flight reconfiguration of the MCC must be automated to support the flight rate. MCC Level I, funded under the Shuttle development program, provides hardware and software to configure the MCC to support Shuttle development flights. During the operational era, the MCC will require additional flight control rooms, support rooms, hardware and software to accommodate any combination of two - and finally three - simultaneous orbiter flight operations (two real-time flights, one simulation, two pad tests) including Spacelab and IUS systems monitoring and flight control.

Upgrading the Mission Control Center (Level 11) at JSC will continue in FY 1982 with accomplishment of the three-vehicle design review and full achievement of the single operations capability. Funds will be required for procurement of hardware including communication interface equipment.

Reconfiguration software development, as well as design, checkout, and testing of the trajectory, telemetry, and command software systems will continue.

BASIS OF FY 1983 ESTIMATE:

Mission Control Center (Level 11) upgrading will continue, completing elements of the basic upgrade, including the Payload Operations Control Center (POCC) interface in support of Spacelab. Substantial progress will be made toward the two-vehicle capability, necessary for flight rates above 12-15 per year which will occur after FY 1985.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Payload and operations support.....	9,300	10,700	13,700	10,000

OBJECTIVES AND STATUS:

The payload and operations support activity consists of two major areas of effort: Payload Operations Control Center (POCC) and orbital flight test (OFT) payload integration.

Orbital flight test payload integration provides for the analytical and physical integration of payloads launched on STS-3 and STS-4, the two remaining orbital flight tests. One major NASA

scientific payload (Office of Space Science-1) and several important pieces of test equipment will fly on STS-3. The latter includes the first Get-Away Special test cannister. A DOD payload is flying on STS-4.

Payload integration includes the unique planning, engineering, physical installation, and checkout of payloads and equipment that NASA must perform for each flight. Activities include defining and checking equipment interfaces, performing safety analyses, completing flight and ground simulations, as well as post flight data provision and equipment deintegration.

The POCC, located at the Johnson Space Center (JSC), provides for the command and control of Spacelab attached payloads that operate in the Shuttle cargo bay. It operates in conjunction with the JSC Mission Control Center. Funding is required for the acquisition of computers, displays, communication links, and associated software.

In FY 1982, development of hardware and software systems for the POCC at JSC will continue in order to allow payload command and control and some real-time data review and analysis during STS-2 and STS-3. Analytical integration activities associated with the orbital flight test payloads on STS-3 will be completed in FY 1982.

CHANGES FROM FY [illegible] BUDGET ESTIMATE:

The POCC estimate for FY 1982 [illegible] increased by $[illegible] million [illegible]lecting [illegible] cost estimates to [illegible]ide the required [illegible] ability to meet the [illegible] needs for experimenter using the STS [illegible]ommenc[illegible] th the firs[illegible] Spacelab fl[illegible]ht.

The OFT payload integration estimate for FY 1982 has been increased by $1.4 million to reflect the requirements resulting from the addition of a DOD payload on STS-4 and the shift in flight sequence of NASA payloads which required additional integration analysis.

BASIS OF PY 1983 ESTIMATE:

FY 1983 funds for payload integration will be used to complete post-flight activities.

FY 1983 funds for the POCC will be used to continue to work toward the completion of checkout and testing of the POCC in order to meet the readiness date required to support the operational flight schedule requirements.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Space ranspo ation systems operations effectiveness.....	---	10,000	3,000	4,000

OBJECTIVES AND STATUS:

Effective utilization of the space transportation system (STS) is necessary to meet future operational requirements at the lowest possible cost. Objectives of the operations effectiveness program are (1) reducing the cost and complexity of STS operations as the transition is made from development to full-scale operations, (2) defining alternative approaches to eventual institutionalization of the STS, and (3) developing strategies to insure maximum utilization of the STS.

The first objective will be met through both system improvements and procedural changes to achieve reduction of vehicle turnaround times, simplification of cargo processing and flight mission operations, improved risk management to make better use of system design margins within accepted safety/reliability limits, automation, and effectiveness-oriented management procedures. Analyses are being initiated in FY 1982 to identify and prioritize problem areas with emphasis on significant measurable benefit ratios and near term implementation.

CEANGES FROM FY ? BUDGET ESTIMATE:

The reduction from $10 million to $3 million was necessary as part of program rebalancing to meet current system requirements within budget constraints.

BASIS FOR 1983 ESTIMATE:

FY 1983 funding will be used to develop approaches to solving the problems defined in FY 1982 studies and to begin implementation in selected areas.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

DEVELOPMENT. TEST. AND MISSION SUPPORT/ENGINEERING AND TECHNICAL BASE

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and test support.....	35,436	35,900	33,400	34,900	RD 2-16
Data systems and flight support..	38,255	35,700	42,800	12,700	RD 2-16
Operations support.....	51,294	49,500	48,300	32,000	RD 2-16
Launch systems support.....	58,515	62,900	59,500	2,800	RD 2-17
Total.....	183,500	184,000	184,000	82,400	

OBJECTIVES AND STATUS:

In FY 1982, development, test, and mission support (DTMS) continues to provide the common engineering scientific and technical support required to conduct space transportation system (STS) research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories. The DTMS effort is focused on four areas: research and testing, data systems and flight activities and operations and launch systems. These activities include engineering support for indepth technical examination of flight hardware and Shuttle related systems. DTMS also provides necessary equipment and supplies and performs alternative design, testing, and analysis in high technology areas of design and development.

Research and test support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. Activities at the Johnson Space Center continue to certify and verify flight and ground hardware; refurbish and recertify flight hardware; conduct anomaly and resolution testing; and operate crew training stations. Marshall Space Flight Center activities support the Shuttle main engine static test firing exercises and integrated component testing as well as the qualification of the main propulsion system. Marshall Space Flight Center also supports refurbishment efforts for the solid rocket booster and provides flight evaluation of the external tank, solid rocket booster, main engine, and related systems.

In FY 1982, data systems and flight support efforts are associated with the ground-based data systems and general purpose data systems. The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center. This includes the Shuttle Data Processing Complex which supports the Shuttle orbiter flight tests, as well as operation and maintenance of those facilities in preparation for operational mission support. Also included is the operation of the Johnson Space Center central data computation facility Cyber system required to support centerwide activities in mission analysis, systems engineering development, and test functions for the Shuttle program.

Operations support provides for contractor effort and related supplies and equipment to operate and maintain on-site activities at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center (until FY 1983), the National Space Technology Laboratories, and for off-site operations at the White Sands Test Facility.

Launch systems support provides for the development and test of the checkout and launch facilities and associated ground support equipment, as well as the technical services required to support the test, checkout, and launch of the Shuttle and payloads for the development test flights. Funding will provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Shuttle; maintenance and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

Starting in FY 1983, DTMS has been redefined and retitled Engineering and Technical Base (ETB). The redefined content provides only for the minimal core capability to sustain an engineering and development base to support various space transportation system programs. This core capability provides for a five-day, one-shift operation of designated institutional research and development facilities except for the Johnson Space Center's computer complex which is based on a five day, two-shift operation. Any demands in excess of this one-shift base would be funded by the benefiting programs.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The total funding for DTMS has not changed in FY 1982. There has been a reallocation within the total estimate consistent with the requirements to support pre-mission, mission, and post-mission flight data analysis, post-flight anomaly testing, and, where necessary, recertification and verification of the Space Shuttle systems. Reductions have been possible in several areas by

directing that only mandatory tasks be undertaken, thereby reducing facility support requirements, and by reassigning responsibility for certain support operations to the Space Shuttle DDT&E program. These reductions have offset increases in several areas, notably the Mission Control Center--where additional console operators have been required to support current and projected future workloads.

BASIS OF PY 1983 ESTIMATE:

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Research a d t t suppo t..	35,436	35,900	33,400	34,900

Beginning in FY 1983, Johnson Space Center will provide a five day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Shuttle Avionics Integration Laboratory, the Crew Systems Laboratory, the Electronic Systems Test Laboratory, and Water Immersion Facility. Present supporting activities at the Marshall Space Flight Center will be continued during FY 1983.

Data systems and flight support	38,255	35,700	*42,800*	12,700

In FY 1983, data systems and flight support will provide a minimal core level of support based on a five day, two-shift operation of the central computer facility at the Johnson Space Center.

Operations support.....	51,294	49,500	48,300	32,000

Funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in 1983 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, 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 surveillance of tests; (5) photographic services, including still and motion picture

processing, and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (9) management services in support of center operations, including data management, microfilming, and preparation of technical documentation.

In addition, FY 1983 funds will provide the basic level of support at the National Space Technology Laboratories for static test firing at the full power level (109% of rated power) of the main propulsion system and integrated component testing of the Space Shuttle main engine.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Launch systems support.....	58,515	62,900	59,500	2,800

The FY 1983 estimate supports a core of 65 manyear equivalents, a minimal manpower level, to maintain, develop, and capitalize on the research and development technologies available to enhance space flight hardware, ground processing, and support systems.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

ADVANCED PROGRAMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget. Estimate
		(Thousands of	Dollars)	
Advanced programs..	11,800	8,800	8,800	11,900

OBJECTIVES AND STATUS:

The principal objective of advanced programs is to provide technical and programmatic data for the definition and evaluation of potential future space programs and systems. Future systems requirements, cost, and capabilities are identified to provide the basis for selection of new flight systems. These efforts have continually provided the basis for new programs and systems, such as Apollo, Skylab, and the Shuttle. Subsystems studies and support development activities are conducted to demonstrate significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In 1982, the advanced programs effort will be focused on conducting system and subsystem development studies for the definition of space platforms for low and geosynchronous orbits and tether systems; the continued definition of alternative facility concepts to support the permanent presence of man in low Earth orbit; assembly and construction operations for large space systems and structures in orbit; the investigation of systems and subsystems concepts involving satellite services (i.e., placement, retrieval, and on-orbit maintenance and repairs); the definition of advanced transportation vehicle concepts including orbital transfer vehicles and Shuttle-derived launch vehicles; and the definition and analysis of satellite placement and retrieval systems remote from the orbiter. Completion of the alternative systems concept studies for the space platform will be accomplished.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, major emphasis will be placed on continuing studies, engineering investigations, and definition of mission options that will soon be possible because of the operational capability and flexibility of the space transportation system. These options will generally fall into

three major categories: unmanned platforms in both low Earth orbit and geosynchronous orbit, a permanently manned facility in low Earth orbit, and various elements of orbital test and transportation for their support. In the unmanned platform area, design will be continued to define platform and power support systems to support user identified science and applications requirements. Alternative concepts will be developed for a permanent, Shuttle tended, manned facility in low earth orbit to support sciece, applications, and commercial research and development, as well as space operations and potential national security functions.

The FY 1983 activities will focus on developing concepts to satisfy emerging science, applications, and commercial research and development requirements, and on performing trade-off studies on alternate approaches to space operations. For orbital test and transportation, the focus will be on large structures, satellite servicing, and advanced transportation options.

As part of the orbital test and transportation category, definition studies of life and crew support engineering activities required for extended orbital missions will be continued. Further investigations of potential tools and equipment for use in extravehicular activity and teleoperator operations will be carried out. Also, systems, subsystems, and engineering development studies to support deployable and erectable space structure activities will be continued. As part of construction operations, studies of assembly and repair of future structures in space will be continued as well as studies of extravehicular activity operations essential for satellite and platform maintenance. Concept and engineering development efforts on teleoperator systems to permit remote satellite servicing and studies will also be conducted to develop candidates for orbital testing of systems and end items that lie between Phase B and Phase C of the usual development approach in order to test feasibility and capability. Other planned activities for FY 1983 in this area include continuation of studies of advanced transportation to permit improved geosynchronous operations. As part of these efforts, emphasis will be placed on upper stages such as various approaches to a reusable orbital transfer vehicle, and the concept of a Shuttle-derived heavy lift launch vehicle.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SPACELAB

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacelab.....	138,800	110,700	100,800	113,200

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 conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, nine of which 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 fnclude the design, development, production, and delivery of the first Spacelab, associated ground support equipment, and the Instrument Pointing System (IPS). NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development Spacelab operations capabilities, and procurement of additional flight and ground hardware needed to support NASA's Spacelab missions.

The first flight unit and one set of ground support equipment were delivered by ESA to NASA in the first quarter of FY 1982. These deliveries will increase Spacelab activities at the Kennedy Space Center involving the receipt, assembly, installation, checkout, and processing of the Spacelab hardware. Ground support equipment and facility verification testing will be accomplished certifying that the complex is ready for Spacelab launch processing. This work is performed for NASA by the Spacelab integration contractor who is also performing systems engineering, logistics planning, systems software preparation, and analytical experiment integration for the early Spacelab missions.

In FY 1982, the manufacture of the crew transfer tunnel will continue. The tunnel will link the Spacelab module to the Shuttle orbiter cabin. With the design complete, the fabrication of the verification flight instrumentation (VFI) equipment will continue, with deliveries beginning in FY 1982. The VFI includes sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems and to monitor the environment to which payloads will be subjected. The procurement of initial spares for United States manufactured, but ESA developed, Spacelab hardware will continue in FY 1982.

Integration of the software for the Spacelab simulator will be completed in FY 1982. The utility kits, which serve as Spacelab-to-Shuttle orbiter mating hardware, will be delivered in FY 1982. The development of NASA provided ground support equipment will continue with additional deliveries to occur in FY 1982. During FY 1982, ESA engineering model pallets will be flown with experiments on two STS orbiter test flights. OSTA-1 was flown on STS-2 in November 1981 and OSS-1 will be flown on STS-3.

In early FY 1980, NASA signed a contract with ESA for the procurement of the second set of Spacelab hardware. Delivery of initial hardware, including racks and pallets, is to occur in FY 1982. The production and delivery of this follow-on hardware is planned to be completed in FY 1984.

CHANGES FROM 1982 BUDGET ESTIMATE:

The FY 1982 budget estimate has been reduced by $9.9 million resulting in the deferral of procurement items such as some spares as well as flight hardware modifications until FY 1984.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funding is required to continue the procurement of the Spacelab follow-on hardware from ESA and to provide for a first flight in September 1983. The procurement includes a second set of flight elements and spares to support early Spacelab flights.

Work will continue on the crew transfer tunnel and the Spacelab simulator with FY 1983 funding. The first transfer tunnel is scheduled to be completed and the Spacelab simulator ready for crew training in FY 1983. The manufacture of ground support equipment will continue with additional elements to be delivered in FY 1983. The procurement of initial spares for United States manufactured, but ESA developed, Spacelab hardware will continue in FY 1983. FY 1983 funds will also be used to establish a repair capability to maintain Spacelab hardware during operations.

The Spacelab integration contractor will continue to perform the integration of the flight hardware for the first Spacelab missions. FY 1983 funds will provide for the preparation of procedures for processing and testing flight and ground hardware, as well as continued efforts in the areas of system engineering, logistics planning, and analytical integration for early missions.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SPACE TRANSPORTATION SYSTEMS (STS) OPERATIONS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Shuttle operations.	213,500	396,000	435,300	1,316,600
Upper stages operations	30,900	40,000	67,500	63,000
Payload support operations	19,000	28,200	20,200	34,500
Total	263,400	464,200	523,000	1,414,100

OBJECTIVES AND STATUS:

Space transportation system operations will provide the transportation services and operational activities to bring about a more effective access to, and utilization of space for the expansion of human knowledge and for practical benefits on Earth. The space transportation system will provide for the delivery of free-flying payloads to low Earth orbit, facilitate the conduct of experiments using the Shuttle orbiter as a carrier vehicle for experiments mounted in Spacelab pressurized modules and on Spacelab pallets in the orbiter payload bay, deliver payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages, retrieve free-flying payloads from Earth orbit, and provide on-orbit servicing of satellites.

The space transportation system operations activities integrate the Shuttle system, the Spacelab, and the upper stages into a versatile transportation system. Shuttle mission planning, procurement of recurring hardware and consumables, and support for operations involving launch, flight and recovery crews and related activities are well underway.

Upper stage operations provide for the procurement of upper stage hardware and related support necessary for orbital placement of spacecraft following low orbit deployment from the Shuttle orbiter. The upper stages include inertial upper stages and spinning solid upper stages.

Payload support operations provide €or operational payload related hardware, services and launch site capability development required to meet a user's transportation requirements outside the scope of currently defined standard space transportation system services.

CHANGES FROM PP 1982 BUDGET ESTIMATE:

FY 1982 funding for Shuttle operations was revised to reflect current requirements consistent with the Shuttle flight manifest covering the planned schedule and payloads for early operational missions and some revised estimates for hardware and manpower in Shuttle operations. Upper stage operations funding reflects the requirements for additional IUS procurement to launch Galileo in FY 1985 and the International Solar Polar Mission in FY 1986. Payload support operations FY 1982 funding reflects the revised STS flight schedule.

BASIS OF PY 1983 ESTIMATE:

Shuttle operations - FY 1983 funding is requtred for continuation of procurement of raw materials and subassemblies for external tanks and solid rocket boosters as well as manufacture, assembly, and checkout of this flight hardware to support the currently planned flight rate €or early operational missions. FY 1983 funding is also required for flight operations at the Johnson Space Center which includes mission operations planning, crew training, engineering support, and analytical integration for early operational flights in FY 1983 and subsequent. In addition, FY 1983 funding is required to conduct launch operations and vehicle refurbishment activities at the Kennedy Space Center.

Upper stage operations - Funding in FY 1983 is required to continue the procurement of major components and initial subsystem assembly of the upper stages to support NASA missions including the Tracking and Data Relay Satellite, Galileo, and the International Solar Polar Mission. *Also* funding is required for continuation of procurement of the spinning solid upper stage.

Payload support operations - Funding in FY 1983 is required to support ongoing payload integration analysis and implementation for currently scheduled launches. NASA payloads requiring significant support in FY 1983 include: Galileo, International Solar Polar Mission, Tracking and Data Relay Satellite, Space Telescope, and early Spacelab missions.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Shuttle operations..... ..	**213,500**	396,000	**435,300**	1,316,600

OBJECTIVES AND STATUS:

Shuttle operations funding provides for the hardware and services necessary to conduct launch, on-orbit activities, recovery, and refurbishment of the Space Shuttle. This funding also provides for maintenance and repair of the Space Shuttle as well as replenishment spare hardware required during operational flights. The major elements of Shuttle operations include: procurement of external tanks; solid rocket boosters and propellants, vehicle ground operations for refurbishment and turnaround activities, mission operations and crew training, cargo and vehicle integration, procurement of spare ground and flight hardware including main engines, and, logistics, transportation and sustaining engineering.

CHANGES FROM 1982 BUDGET ESTIMATE

FY 19 funding equirements re incr y $ to lect revised timate to manufacture and emble operati l fligh hardware d or manpower to conduct mission planning and integration for the y er al flights Additionally has been included f the lar Maximum Mission revial/Repa lissic .

BASIS OF FY 1983 ESTIMATE:

Shuttle operations funding in FY **1983** provides for continuation of procurement of raw materials and subassemblies for external tanks and solid rocket boosters as well as the manufacture, assembly, checkout and delivery of these elements of flight hardware to support operational missions. Funding is also required for flight operation activities at the Johnson Space Center where preparations are conducted in the areas of mission operations, crew training, and analytical engineering and integration for early operational flights scheduled in FY **1983** and FY **1984.** In addition, FY **1983** funding is required at the Kennedy Space Center to conduct vehicle and cargo ground operations related to launch preparation, launch and booster recovery, and total vehicle refurbishment for operational missions. Replenishment spares for ground support equipment are also provided by Shuttle operations

in FY 1983. Major increases in FY 1983 above the current estimate for FY 1982 are the result of increased costs associated with the buildup in the number of operational flights.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Upper stages operations	30,900	40,000	67,500	63,000

OBJECTIVES AND STATUS:

Upper stages operations provides funding required to continue the procurement of major components and subsystem assemblies to support ongoing production of inertial upper stage (IUS) and spinning solid upper stage (SSUS) vehicles. The initial flight of the IUS vehicle will occur in the second quarter of FY 1983 in support of the first Tracking and Data Relay Satellite (TDRS).

CHANGES FROM FY 1982 BUDGET ESTIMATES:

The increase in the FY 1982 budget estimate of $25.5 million provides for the phased procurement of two additional two-stage IUS vehicles to support a 1985 Galileo launch and a 1986 International Solar Polar launch.

BASIS OF FY 1983 ESTIMATE:

FY 1983 upper stages operations funding provides for the phased procurement of upper stages consistent with the current manifest for operational missions, including the TDRS System. FY 1983 funding also provides for procurement of two additional two-stage IUS vehicles to support a 1985 Galileo launch and a 1986 International Solar Polar launch.

Payload support operations	19,000	28,200	20,200	34,500

; AND STATUS

Payload support operations provides the unique services required to prepare and launch NASA payloads. These services include unique integration hardware, loads and thermal analyses, spacecraft to upper stage analytical integration, and payload launch site support.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 funding decrease of $8.0 million represents adjustments to the flight manifest.

BASIS OF FY 1983 ESTIMATE:

Funding in FY 1983 is required to support continuing and new payload services for NASA payloads. Major payloads receiving support in FY 1983 include Galileo, International Solar Polar Mission, Tracking and Data Relay Satellites, Spacelab 1 and 2, and Space Telescope.

EXPENDABLE
LAUNCH
VEHICLES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION OPERATIONS — **EXPENDABLE LAUNCH VEHICLES PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Scout	900	800	800	---	RD 3-3
Centaur	5,600	---	---	---	RD 3-4
Delta	47,900	30,400	30,400	42,800	RD 3-4
Total	54,400	31,200	31,200	42,800	
Distribution of Program Amount by Installation:					
Kennedy Space Center	2,300	1,700	2,200	1,800	
Goddard Space Flight Center	45,200	28,200	27,600	40,700	
Langley Research Center	900	800	800	---	
Lewis Research Center	5,600	---	---	---	
Headquarters	400	500	600	300	
Total	54,400	31,200	31,200	42,800	

OFFICE OF SPACE TRANSPORTATION OPERATIONS **EXPENDABLE LAUNCE 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, and for other agencies and organizations utilizing these systems and services on a reimbursable basis.

NASA's expendable launch vehicle transportation systems consist of the Scout, the Atlas Centaur, the Delta and the Atlas-F vehicles. This family of launch vehicles has been developed to support NASA's automated spacecraft launch requirements and, on both a cooperative and a reimbursable basis, to support other government, international, and commercial agencies and organizations. The expendable launch vehicle program includes the procurement of vehicle hardware, launch services, engineering and maintenance support, including the necessary reliability improvement of the launch vehicle, and the ancillary ground equipment. In FY 1983, all launches of the Scout, Atlas Centaur, and Atlas-F vehicles will be reimbursable.

Launches under this program are conducted from sites located at the Eastern Space and Missile Center (ESMC) formerly called the Eastern Test Range (ETR) in Florida, the Western Space and Missile Center (WSMC) formerly called Western Test Range (WTR) in California, the Wallops Flight Center in Virginia, and the San Marco Platform off the African coast near Kenya.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

No changes have been made in the FY 1982 amounts appropriated.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SCOUT	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Scout.....	900	800	803	---

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and re-entry experiments. The first Scout launch occurred in July 1960. In the ensuing 21 years, there have been 102 launches.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. Scout vehicles are launched from the Western Space and Missile Center, California; from Wallops Island, Virginia; and from the San Marco Platform off the African coast near Kenya.

BASIS FOR FY 1983 ESTIMATE:

No appropriated funds are required for FY 1983 since the only NASA activity utilizing this vehicle system will be launching of a San Marco Cooperative Mission in 1983. Fiscal Year 1982 funds are estimated to be sufficient to support the NASA effort in this cooperative program. However, this vehicle will be used to support DOD launches at least through 1985 on a reimbursable basis.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

CENTAUR

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Centaur.....	5,600	---	---	---

OBJECTIVES AND STATUS:

This project provides for the procurement and launch of the Atlas booster stage and the Centaur upper stage. The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions to synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet). The first Atlas Centaur launch occurred in 1962. In the ensuing 19 years, there have been 58 launches.

BASIS OF FY 1983 ESTIMATE:

No appropriated funds are required for FY 1983 since no NASA spacecraft are planned to be launched with this vehicle system. However, this vehicle will be used for INTELSAT launches at least through 1984, for which NASA will be reimbursed.

BASIS FOR FY 1983 FUNDING REOUIREMENTS:

DELTA

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Delta.....	47,900	30,400	30,400	42,800

OBJECTIVES AND STATUS:

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 158 launches and has experienced a success record of over 92 percent. It is presently operational with two and three stage configurations. 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 €or guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload *(2,400* pounds) into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet).

BASIS OF FY 1983 BUDGET ESTIMATE:

The FY 1983 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support Landsat-D′ and AMPTE NASA spacecraft requirements. Funds are also required €or technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

This vehicle system, planned to be operational at least until 1985, is the most utilized of our current vehicles. It is being used to support backup Shuttle user requirements, on a reimbursable basis, for launching missions for other United States Government, commercial, and international mission users. Development of an uprated second stage capable of placing a 1,270 kilogram payload (2,800 pounds) into a synchronous transfer orbit is continuing on schedule. This new vehicle configuration will be launched for the first time in mid-1982 when it will boost the NASA Landsat-D mission into orbit.

SPACE SCIENCE AND
APPLICATIONS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS PROGRAMS

Programs	Budget Plan			
	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Physics and astronomy	323,700	325,400	323,500	471,700
Planetary exploration	175,600	215,300	205,000	154,600
Life sciences	42,188	43,500	39,500	55,700
Space applications	331,550	372,900	325,800	316,300
Technology utilization	8,800	4,600	8,000	4,000
Total	881,838	961,700	901,800	1,002,300

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — **PHYSICS AND ASTRONOMY PROGRAM**

SUMMARY OF RESOURCE IREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
	(Thousands of Dollars)				
Space telescope development.....	119,300	119,500	121,500	137,500	RD 4-8
International solar polar mission development.....	28,000	5,000	5,000	21,000	RD 4-11
Gamma ray observatory development.....	8,200	8,000	8,000	34,500	RD 4-13
Shuttle/Spacelab payload development and mission management.....	27,400	35,000	40,000	81,400	RD 4-15
Explorer development.....	33,300	36,600	33,300	34,300	RD 4-18
Mission operations and data analysis....	38,900	47,000	50,000	85,600	RD 4-21
Research and analysis....	37,700	38,800	32,900	39,200	RD 4-24
Suborbital program.....	30,900	35,500	32,800	38,200	RD 4-29
Total.....	323,700	325,400	323,500	471,700	

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Disbribution of Program Amount by Installation:				
Johnson Space Center	2.001	3.130	1,485	4.360
Kennedy Space Center	3.146	2.791	1,215	1,700
Marshall Space Flight Center	159.468	163.443	165.184	221.779
Goddard Space Flight Center	79.980	109.420	104.431	170.226
Jet Propulsion Laboratory	36.626	15.140	21.766	36.871
Ames Research Center	10.969	7.297	4.717	6.617
Langley Research Center	37	13	18	18
Headquarters	31.473	24.166	24.684	30.129
Total	323.700	325.400	323.500	471.700

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDI

PROJECT	MISSION	YEAR
Space Telescope	ST	1985
International Solar Polar Mission (ESA spacecraft only)	ISPM	1986
Gamma Ray Observatory	GRO	1988
Spacelab Payload Development and Mission Management	OSS-1	1982
	Spacelab-1	1983
	Spacelab-2	1984
	OSS-3	1985

(NASA Shuttle/Spacelab payloads will build to a flight rate of approximately 2.5 equivalent Spacelab missions per year by 1985.)

Explorers:	San Marco-D/Low Orbit	1982
	Infrared Astronomical Satellite	1982
	Cosmic Ray Isotope Experiment	1982
	Active Magnetospheric Particle Tracer Explorer	1984
	Cosmic Background Explorer	1987
	Extreme Ultraviolet Explorer	1988

Suborbital Programs:

Sounding Rockets	About 50 launches per year
Balloon Flights	About 20 launches per year
Airborne	About 65 flights per year of Kuiper Airborne Observatory (C-141)

OFFICE OF SPACE SCIENCE AND APPLICATIONS **PHYSICS AND ASTRONOMY PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the solar-terrestrial space environment and of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space-based research is being conducted to investigate the physics, chemistry, and the transport processes occurring in the Earth's magnetosphere, ionosphere, and atmosphere, and the responses of the transport processes to solar phenomena and variability; the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, x-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, blackholes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon, and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education, and technology.

The physics and astronomy missions undertaken to date have been extraordinarily successful. Although the last two of the highly successful High Energy Astronomy Observatories (HEAO's) have ceased operation in the last year, four missions continue to bring us a rich harvest of data -- the International Ultraviolet Explorer (IUE), the Solar Maximum Mission (SMM), the International Sun-Earth Explorer (ISEE), and the Dynamics Explorer (DE) missions. The SMM has given us a new picture of the sequence of events that occur in a flare of the Sun; it has also measured nuclear processes that

accompany these energetic events. After observing a large number of flares, data from the Solar Maximum Mission have contributed significantly to the development of a new model of how solar flares occur.

The explorer satellites are generally relatively low cost missions whose origin dates back to the beginning of our country's space program. One of the newest in the space physics series is the Dynamics Explorer, launched August 3, 1981. This two-spacecraft mission is studying the coupling between the magnetosphere at high latitudes and the ionosphere by making simultaneous measurements from the two regions of space. Already, scientists are correlating auroral images taken at the same time electric fields were measured and plasma waves observed in the magnetosphere. International Ultraviolet Explorer results include recent observations of a binary star system from which the flow of gas from one star was mapped as it wound around its companion white dwarf and left the system entirely. The International Sun-Earth Explorer program continues to return data on the effect of the solar wind on the boundary between the solar wind and the Earth's magnetosphere. With the Sun at its peak of activity, the last two years have been an especially interesting time, while the solar wind has buffeted the magnetosphere with great force.

Major accomplishments during 1981 also included the completion of development activities for the Solar Mesosphere Explorer (SME) leading to a launch on October 6, 1981. The SME is investigating the global distribution of ozone in the stratosphere to determine how this distribution changes with the seasons of the year, and to understand how solar activity affects the ozone distribution in the Earth's atmosphere.

In FY 1982, development activities will continue on the Space Telescope which will allow optical and ultraviolet research for decades. Initial design and development activities will be largely completed and hardware development for the Gamma Ray Observatory will be started leading to a launch in late 1988. Work will also continue on instruments which will be flown on the International Solar Polar Mission.

Development will continue in FY 1982 on the Active Magnetospheric Particle Tracer Explorer, a cooperative program with the Federal Republic of Germany, leading to a launch in 1984. Development on the Infrared Astronomical Satellite, a cooperative effort with the Netherlands and the United Kingdom to carry out a detailed all-sky survey of infrared sources, will be essentially completed leading to a launch in late 1982. Similarly, development efforts will be completed on the San Marco-D mission, a cooperative mission with Italy, and on the Cosmic Ray Isotope Experiment, both scheduled for launch in 1982. Development will be initiated on the Cosmic Background Explorer leading to a launch in 1987.

This mission will carry out a definitive all-sky mapping of the infrared and microwave radiation which comes from the remains of the "Big Bang." The data obtained will provide information on the nature of the earliest events in the universe.

Besides receiving data from operating spacecraft, suborbital observations are conducted from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere. Development is also continuing on instruments which will be flown on the Shuttle orbital flight tests and later Spacelab missions. Significant progress has been made in the preparation of the Spacelab-1 and 2 missions which are operational demonstration flights of the Spacelab hardware developed by the European Space Agency.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The current estimate for the FY 1982 Physics and Astronomy program is $1.9 million below the budget estimate. This net reduction is the result of the general reduction in the appropriation request, offset by the addition of funding for the retrieval/repair of the Solar Maximum Mission spacecraft and instruments, and the Congressional apropriations increase for Spacelab payload development and mission management.

BASIS OF FY 1983 ESTIMATES:

FY 1983 funding will support continued development work on the Space Telescope, the Gamma Ray Observatory, the Active Magnetospheric Particle Tracer Explorer, and on the Cosmic Background Explorer and experiments for the International Solar Polar Mission. FY 1983 funding will support continued mission management efforts for all NASA Spacelab payloads. The FY 1983 funds will provide for continued instrument development and mission management for Spacelabs-1 and 2, and for instrument development, including the Solar Optical Telescope, and mission management activities for future Spacelab missions.

FY 1983 mission operations and data analysis activities will focus on the operation and analysis of data from satellites which are producing valuable scientific data. These satellites include the Dynamics Explorer, the Solar Mesosphere Explorer, the Infrared Astronomical Satellite, the Solar Maximum Mission, the International Ultraviolet Explorer, and the International Sun-Earth Explorers. In addition, FY 1983 funding will support the analysis of the data acquired by the highly successful High Energy Astronomy Observatory missions, preparations for science operations for the Space Telescope, and initial activity to provide the capability for maintaining and refurbishing the Space

Telescope after launch, including the development of new scientific instruments. Funding in FY 1983 will also support preparations for carrying out retrieval/repair of the Solar Maximum Mission spacecraft and instruments with the objective of returning the spacecraft to full operational status.

The FY 1983 suborbital program will provide for continuing scientific investigation through balloon, aircraft, and sounding rocket flights.

FY 1983 research and analysis funding will support a broad range of efforts to provide the research and technology base required for well-conceived and defined future programs. In the supporting research and technology program, tasks critical to maintaining a firm scientific base for physics and astronomy will continue. In the area of advanced technology development, design and definition will be carried out for potential future missions, including Shuttle/Spacelab payloads and free-flying spacecraft. The data analysis activity will include operation of the National Space Science Data Center and general data analysis activities.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

SPACE TELESCOPE DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	85,000	83,500	85,500	110,000
Experiments	34,300	36,000	36,000	27,500
Total	119,300	119,500	121,500	137,500
Mission operations and data analysis	(6,700)	(15,200)	(13,200)	(43,900)
Space transportation system operations	(200)	(3,000)	(4,200)	(11,200)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase by several hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to conduct investigations that could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere.

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observation of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute

significantly to the study of the early state of stars and the formation of solar systems, as well as to the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Space Telescope, we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy, and it may also be possible to determine whether some nearby stars have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Space Telescope design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment, and reuse.

During FY 1981, continued progress was made in the design and development of the space telescope. Polishing was completed on the flight and backup primary mirrors, as well as on the secondary mirror. The flight primary and secondary mirrors will be coated in early FY 1982. Critical design reviews were completed on the scientific instruments. All flight optical benches for the instruments have been fabricated and tested. A systems interface review for all elements of the program was held in 1981. Approximately 65-70 percent of the drawings for the support systems module were completed.

FY 1982 activities continue to support detailed design, development, and manufacture of the optical telescope assembly, the support systems module, and the scientific instruments. Assembly and test of the scientific instruments will be initiated in FY 1982. Assembly of the optical telescope assembly subsystems will continue. In addition, the critical design review for the support systems module will take place in FY 1982, and manufacturing will be initiated.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 estimate for Space Telescope development has been increased by $2 million above the March budget request in order to provide additional management reserve for schedule maintenance during this critical phase of development activity. The new estimate of $121.5 million exceeds by $2 million the funding cap of $119.5 million set forth in the 1982 Appropriation Act. As the work progresses this year, unanticipated new problems may require increased funding to sustain technical progress. The Committees will be notified of any new requirements.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding will support the continued fabrication, assembly, and testing activities of the optical telescope assembly, the scientific instruments, and support systems module. Assembly of the scientific instruments will be completed and verification testing will be conducted. Assembly and test of the optical telescope assembly will be completed, as well as fabrication and assembly of the support systems module leading to initiation of assembly of the total Space Telescope in the first half of 1984.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

INTERNATIONAL SOLAR POLAR MISSION DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	13,000	500	500	---
Experiments	13,400	4,000	2,000	2,000
Ground operations	1,600	500	500	1,000
Auxiliary propulsion system (kick stage)	---	---	2,000	18,000
Total	28,000	5,000	5,000	21,000
Space transportation system operations	(200)	(3,200)	(3,300)	(12,600)

OBJECTIVES AND STATUS:

The International Solar Polar Mission is a joint NASA and European Space Agency (ESA) mission designed to obtain the first view of the solar system from a new perspective -- a view from far above the plane in which the planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, and hence allow us to gain insight into the effects of solar activity on the Earth's weather and climate.

In FY 1981, restructuring of the International Solar Polar Mission program to a single-spacecraft mission was implemented. Although the United States is no longer developing a spacecraft for this mission, United States participation remains substantial. Of the nine investigations to fly on the remaining European spacecraft, five have United States principal investigators and three of the four European investigations have United States co-investigators. In addition, the United States will provide the radioactive thermal power generator, spacecraft auxiliary propulsion system ("kick" stage), launch services, and tracking and data acquisition for the mission.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The total FY **1982** funding requirement for the International Solar Polar Mission development is unchanged. However, there is a redistribution of the funds within the ISPM program to provide for the development of an auxiliary propulsion system (kick stage and interstage) resulting from the change of launch vehicle from a Shuttle/Centaur to a Shuttle/inertial upper stage. The kick stage and interstage are required in order to provide sufficient thrust capability. In addition, the experiments funding has been rephased to be more consistent with the **1986** launch.

BASIS OF FY 1983 ESTIMATE:

In FY **1983,** development work will continue on the science instruments which will be flown on the single International Solar Polar Mission spacecraft. FY **1983** funding will also support continued development of an auxiliary propulsion system (kick stage and interstage) to accommodate the launch on the Shuttlelinertial upper stage in **1986.**

BASIS OF FY 1983 FUNDING REQUIREMENT:

GAMMA RAY OBSERVATORY DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	3,472	3,100	3,100	19,500
Experiments	4,728	4,900	4,900	15,000
Total	8,200	8,000	8,000	34,500

OBJECTIVES AND STATUS:

The objective of the Gamma Ray Observatory mission is to measure gamma ray radiation from the universe and, thus, to explore the fundamental c ss p l g i· Certain celestial phenomena are il only t gamma ray energies. The observational bjectives of the Gamma Ray Observatory are to search for direc de of the ıthesis of the chemical ı to ob er high . astrophy ss curring in supernovae neutron rs and black holes; to te ga ıma ray burst sources; to ı the diffu g ray radiation for osmol idence of it rigin; and to search for unique gamma ray emitting objects.

Gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored because the required technology has only recently been developed. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes. Astronomy is now to the point where our understanding of these objects is being seriously impaired by lack of data in the gamma ray region of the spectrum. Comprehensive research in gamma ray astronomy has consistently been given high priority by the science community.

The Gamma Ray Observatory will be launched by the Space Shuttle. The spacecraft is designed to accommodate several gamma ray instruments. It is planned that the majority of the instruments will have their principal axis pointing in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods (hours to weeks).

FY 1981 activities included the selection of the mission system contractor, initiation of spacecraft design, confirmation of the scientific instruments, and initiation of the instrument development contracts. In **FY 1982,** procurement was initiated on long-lead items, and the design of the scientific instruments and spacecraft will be completed. Configuration drawings, resulting from studies of instrument placement and thermal requirments, have been completed. Preliminary interfaces with the scientific instruments, the Space Shuttle, and the Tracking and Data Relay Satellite System have been defined.

BASIS FOR FY 1983 ESTIMATES:

During **FY 1983,** critical design reviews on the scientific instruments will be completed. Planning and tooling for the spacecraft structure and appendages will be initiated, as well as development buildup for the spacecraft and instrument hardware. In addition, the development of procedures for spacecraft integration and test will be initiated.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Payload development and mission management.....	27,400	35,000	40,000	81,400

OBJECTIVES AND STATUS:

The objectives of Shuttle/Spacelab payload development and mission management are to acquire new knowledge in the disciplines of physics and astronomy and to manage the mission planning and execution of the complete NASA Spacelab payload program. The funding provides for the development of all physics and astronomy Spacelab experiments, the system management and engineering development of the flight equipment and software, the payload specialist support, the physical integration of the payload with the Spacelab system, the operation of the payload during flight, the dissemination of data to experimenters, and the analysis of physics and astronomy flight data.

Instruments to be flown on three missions primarily dedicated to physics and astronomy science are now under development. The OSS-1 pallet will be flown on a Shuttle orbital flight test mission in 1982. The OSS-1 mission consists of six instruments that will gather solar physics data, evaluate the Shuttle environment, and provide data on thermal control technology. Integration and test of the OSS-1 payload is now nearing completion. Spacelab-1, which will consist of a pressurized Spacelab module and a pallet, is scheduled for flight in 1983. The objectives of Spacelab-1 are to demonstrate the capabilities of the Spacelab system and to obtain multidisciplinary scientific data with emphasis on atmospheric and space plasma physics. In 1982, the Spacelab-1 payload will be integrated with the Spacelab equipment. Spacelab-2, an all-pallet configuration, is scheduled to fly in 1984. The objectives of Spacelab-2 are to verify the Spacelab igloo and pallet systems and to obtain scientific data, with emphasis on astrophysics and solar physics. The instrument pointing system, developed by the European Space Agency, will be used for the first time on the Spacelab-2 mission. During FY 1982, Spacelab-2 mission management activities and instrument development will continue.

The OSS-3 mission is also under development leading to a launch scheduled for 1985. OSS-3 is a Spacelab pallet payload of three ultraviolet telescopes that will carry out ultraviolet imaging, spectrophotometry and polarimetry at resolutions and sensitivities previously unavailable. This payload will allow unique new scientific investigations of a broad range of objects from nearby comets and planets out to the most distant quasars. Data gathered by the OSS-3 mission will be used to define and future direct Space Telescope observations. The OSS-3 science instruments will be reflown on the Shuttle during the period of Halley's Comet for unique scientific observations of the comet from the near-Earth orbital environment.

Several physics and astronomy instruments are under development for flights on the Shuttle/Spacelab in 1984 and subsequent years. Two general types of instruments are under development: principal investigator instruments and multiuser instruments. Principal investigator instruments are for a specific scientific investigation by a single investigator who may have co-investigators. Multiuser instruments have a broad scientific capability, can accommodate a number of principal investigator-furnished focal plane or ancillary instruments, and have a large user community. In 1982, the development contractor for a multiuser instrument, the Solar Optical Telescope, will be selected. Another multiuser instrument under definition is the Shuttle Infrared Telescope Facility which will be used to conduct high resolution studies of selected celestial infrared objectives. These studies will provide valuable insight into many questions of modern astrophysics, including the early stages of star formation and the later stages of star evolution, the unusually high energy output of the nuclei of certain galaxies and quasars and the early evolution of galaxies and the universe. Definition and development schedules of physics and astronomy instruments are phased to form scientifically focused payloads. Instruments, both those that are now being developed for OSS-1, Spacelab-1, and Spacelab-2, as well as the principal investigator and multiuser instruments, will be reused on future Shuttle/Spacelab missions, thereby significantly increasing the scientific value of the original investment.

Part of the Shuttle/Spacelab payload development and mission management activities involve the development of several systems necessary for the optimum use of the Shuttle/Spacelab system by all users. At the Kennedy Space Center, a system is being implemented to assemble experiments with Spacelab hardware to form an actual mission payload and subsequently to test the integrated system. An annular suspension pointing system will significantly enhance the quality of scientific data from mounted instruments and will allow more efficient use of the Spacelab provided instrument support systems. This pointing system will be used for both principal investigator and multiuser instruments.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

The Spacelab payload and mission management estimate has been increased by $5 million, from $35 million to $40 million, consistent with the intent of the Congressional appropriation action. The additional funds will be used to accelerate a demonstration flight of the large format camera and to assure continuation of ongoing payload development and mission management in an efficient manner.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, mission management of the ongoing NASA Shuttle/Spacelab missions will continue. Mission management for the nonphysics and astronomy missions involves all the Spacelab payload functions except instrument or experiment development and data analysis. Included among the activities outside the physics and astronomy disciplines are mission management for the space applications, technology and life sciences program.

The FY 1983 funding is also required for analysis of data from the OSS-1 flight. OSS-1 will be flown on a Shuttle orbital flight test in 1982. Efforts will be completed on Spacelab-1 leading to a launch in 1983. Spacelab-2 integration and test activities will be continued in FY 1983 leading to a launch in 1984. Instrument development for the OSS-3 flight will be continued as well as development efforts on the Solar Optical Telescope.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

EXPLORER DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Dynamics explorer	12,100	---	600	---
Solar mesosphere explorer	3,861	---	---	---
Infrared astronomical satellite	15,796	6,600	12,600	---
Active magnetospheric particle tracer explorer	1,200	15,200	11,800	11,700
Cosmic background explorer	---	---	2,500	16,100
Other explorers	343	14,800	5,800	6,500
Total	33,300	36,600	33,300	34,300
Mission operations and data analysis	(15,029)	(18,900)	(18,680)	(28,350)
Scout and Delta (expendable launch vehicles program)	(8,200)	(5,000)	(6,300)	(6,300)

OBJECTIVES AND STATUS:

The explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment having limited, specific objectives and not requiring major observatories. Included in the present program are missions to study atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; and x-ray, ultraviolet, and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving NASA objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere, to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1982 include completion of development activity for the San Marco-D (low orbit) mission and continuation of development on the Active Magnetospheric Particle Tracer Explorer. The San Marco-D mission, a cooperative project with Italy, will include a group of United States experiments to study the relationship between solar activity and the Earth's meteorological phenomena. The Active Magnetospheric Particle Tracer Explorer, a cooperative project with the Federal Republic of Germany, will involve the use of two spacecraft, one designed and built in the United States, to study the solar wind at the subsolar point and to identify particle entry windows, energization processes and transport processes into the magnetosphere. The two Dynamics Explorer spacecraft, launched in August 1981, are already providing valuable data on interactive processes of the magnetosphere, ionosphere, and upper atmosphere. The Solar Mesosphere Explorer, launched in October 1981, is investigating the global distribution and production of atmospheric ozone, and variability in solar ultraviolet radiation.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, and low frequency radio regions of the electromagnetic spectrum. A major effort underway in FY 1982 is the completion of satellite integration and testing activities on the Infrared Astronomical Satellite, which is scheduled to be launched in late 1982. This satellite is expected to record precise flux levels and locations of over a million infrared sources in the universe. A smaller development effort which is nearing completion is the Cosmic Ray Isotope Experiment. This payload, which will be launched in 1982 on a Department of Defense spacecraft, will be used to study galactic cosmic rays, as well as nuclei accelerated from solar flares, in order to shed light on models of nucleosynthesis and to identify probable sources of cosmic ray nuclei.

In addition, development will begin in late FY 1982 on the Cosmic Background Explorer (COBE). COBE will carry out a definitive all-sky exploration of the diffuse cosmic background radiation of the universe between the wavelengths of 1 micrometer and 13 millimeters. The detailed information this mission will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insights into basic cosmological questions of the origin and evolution of the universe.

FY 1982 funding will also support definition studies for future candidate explorer missions including the Extreme Ultraviolet Explorer and the X-Ray Timing Explorer.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The FY 1982 explorer funding has been decreased by $3.3 million as a result of the general reduction to the appropriation request. The reduction will be accommodated by delaying the start of the Cosmic Background Explorer development from early FY 1982 to late FY 1982.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funding will provide for continued development activity on the AMPTE and COBE missions. FY 1983 funding will also provide for design and definition studies for future candidate missions, including the Extreme Ultraviolet Explorer and the X-Ray Timing Explorer. The Extreme Ultraviolet Explorer, the next candidate Explorer mission, is approaching readiness for a development start. This mission will carry out the first detailed all-sky survey of ultraviolet radiation between 100 and 900 angstroms -- a hitherto unexplored portion of the electromagnetic spectrum.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
High energy astronomy observatory extended mission	10 601	6,6 00	4,9 70	2,050
Solar maximum mission basic mission	3 400	600	603	---
Solar maximum mission extended mission	1 600	5,000	2,960	2,100
Solar maximum mission retrieval/repair mission	---	---	9,000	9,200
Space telescope operations	6,700	15,200	13,200	32,800
Space telescope maintenance and refurbishment	---	---	---	11,100
Explorers	15,029	18,900	18,680	28,350
Orbiting astronomical observatory	1,570	700	590	---
Total	38,900	47,000	50,000	85,600

OBJECTIVES AND STATUS:

The purpose of the mission operations and data analysis effort is to conduct operations and to analyze data from the physics and astronomy satellites after launch. This program also supports the continued operation of a number of spacecraft, after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities are typically carried out under a variety of mission support or center support contracts.

Several explorer spacecraft remain operational and are providing valuable data. The International Ultraviolet Explorer and International Sun-Earth Explorers continue to perform well, with very productive guest investigator programs. Mission operations and data analysis will continue for these missions through FY 1982, as well as for the recently launched Dynamics Explorer and Solar Mesosphere Explorer spacecraft.

In addition to the normal support required for mission operations, the Space Telescope program encompasses several unique aspects which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, based on in-orbit maintenance, recovery, refurbishment, and relaunch and in-orbit changeout of the scientific instruments. During the operational period, the Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. NASA has determined that the most efficient and scientifically satisfactory approach to science operations will involve establishment of an independent Science Institute which will operate under a long-term contract with NASA. While NASA will retain operational responsibilities for the observatory, the institute will implement NASA policies in the areas of planning, management, and scheduling of the scientific operations of the Space Telescope.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 funding level has increased by $3.0 million over the budget estimate. This a net increase which results from the addition of the Solar Maximum Mission Retrieval/Repair, offset by the transfer of funds from Space Telescope operations to Space Telescope development to provide sufficient reserves during a critical phase of the development efforts, and the general reduction in the appropriations request.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds will provide support for the basic mission operations and data analysis activities for the Dynamics Explorers, the Solar Mesosphere Explorer, and the Infrared Astronomical Satellite; data analysis activity for the Cosmic Ray Isotope Experiment which is scheduled for launch on an Air Force spacecraft in 1982; extension of operations and data analysis activity for the International Ultraviolet Explorer, the International Sun-Earth Explorers-1, -2, and -3; and support for continued analysis of the extensive data obtained by the High Energy Astronomy Observatory missions. FY 1983 funding will also support the continued operation and data analysis activities of the Solar Maximum Mission (SMM), including the planned retrieval/repair of the partially disabled SMM spacecraft and

instruments as well as the continuation of preparations for science operations of the Space Telescope, including development of the Space Telescope Institute and the science operations ground system. The FY 1983 funding is also required for initiation of design and fabrication of support equipment and orbital replacement units to be used €or Space Telescope maintenance and refurbishment.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology.....	24,202	23,800	21,000	25,200
Advanced technology development.....	6,513	7,700	5,500	6,100
Data analysis.....	6,985	7,300	6,400	7,900
Total.....	37,700	38,800	32,900	39,200

OBJECTIVES AND STATUS:

This program provides for the research and technology base necessary to define, plan, and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

SUPPORT RESEARCE AND TECHNOLOG (SR&T)

The jectiv of supporti research and technology are: (1) to optimize the urn i from future missions by problem definition, devel n f advanced instrument tion i concepts, and sound definition of proposed new missions; (2) to enhance the ı of current space missions by ry out complementar and ementary i obser ti and laborator experiments; (3) t develop theories to explain observed na and predict new ones; and (4) to t the echno base fo · and instr ment and t nduct : researcl necessary t support our standing of astrophy and olar err r relat

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 space environment and

comparative studies of other planetary environments, including the study of Sun-Earth environmental factors. In addition, the Earth's environment contains the most accessible space plasma in which we study processes of importance elsewhere in the universe. The work in solar and heliospheric physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary phenomena. Research supported in astronomy and astrophysics involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SR&T program have a direct bearing on future flight programs. For example, the development of advanced x-ray and ultraviolet astronomy imaging devices under this program will enable spacecraft in high Earth orbits to watch the flow of energy into the auroral zones.

A major activity in SR&T is the solar terrestrial theory program which provides for theoretical investigations of the predominantly plasma physics processes important to solar physics and the solar terrestrial environment. The intent of the program is to enhance and assure the systematic development of scientific investigation of solar system plasmas and for this to play a vital role in the planning of future missions and research efforts.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers, and other government agencies. Current emphasis is being placed on studies for advanced instrumentation to increase both sensitivity and resolution. Feasibility and scientific definition studies are being conducted on Gravity Probe-B (GP-B), a mission to carry out an experimental test of Einstein's general theory of relativity in which measurements would be obtained of the relativistic precession of an extremely stable, cryogenic gyroscope in Earth orbit.

ADVANCED TECHNOLOGICAL DEVELOPMENT

The advanced technological development activities support detailed planning and definition of new physics and astronomy missions including Shuttle/Spacelab missions. ATD activities assure that advanced missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems and elements critical to eventual mission development, in order that technical readiness and resources may be better defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Origin of Plasmas in the Earth's Neighborhood (OPEN), the Advanced X-ray Astrophysics Facility (AXAF), the Starprobe, and the Solar Internal Dynamics Mission (SIDM). The OPEN project will study systematically the origin, storage, transport, and loss of plasmas in the Earth's environment from input by the solar wind and ionosphere to loss in the atmosphere. The mission will assess the importance to the terrestrial environment of variations in energy input to the Earth's atmosphere caused by geospace processes. The AXAF will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's 1.2 meter class imaging x-ray telescope is planned to have sensitivity approximately 20 times that of HEAO-2. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within three solar radii of the Sun's surface. The Solar Internal Dynamics Mission (SIDM) will observe the oscillations visible on the Sun and use the data obtained to investigate the dynamics of the Sun's interior.

Major Spacelab payloads requiring advanced technological development support include the following multiuser facilities: the Shuttle Infrared Telescope Facility (SIRTF), a cryogenically-cooled telescope which will carry out high sensitivity infrared observations; the Pinhole/Occulter Facility, a coded mask and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class ultraviolet/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space Telescope. During FY 1982, major emphasis is being given to definition of the OPEN and AXAF missions. In addition, further definition of Spacelab instruments and facilities will continue, including detailed description of instruments, payload configurations and operational requirements.

DATA ANALYSIS

The acquisition, analysis, and evaluation of data represents the primary purpose of the laboratory, balloon, rocket, and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is generally required to reap the full benefit from these programs. The full benefit can be realized from these programs only when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g, one solar cycle) effects can be studied using complementary sets of data, and when new ideas can be tested that originate from the results of the initial analysis.

For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to

obtain a maximum amount of information from the data they obtain from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices (CCD'S) now being ground-tested for eventual use on the Space Telescope.

Support of the operation of the National Space Science Data Center (NSSDC) is also provided under this program. The NSSDC, located at the Goddard Space Flight Center, was established to serve as a central respository and clearing house for scientific data resulting from space investigations. The NSSDC is now in a stage of transition from a repository to a facility where correlative research can be accomplished using data sets from many sources, including active spacecraft. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft, so that data acquisition and analysis efforts can be coordinated at times when several spacecraft are favorably situated for correlative geophysical studies.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The research and analysis funding level has been reduced by $5.9 million from the budget estimate as a result of the general reduction in the appropriation request. This reduction will be accommodated by pursuing advanced missions studies and advanced technological development for future candidate missions at a slower pace.

BASIS OF FY 1983 ESTIMATE:

During FY 1983, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detector development and on expansion of technology activities related to large x-ray mirrors, advanced x-ray detectors, gamma ray spectrometers, and instrumentation. Feasibility and scientific definition studies will be conducted on future potential candidate missions such as Gravity Probe-B. Emphasis will also be placed on the development of a large area electrographic camera for astronomical use, and on the continued development of large array multichannel plate and intensified charge-coupled imagery devices.

In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. New thrusts will be initiated in the development of advanced generation instrument concepts, especially for the extreme ultraviolet and x-ray wavelength, and for analyzing the internal structure of dynamics of the solar interior. In the area of theoretical studies, investigations will be carried out by concentrating groups of theorists in the fields of

solar, interplanetary, magnetospheric, ionospheric, and atmospheric physics in a coordinated program aimed at the understanding of the detailed behavior of each of these components of the solar terrestrial relationship and their interrelationships.

Emphasis in the data analysis activities to be carried out at universities and government research centers, will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft, and ground observatories). FY 1983 funds will also support the operation of the National Space Science Data Center at the Goddard Space Flight Center. The FY 1983 funding will also allow for further system definition studies, and instrument definition for investigations selected for the Origin of Plasmas in the Earth's Neighborhood mission. In addition, funding will support studies on the Advanced X-ray Astrophysics Facility, the Starprobe and the Solar Internal Dynamics Mission. Definition studies will be continued to assure the technological and scientific readiness of candiate future missions. FY 1983 funding is also required to support definition of new Spacelab payloads as well as those currently under study.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Sounding rockets	25,000	27,400	26,200	28,800
Airborne research	4,500	5,700	4,200	5,900
Balloon program	1,400	2,400	2,400	3,500
Total	30,900	35,500	32,800	38,200
Sounding rockets	25,000	27,400	26,200	28,800

OBJECTIVES AND STATUS:

The sounding rocket program provides versatile, relatively low cost research tools that complement the capabilities of balloons, aircraft, free-flying spacecraft and the Space Shuttle in all the space science disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis.

A primary objective of the sounding rocket program is to conduct a coordinated research program with flight requirements that cannot be met by vehicles with different performance characteristics. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Specific areas of study include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including

the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes; and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In FY 1981, 48 rockets were launched from seven locations in the United States, Canada, Sweden, Norway and Antarctica. These rockets supported the research activities of about 50 groups from universities, private industry, NASA field centers, other government agencies and foreign space organizations.

During FY 1981, sounding rocket flights, in coordination with balloon and aircraft flights from Wallops Island, Virginia, produced invaluable data on the electric fields associated with thunderstorms. This coordinated project illustrates the synergism possible within the elements of the suborbital program. Chemical release experiments will continue to be launched on sounding rockets in FY 1982 to measure winds, wind shears, temperatures, plasma motions, and electric fields in support of solar terrestrial studies. A new vehicle, the Black Brant X, has been successfully flown from Cape Perry, Canada, to facilitate studies of the polar cusp of the magnetosphere. This vehicle's extended performance provides a valuable new tool for the plasma physics program.

In the astronomy and high energy astrophysics disciplines, continuing emphasis is being placed on the development of instruments to be used for studies of stars and extended sources in the ultraviolet and x-ray spectral regions. Of special interest in FY 1981 was the development of an imaging gas scintillation proportional counter for X-ray astronomy. This instrument was flown successfully and produced good scientific results. The instrument is an excellent future candidate for the deployable special payloads concept described below, or for flight on the Advanced X-ray Astrophysics Facility, a major observatory mission under consideration for development later in the decade.

In FY 1982 emphasis will be placed on a concept called deployable special payloads (DSP). Under this concept, the capabilities of the Shuttle will be made available for sounding rocket experimenters, and will potentially increase scientific data acquisition periods from the present five minutes per flight up to 40 hours. The DSP concept calls for sounding rocket-type scientific instrumentation and support hardware to be carried aloft by the Shuttle as either attached or free-flying payloads, as appropriate, and then returned by the Shuttle. These payloads will have minimum interface with the Shuttle. Work on two such payloads will continue in FY 1982, one for high energy astrophysics and one for solar astronomy.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $1.2 million from the FY 1982 budget estimate is a result of the general reduction in the appropriation request. This reduction will be accommodated by a reduction of overall sounding rocket activity in FY 1982. Specifically, the number of FY 1982 flights will be reduced by 5–8 flights, depending on actual flight readiness of experiments to be flown.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds will provide for continuation of the efforts described above. FY 1983 funds will also support continued efforts on the deployable special payloads development activities.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Airborne research.....	4,500	5,700	4,200	5,900

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 and may be transported readily to high operational altitude near 13 kilometers (over 40,000 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, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in opening to astronomy the infrared region of the electro-magnetic spectrum from one micrometer to one millimeter. The airborne platform also has the advantage of enabling scientists to participate directly in space research.

The airborne research program utilizes two aircraft, a C-141 instrumented with the 91 centimeter infrared telescope and a Lear jet instrumented for unique individual missions. The C-141A "Kuiper Airborne Observatory," which began operational flights in 1974, is a full-scale, manned facility. The 91 centimeter f/13.5 infrared telescope operates through an open port, with a pressure bulkhead giving the astronomers a comfortable, shirt-sleeve 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).

In FY 1981, 72 flights were flown to take advantage of the high altitude to make far-infrared observations, including, for the first time, an observation of the limb of the Sun at these wavelengths. We expect that the data will lead to a new understanding of the fine structure in the lower chromosphere. In FY 1982, approximately 65 flights of the C-141 will be supported to continue exploration in the infrared of star forming regions, and to continue the development of more sensitive instrumentation for both photometry and spectroscopy.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $1.5 million from the FY 1982 budget estimate is a result of the general reduction in the appropriation request, and will result in a somewhat reduced number of C-141 flight opportunities for airborne astronomical investigations.

BASIS OF PY 1983 ESTIMATE:

In FY 1983, airborne research funds will be used €or the continuation of operation of the Kuiper Airborne Observatory to provide support for astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Balloon program.....	1,400	2,400	2,400	3,500

OBJECTIVES AND STATUS:

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared and cosmic ray astronomy. In many instances, it is necessary, because of size and weight, as well as being less expensive, to fly these experiments on balloons.

The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from the supporting research and technology program.

During FY **1981,** twelve balloon flights were flown from four global sites to support the research activities of approximately six scientific organizations. One of these flights, launched from Australia, in conjunction with observations from the High Energy Astronomy Observatory, have established that the center of our galaxy is a variable gamma ray source. There is no satisfactory explanation for this variability within given theoretical models. Another noteworthy achievement by a recent series of balloon flights is the detection of what is believed to be radiation intrinsic to the remnant of the "Big Bang" explosion which may have started this universe.

In FY **1982,** about twenty balloon flights are planned which will continue scientific research in high energy astrophysics, solar astronomy, galactic astronomy, and space plasma physics. A scientific discipline which will receive added emphasis is that of gamma ray astronomy. Of particular interest is the area of nuclear line spectroscopy based on increased interest in nucleosynthesis of elements.

BASIS OF FY 1983 ESTIMATE:

The FY **1983** funding provides for continuation of the balloon program. In addition, discussions are taking place with the National Science Foundation for NASA to assume the management and operation of the National Scientific Balloon Facility (NSRF), which is the nation's primary means for carrying out scientific balloon operations. The National Science Foundation, which currently funds the NSBF, has no plans for supporting this facility after FY **1982;** therefore, the FY **1983** balloon program funding assumes responsibility for a larger share of the costs to operate this facility.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **PLANETARY EXPLORATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Galileo development	63,100	108,000	120,000	92,600	RD 5-5
Venus orbiting imaging radar (VOIR) development	---	10,000	---	---	RD 5-7
Mission operations and data analysis	61,800	45,800	38,300	26,500	RD 5-8
Research and analysis	50,700	51,500	46,700	35,500	RD 5-11
Total	175,600	215,300	205,000	154,600	

Distribution of Program Amount by Installation:

Johnson Space Center	8,397	8,011	11,400	8,900
Marshall Space Flight Center	30	197	---	---
Goddard Space Flight Center	3,943	3,141	3,900	3,500
Jet Propulsion Laboratory	99,471	143,393	146,500	120,200
Ames Research Center	27,194	28,776	30,650	12,000
Langley Research Center	7	---	---	---
Headquarters	36,558	31,782	12.550	10,000
Total	175,600	215,300	205,000	154,600

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Galileo	Galileo	1985

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Planetary Exploration program includes the scientific exploration of the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the other planets, and to understand how the appearance of life in the solar system is related to the chemical history of the system. The projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the terrestrial-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these planetary bodies start at the level of reconnaissance and exploration to achieve the most fundamental characterization of the bodies, and proceed to a level of detailed study. The reconnaissance phase of inner planet exploration began in the 1960's and has now been completed, though we still know little about the nature of the Venus surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of this planet forward to a new level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of the moon rock samples returned by Apollo continue to be highly productive as new insights into the early history of the inner solar system are achieved and as our theoretical concepts are revised accordingly. The continuing Pioneer Venus mission is carrying the study of our nearest neighbor, and closest planetary analogue, beyond the reconnaissance stage to the point where we have made a basic characterization of the massive cloud-covered atmosphere of Venus. This characterization has also provided some fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently with the Pioneer-10 and 11 flybys of Jupiter in 1973 and 1974. These simple reconnaissance spacecraft returned excellent data which contributed much to the later successes of the Voyager-1 and 2 spacecraft. Voyager-1 encountered Jupiter in March 1979 and Saturn in November 1980. Voyager-2 flew by Jupiter in July 1979, and then Saturn in August 1981. Our scientific knowledge of this part of the solar system has increased greatly in less than a decade. New data on the planets, satellites, and rings have revolutionized our concepts of the formation and evolution of the solar system. Now, the Pioneer-10 and 11

and Voyager-1 spacecraft are on escape trajectories from the solar system as they continue to monitor their uncharted environments. The Voyager–2 spacecraft is headed for an encounter with Uranus in 1986.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany. A wide range of science experiments, chosen to make maximum progress beyond the Voyager findings, has been selected. The Galileo development efforts are proceeding on schedule for a 1985 launch.

The pre–eminence of the United States program of planetary exploration has been based on technology leadership and on a foundation of strong, coordinated research and analysis programs. These programs ensure that full advantage is taken of the spacecraft data and samples acquired on completed and on–going missions, and that the necessary research is performed to maximize the return from ongoing and future missions. Included in the research and analysis efforts are data analysis, lunar sample and meteorite analysis, telescopic observations, theoretical and laboratory studies, and instrument definition. The highest scientific standards are maintained in these programs and both new and old concepts are subject to intense scrutiny. The programs also involve interdisciplinary coordination among various research groups. The results of the research are widely disseminated. The lunar sample analysis effort is mission-oriented and is coordinated with research by the National Science Foundation. A close coupling is maintained between the research programs and the planning activities that are undertaken to define the scientific rationale and technology needs for future missions.

A long term mission strategy for future low cost exploration of the solar system is in the process of formulation. Such a strategy will include missions to characterize the surface of Venus, to undertake initial missions to comets and asteroids, to further the exploration of Mars, and to continue the exploration of the outer planets and their moons. New approaches to spacecraft development and to mission operations are being examined.

BASIS OF FY 19 F REQUIREMENTS:

GALILEO DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	47,700	79,836	97,000	68,600
Experiments	8,800	12,181	12,000	8,000
Ground operations.	6,600	15,983	11,000	16,000
Total.	63,100	108,000	120,000	92,600
Space transportation system operations	(2,400)	(41,000)	(19,600)	(35,800)

OBJECTIVES AND STATUS:

The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance, and orderly progression of the exploration of the solar system.

The objective of this program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites, through a new deep space spacecraft concept which combines both remote sensing and direct measurements by an orbiter and an atmospheric probe.

The Galileo launch has recently been changed from a Shuttle/Centaur upper stage to a Shuttle/two-stage inertial upper stage. In order to provide sufficient energy to inject the Galileo spacecraft onto the trajectory to Jupiter, a small "kick" stage will be developed and integrated with the spacecraft to provide the final energy increment.

The Galileo mission will utilize a single Space Shuttle/inertial upper stage launch in 1985 of the orbiter and probe which will follow a Delta VEGA trajectory to Jupiter. The orbiter and probe will arrive on target in 1989 to conduct a twenty-month investigation of Jupiter, its satellites, and its

magnetosphere. This mode of launch will allow six encounters with the satellites of Jupiter during the tour instead of eleven as originally planned. The probe will penetrate the atmosphere of Jupiter to conduct scientific investigations down to a depth where the pressure is equivalent to ten times the pressure exerted by the Earth's atmosphere, and the orbiter will relay information back to Earth.

In FY 1982, the orbiter and probe design, development, and fabrication activities are continuing and the fabrication of the major subsystems will be completed. Preparation for probe and orbiter system integration activities will take place during FY 1983.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The Galileo development estimate has been increased by $12.0 million, from $108 million to $120 million, to accommodate a single inertial upper stage (IUS) launch of Galileo versus a single Centaur launch as assumed in the FY 1982 Amended (March) Budget. The increase is required for the development of a Star-48 kick-stage and interstage for integration of the Galileo spacecraft with the inertial upper stage. The change from a Centaur launch to an IUS launch will add approximately 30 months to the mission trip time, and will increase the Galileo total project cost estimate by approximately $170 million. There is, however, a decrease in upper stage development reqruirements.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding will provide for continuation of the orbiter, probe, and scientific instrument fabrication. The baseline Galileo spacecraft design will be retained with minimum modifications to accommodate the addition of a "kick" stage development which is required for an IUS launch of the Galileo mission. Funding will also be used for the procurement of long-lead parts for this propulsion system.

BASIS OF FY 1983 FUNDING REOUIREMENTS:

VENUS ORBITING IMAGING RADAR (VOIR) DEVELOPMENT

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Venus orbiting imaging radar.....	---	10,009	---	---
Space transportation system operations	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The Venus Orbiting Imaging Radar (VOIR) mission was planned as the first mission to map the surface of Venus globally to a resolution of better than one kilometer in order to characterize the current state of the planet and to determine its evolutionary history. The mission will not be initiated in FY 1982 as previously planned in accordance with the Administration's FY 1983 budget decision not to undertake development of this mission at this time.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

This project will not be initiated at this time; therefore, no funds are included in the current estimate for FY 1982.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Voyager basic mission.....	25,666	---	---	---
Voyager extended mission.....	3,300	17,300	17,300	14,000
Pioneer Venus basic and extended mission.....	4,700	5,900	4,000	---
Pioneer 6-11 extended mission.....	2,000	1,900	1,600	---
Helios extended mission.....	142	---	---	---
Planetary flight support.....	25,992	20,700	15,400	12,500
Total.....	61,800	45,800	38,300	26,500

OBJECTIVES AND STATUS:

Funds for the mission operations and data analysis program provide for the operations phase of planetary missions after development, launch, and initial in-flight checkout are completed. It also provides for multimission flight support. Currently active planetary missions being supported within mission operations and data analysis are Voyager-1 and 2, Pioneer-Venus, and Pioneer 6-11.

The objective of the Voyager mission has been to conduct comparative studies of the Jupiter and Saturn planetary systems and to perform studies of the interplanetary medium between the Earth and Saturn. Since their launches in 1977, the two Voyager spacecraft have encountered both the Jupiter and Saturn systems and achieved all of their original objectives. Many remarkable discoveries were made at these giant outer planets and much valuable scientific data (including 64,000 images) has been obtained. Voyager-1 is now on a cruise trajectory which will take it out of the solar system at a steep angle to the plane of the ecliptic. The spacecraft will collect data on the space environment as it proceeds to the outer limit of our solar system. Voyager-2 successfully flew near Saturn in

August 1981 and was placed on a trajectory which will take it to an encounter with the planet Uranus in January 1986. If this spacecraft continues to operate satisfactorily, Voyager-2 may be sent outward from Uranus to an encounter with Neptune in 1989. Both spacecraft have experienced minor equipment failures, but are operating satisfactorily because of their design redundancies. Voyager-2 has an impaired command receiver and an instrument scan platform with reduced capabilities; however, a rewarding encounter at Uranus in 1986 is expected.

The objective of the Pioneer-Venus mission was to obtain detailed information on the Venusian atmosphere, to investigate the planet's environment, and to learn why the planet, so Earth-like in many respects, has an atmosphere so different. The mission consisted of two spacecraft: an orbiter launched in May 1978 and a multiprobe launched in August 1978. The orbiter arrived at Venus on December 4, 1978, and the four probes and multiprobe bus entered the atmosphere on December 9, 1978. This mission has been an outstanding success.

The objective of Pioneers 6-9 was to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 astronomical units (the Earth's distance from the Sun is 1 astronomical unit). The objective of Pioneer-10 and 11 was to explore space beyond 1 astronomical unit, the Asteroid Belt, and the environment of Jupiter. Pioneers 6-9, which were launched in 1965, are still operational. However, data is acquired only when unusual solar activities or special alignment with other spacecraft occur. Pioneer-10, launched in 1972, reached Jupiter in December 1973, and the gravity of the massive planet provided the extra impetus to ultimately take the spacecraft out of the solar system. Pioneer-11, launched in 1973, passed Jupiter in December 1974, and the spacecraft trajectory was influenced by the planet's gravity field in such a way that it flew by Saturn in 1979. Both Pioneer-10 and 11 have returned excellent data and continue to operate successfully as they proceed to escape the solar system in opposite directions. These spacecraft are attempting to detect the outer boundary of the Sun's influence while continuing to measure the space environment in the outer region of the solar system. Pioneer-10 is now more than 25 astronomical units from the Sun, closing on the orbit of Neptune.

The Viking Lander 1, redesignated the Mutch Memorial Station in January 1981 by the NASA Administrator, continues to operate in an automatic mission mode. In this mode, it collects and stores selected data at reduced levels for transmission to Earth at periodic intervals upon command. It is expected to continue to do so for several more years.

Planetary flight support provides for mission control and other activities which support the tracking, telemetry, and command functions for all planetary spacecraft. These activities include the

acquisition, operation, and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory.

CHANGES PROM PY 1982 BUDGET ESTIMATE:

The FY 1982 budget estimate for the operation of the Pioneer–Venus and Pioneer–10 and 11 spacecraft has been reduced. This reduction is the result of the general reduction in the overall appropriation request.

BASIS OF PY 1983 ESTIMATE:

The FY 1983 funding will provide for the continuation of Voyager–1 post–Saturn encounter mission operations and the Voyager–2 cruise to Uranus. Analysis and publication of the results of the Jupiter encounter will be continued in FY 1983.

The FY 1983 planetary flight support funds will provide mission control and computing support for the Voyager mission and will also support the operation of the Pioneer–Venus and Pioneer–10 and 11 spacecraft. Operations of the Pioneer spacecraft are currently planned to be terminated in January 1983.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology	37,500	37,800	33,600	28,500
Advanced programs.....	8,800	8,500	6,500	5,500
Mars data analysis.....	4,400	3,200	2,900	---
Halley's comet co-investigations and watch.....	---	2,000	2,000	1,500
Infrared telescope mid-level facility ...	---	---	1,700	---
Total.....	50,700	51,500	46,700	35,500

OBJECTIVES AND STATUS:

The research and analysis program contains five elements required to assure that data and samples returned from flight missions are fully exploited; undertaking complementary laboratory and theoretical efforts; defining science rationale and develop required technology to undertake future planetary missions; coordinating an International Halley's Comet Watch, providing co-investigator support to the European Space Agency's Giotto mission to Halley's comet; and for a proportionate share and occupancy of the mid-level facility for visiting scientists at the Infrared Telescope facilities on Mauna Kea, Hawaii. This facility will be titled to the University of Hawaii.

Supporting Research and Technology -- The supporting research and technology is made up of six areas of effort; (1) planetary astronomy; (2) planetary atmospheres; (3) planetary geochemistry and geophysics; (4) planetary geology; (5) planetary materials; and (6) instrument definition.

The planetary astronomy activity includes all planetary observations made by ground-based, airborne and Earth-orbital telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high. The data acquired are used both for basic research in support of planetary program objectives and for direct support of specific flight missions.

The planetary atmospheres activity includes data analysis, and laboratory and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement and can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus and of Jupiter, acquired by Pioneer Venus and by Voyager, have laid the basic groundwork for major advances in our knowledge about atmospheric sciences.

The planetary geochemistry and geophysics activity is broad in scope and includes studies of the composition and structure of all classes of solar system objects and the synthesis of data from all sources that relate to the origin and evolution of the solar system. The program supports the synthesis of planetary data already obtained, and the assembly of information needed to prepare for future missions. Both Voyager and Pioneer Venus are providing key data for the research efforts undertaken in this program;

To date, the planetary geology activity has focused on studies of the inner planets (including the Moon). Voyager data pertaining to the moons of Jupiter and Saturn have provided a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting all the inner planets provide a powerful technique for unravelling individual planetary histories, including their early states. Imaging data, from both spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The planetary materials activities support an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties, and other characteristics of returned lunar samples and of meteorites that fall to Earth. Recently, extraterrestrial dust grains have been collected for analysis. These studies continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. This program is coordinated with lunar sample research supported by the National Science Foundation.

The instrument definition activity is directed toward ensuring that the science return from future spacecraft missions is maximized by the availability of the state-of-the-art scientific instrumentation.

Advanced Programs -- The objective of advanced programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. For near-term missions, detailed project planning and

technology readiness studies are carried out so that these missions may be undertaken on schedule and within fiscal constraints.

Mars Data Analysis -- The Mars data analysis efforts continue to assure that we capitalize on the wealth of data provided by Viking. This activity covers a broad scope of the returned data related to the disciplines of biology, chemistry, geology, and meteorology. This effort will be discontinued in FY 1983.

Halley's Comet Co-Investigations and Watch -- The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985-1986 by supporting co-investigating scientists on the European Space Agency (ESA) Giotto mission and by conducting complementary remote sensing investigations using both Earth orbiting and ground-based facilities. ESA is planning its Giotto mission to fly by Halley in March 1986. Concurrently, an observation program called the International Halley Watch will be conducted to coordinate scientific observations of Comet Halley. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley throughout its 1985-1986 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data are properly documented and archived; and (4) to receive and distribute data to participating scientists.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The FY 1982 budget estimate for planetary research and analysis has been reduced by a net amount of $4.8 million due to the general reduction in the appropriation request, offset by Congressional action which provided funds for the infrared telescope mid-level facility on Mauna Kea in Hawaii.

BASIS OF PY 1983 ESTIMATE:

During FY 1983, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geochemistry and geophysics, planetary geology, planetary materials, and instrument definition. Telescopic observations will provide data complementary to that obtained from the flight missions with emphasis on the outermost planets, the comets and the asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep atmospheres and in tenuous cometary atmospheres. In the geochemistry-geophysics area, research efforts will be carried out to better understand the present state of evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, and

will also include geological analyses and a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and cosmic particles will continue in order to determine their chemical and physical properties and thereby to derive their origin and evolutionary history. Instrument definition for future missions will be continued in FY 1983.

In FY 1983, work will proceed on advanced mission definition, and on instrument definition and development in support of future planetary science mission opportunities.

The FY 1983 Halley's Comet Co-Investigations and Watch funding is required to support United States co-investigators involved in the design of the European Space Agency's Giotto experiments for the Halley's Comet mission, and also to provide support for a Jet Propulsion Laboratory management team together with several scientists at other institutions who are establishing a worldwide network for the astronomical study of Comet Halley in 1986.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **LIFE SCIENCES PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Life sciences flight experiments..	12,700	14,000	14,000	24,000	RD 6-4
Research and analysis.....	29,488	29,500	25,500	31.700	RD 6-5
Total.....	42,188	43,500	39,500	55,700	
Distribution of Program Amount by Installation:					
Johnson Space Center.....	14,104	13,161	13,120	20,964	
Kennedy Space Center.....	390	1,408	871	1,525	
Marshall Space Flight Center.....,....	8	---	259	350	
Goddard Space Flight Center.....	---	37	---	---	
Jet Propulsion Laboratory.....	1,234	1,184	1,704	2,732	
Ames Research Center.....,.....	17,190	16,450	17,071	21,351	
Langley Research Center.....	176	---	170	170	
Headquarters.....	9,086	11,260	6,305	8,608	
Total.....	42,188	43,500	39,500	55,700	

PROGRAM OBJECTIVES AND JUSTIFICATION:

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight and to understand the basic mechanisms of biological processes using the unique capabilities of the space program. Results from the research program are applied to immediate needs in the maintenance and health of the astronauts; to the design of future support systems for the astronauts; to understanding the response of biological systems to weightlessness; to the design of controlled life support systems for use in future missions; and to the understanding of the larger scale system--the biosphere of the planet Earth.

In the longer term, this program is the key to developing a capability to sustain a permanent manned presence in space. The program includes both ground-based and space research which are mutually supportive and integrated. The program uses a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

In research and analysis, the life sciences program includes several major elements. The operational medicine program is directly applicable to the immediate operational needs of the Space Shuttle. The biomedical research program is focused on understanding and preventing any adverse physiological changes which occur in space flight. Advanced life support is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time. The space biology program consists of flight and ground-based experiments that focus on understanding the effects of zero gravity on plants and animals. The unique properties of space (e.g., microgravity) provide, for the first time, an opportunity to explore significant problems in biology under controlled conditions that cannot be duplicated in laboratories on Earth. Finally, the program in terrestrial biology deals with the origin and early evolution of life and the interaction of life with its environment. The insights gained from this study are important both from a cosmological view and in understanding what would comprise a closed ecological system that could support man in space.

The goals of the operational medicine and biomedical research programs are to assure astronaut and payload specialist health and ability to function effectively in the space environment. Eventually, experience gained from the medical operations support to space flight will allow a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is placed on testing countermeasures designed to prevent untoward physiological responses associated with exposure to the space environment. It is essential that long-term monitoring of the space transportation system crew be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: space motion sickness, cardiovascular deconditioning, bone and muscle loss, and radiation damage. Results of this research have a near-term payoff to operational medicine in the form of countermeasures to be tested in flight. This research will also be utilized in the future development of flight experiments for the first dedicated life sciences Spacelab (Spacelab *4)*.

The advanced life support system program supports activities ranging from the development of less constraining and more efficient space suits for the astronauts, to scientific work in chemistry and biology necessary to understand how life maintains itself in systems which only receive energy from the external environment. All are aimed at future needs of manned space flight.

The objective of space biology is the further understanding of basic physiological mechanisms through the use of gravity and the space environment. Ground-based research and flight experiments have been integrated in the study of fundamental biological questions. Plant and animal experiments have flown on three Soviet Cosmos satellites and as a payload on a Shuttle orbital flight test; and experiments are under development for all Shuttle flights up through Spacelab-4. These experiments explore the physiological effects of space flight on inner ear function, blood factors, bone formation, and plant growth and structure. The information obtained will contribute to the solution of biological and medical problems on Earth as well as contribute to man's effective functioning in space.

One goal of terrestrial biology research is to understand the origin and distribution of life and life-related molecules on Earth and throughout the universe. Particular emphasis is placed on developing sound hypotheses which ultimately will lead to discovering the relationships which link the beginnings of life to the formation of the solar system and the Earth itself. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with flight experiment results, are clarifying the mechanisms of, and environments conducive to, the formation of essential

biomolecules. An immediate extension is to emphasize studies to understand the interaction of the biota with the Earth's environment on a global scale and thereby provide a more comprehensive picture of life--its past, present, and future. NASA's unique ability to monitor changes on a global scale, coupled with its expertise in the required life sciences disciplines, will allow progress toward this goal.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Life sciences flight experiments..... ..	12,700	14,000	14,000	24,000

OBJECTIVES AND STATUS:

The objective of the life sciences flight experiments program is to assimilate information from the various life sciences disciplines and translate it into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analyses, and reporting of medical and biological investigations. Past experience indicates that man clearly undergoes physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth. However, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond a few months, these changes may prove irreversible and acquire medical significance. Early Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early physiological responses to weightlessness, which will improve the management of several existing problems (e.g., space motion sickness) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities involve the development of life sciences flight experiments for early Shuttle flights (e.g., OSS-1, Spacelab-1, Spacelab-2, Spacelab-3, and Spacelab-4). Most of the experiments onboard early Shuttle flights serve as pathfinding activities for Spacelab-4, the first mission

dedicated entirely to life sciences investigations. Hardware and experimental protocols for early flights through Spacelab-2 are well developed and are proceeding toward planned launch dates. Experiments on Spacelab-3 will involve evaluation of functional performance and biocompatibility of hardware that is essential to human and animal investigations to be conducted on Spacelab-4.

Twenty-five investigations have been tentatively selected as the scientific payload for Spacelab 4. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight using both human and animal subjects. Teams of principal investigators will examine cardiovascular adaptation, space motion sickness, muscle wasting, de-mineralization of bone, and the early anemia of weightlessness. This mission is unique in several respects. It is the first mission ever dedicated entirely to life sciences. It involves highly skilled life scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space, and the Spacelab-4 experiments employ complementary experimental designs in human and animal investigations in order to validate animal models for human physiology aloft.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funding is required for the continuing definition and development of investigations which will be flown on future Spacelab missions, particularly Spacelab-4. Final development of engineering and biocompatibility studies for Spacelab-3 will be completed in FY 1983. Tentative selection of investigations for the first dedicated life sciences mission (Spacelab-4) has been completed and, in FY 1983, the design of flight hardware will be finalized and fabrication will be initiated.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Life sciences research and analysis.....	29,488	29,500	25,500	31,700

OBJECTIVES AND STATUS:

The research and analysis activity of the life sciences program is concerned with ground-based research in biological and biomedical problem areas that have been identified in previous manned flights. The program is comprised of five elements: (1) operational medicine; (2) biomedical research; (3) space biology; (4) terrestrial biology; and (5) life support systems research.

The life sciences operational medicine program is responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. This includes assuring physical welfare, performance, and adequate treatment of in-flight illnesses or injuries. The space transportation system will allow for a complement of crews of both sexes and of varied background and age, who will work for different lengths of time in the unique environment of space. The new dimension of frequent and repetitive exposure to zero-gravity has been introduced. Such manifestations as "space motion sickness", fluid shifts, endocrine shifts, which can cause decreased performance in flight, decreased postflight cardiovascular tolerance and possible aggravation of latent diseases, will be carefully documented and either prevented or mitigated to the extent possible. To this end, specific operational require-ments such as careful medical selection, periodic evaluation of health status (including pre- and post-flight medical observation), and in-flight monitoring of the time course of adaptation and performance in the space environment will be continually reevaluated and updated. Significant emphasis is placed on real-time testing, under controlled conditions, of promising countermeasures developed by the research and analysis program.

The objective of the biomedical research program is to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, with each designed primarily to rectify a particular physiological problem known or expected to affect the human organism in prolonged or repetitive space flight. Thus, such problems as motion sickness, bone loss, and hormonal disturbances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventative measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space. In the course of this research, measuring techniques which provide greater insight into physiological processes are frequently developed.

The space biology activity explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal cellular processes, embryonic development, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth and metabolism to provide for long-term survival and multigeneration reproduction of life in space. This program provides important ground-based information needed to develop future space flight experiments and life support systems.

Terrestrial biology includes the study of the origin, evolution, and distribution of life and life-related molecules on Earth and beyond. Sophisticated analyses of life as we know it--its chemical precursors, and its origin, coupled with extrapolation to extraterrestrial environments--afford a unique opportunity to address a most fundamental question regarding the origin of life on Earth and the existence of such processes elsewhere. The current research program also is uncovering an intimate association between the origin and evolution of life on Earth and the processes which shaped the evolution of the solar system itself. The influence of the physical and chemical properties of the primitive environment on the rate and direction of evolution of life is also shedding light on the interaction of the contemporary Earth's biota with the biosphere--the land, oceans and atmospheres. The reverse is also true. Remote sensing and data handling capabilities will be assessed for their ability to provide data, on a global scale, of how life modulates the cycling of elements and molecules through these components. These analyses will allow the development of models to test the stability of the ecosystem and predict its resiliency to perturbations, either natural or life-related, as well as provide insight into the origin and evolution of primative ecologies.

The life support systems research program concentrates on enhancing our ability to support long-duration manned presence in space and on optimizing the productivity of mixed spacecraft crews. Improvements are sought in spacecraft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for improved technology and for new system approaches that would include food recycling for very long missions. Research is in progress on space suits for quick reaction situations and on scientific approaches to designing space tools and work stations.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The research and analysis funding has decreased by $4.0 million from the FY 1982 budget estimate as a result of the Congressional general reduction in the appropriations request. This reduction will be accommodated through the deferral of planned FY 1982 efforts aimed at preparing for longer duration manned space flight, improved life support systems, and the development of advanced concepts for future life sciences experiments.

BASIS OF PY 1983 ESTIMATE:

For each Shuttle flight, the operational medicine program will investigate and collect information on occupational exposures in zero-gravity, inflight clinical testing of countermeasures, especially in the areas of cardiovascular deconditioning and motion sickness, and development of health care procedures compatible with the space environment. Annual and pre- and post-flight medical data will be collected in order to better define responses of different population groups to spaceflight.

The biomedical research program will focus primarily on the motion sickness problem because of its relevance to Shuttle operations. Cardiovascular and musculoskeletal studies will also be pursued in recognition of the considerable fundamental knowledge that must be acquired in these areas before effective countermeasures to the effects of spaceflight can be devised. Increased awareness and understanding of the radiation hazard has resulted in more emphasis being placed on the biomedical effects of high energy radiation and upon radiation protection.

The space biology program will study the stress responses to hypo- and hyper-gravity and the relationship of these responses to those provoked by other stresses and stimuli. The use of gravity as a tool to investigate fundamental hormonal responses and basic biological control mechanisms will be expanded. The space biology program will provide ground-based data for definition of Shuttle/ Spacelab flight experiments for OSS-1 and Spacelab 1 through 4.

Terrestrial biology research will concentrate on studies delineating the effect of the physical and chemical environment of the primitive Earth on both the rate and direction of evolution of life. Studies of both primitive and extant ecologies will be emphasized. Strategies will be developed for measurement of major biologically-mediated molecular cycles through the biosphere. This research forms the foundation, on a small scale, for a more complete understanding of present-day biota-biosphere interactions on a global scale.

The life support systems program will investigate basic biological processes and physical/chemical methods which will provide the capability to recycle waste, food, atmosphere and water. In addition, concepts €or improved space suits for the Shuttle era will be brought to a state of development which will pave the way for implementation on future Shuttle missions.

In addition, the FY 1953 funding will support the reinstatement of a modest effort to support the definition and development of techniques to analyze extraterrestrial radio signals for patterns that may be generated by intelligent sources.

SPACE
APPLICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **SPACE APPLICATIONS PROGRAM**

SUMMARY OF RESOURCE REOUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Resource observations	151.350	165.400	146.400	132.200	RD 7-7
Environmental observations	104.100	135.300	116.500	128.900	RD 7-28
Applications systems	18.100	14.200	13.200	11.700	RD 7-51
Technology transfer	8.100	---	5.000	---	RD 7-52
Materials processing in space	18.700	27.700	23.800	23.600	RD 7-54
Communications and information systems	31.200	30.300	20.900	19.900	RD 7-60
Total	331.550	372.900	325.800	316.300	

Distribution of Program Amount by Installaton:

Johnson Space Center	26.667	32.475	15.062	15.050
Kennedy Space Center	255	170	---	---
Marshall Space Flight Center	16.948	24.720	19.166	18.200
National Space Technology Laboratories	2.814	1.600	3.225	2.800
Goddard Space Flight Center	179.666	215.225	195.800	189.950
Jet Propulsion Laboratory	25.305	32.250	29.480	35.644
Ames Research Center	18.155	11,135	16.755	16.450
Langley Research Center	12.835	17.325	12.070	10.750
Lewis Research Center	19.301	18.180	8.740	6.050
Headquarters	29.604	19.820	25.502	21.406
Total	331.550	372.900	325.800	316.300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS | **SPACE APPLICATIONS PROGRAM**

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Resource Observation:		
Earth Resources Technology Satellites	Launch of Landsat-D	1982
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1981
	Spacelab Payloads	Beginning in 1984
Environmental Observations:		
Earth Radiation Budget Experiment	Launch of ERBS	1984*
	ERBE instrument to be launched on NOAA FCG	1983 & 1985* (subject to NOAA call-up)
Materials Processing in Space:		
Materials Experiment Operations	Sounding Rocket Flights	1 flight in 1983
	Flight of Shuttle Mid-deck Experiments	Beginning in 1982
Space Communications:		
Search and Rescue Mission	Instruments to be launched on NOAA-E, F, G, H, I and J spacecraft	1982, 1984-1988 (subject to NOAA call-up)
Reimbursable Missions		
GOES**	Launch of GOES F - I	1983-1986*
NOAA**	Launch of NOAA D - J	1982-1988* (subject to NOAA call-up)

*Currently under review

**National Oceanic and Atmospheric Administration (NOAA) funded.

PROG JEC S IL JUSTIFICATION:

The objective of the Space Applications program is to conduct research and development activities that demonstrate space-related technology, systems, and other capabilities which provide down-to-Earth practical benefits. These activities are grouped in the following general areas: resources observations, environmental observations, applications systems, technology transfer, materials processing in space, and communications and information systems.

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

Resource Observations - This program addresses the need for information of vital economic value to the United States and of worldwide humanitarian concern required for management of the world's limited food, water, and energy supplies, and the requirement for the identification of potential geological hazards. The principal objectives are to develop and demonstrate the use of space and space technology to provide the United States with a global capability for monitoring and forecasting major agricultural commodities, for water resources management, for land use assessment, for improving the exploration for mineral and energy resources, and for understanding the dynamic characteristics of the solid Earth and its crust, including tectonic plate motion, stability, and crustal deformation.

Principal activities include the identification of user information needs, development of remote sensing and information extraction techniques, and provision for the acquisition of space data leading eventually to the establishment and routine use of global data collection systems. Currently, Landsat-2 and -3 are providing a wide variety of useful data. Landsat-D, with improved sensing capabilities, is under development and will be launched in 1982. NASA will support the National Oceanic and Atmospheric Administration (NOAA) in its new responsibility of managing the operation of the Landsat-D system. Experiments designed to test the applicability of active microwave measurements were successfully conducted on the second Space Shuttle orbital test flight, and a large format camera to obtain high resolution imagery for mapping investigations is planned for flight on subsequent Shuttle missions. Studies are also underway for development of advanced technology for improved

remote sensors for multiple applications. Joint research, development, and testing activities with other Federal agencies are underway to advance our understanding of how to apply multiple data sources in improving agricultural early warning and crop commodity forecasting. Joint research activities are planned with other Federal agencies and coordinated with international organizations for advancing the scientific knowledge of the solid Earth.

Environmental Observations - Understanding the dynamics and limitations of our environment is essential to our long-term survival and to many of our day-to-day activities. Prediction of the weather, control of pollution, ship routing, storm warnings, and modeling of long-term trends in climate and in the stratosphere, are all areas where such understanding is put to day-to-day or strategic planning uses. **NASA's** environmental observations program aims at improving the understanding of processes in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional in extent, they can be most effectively, and sometimes solely, studied from space. **NASA's** program includes research efforts plus the development of new technology for global and synoptic measurements. **NASA's** research satellites give a special view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

The environmental observations program includes studies and flight missions directed at the upper and lower atmosphere and at the upper layer of the oceans. The program areas include: atmospheric chemistry and physics (including upper atmospheric research and tropospheric air quality), weather and severe storms, oceanic processes (including circulation, marine productivity and sea ice); and climate. This integrated approach encompasses such diverse fields as meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography. It focuses on the special opportunities afforded by space based observations.

Studies of the upper atmosphere are producing an understanding of the distribution of ozone and other trace constituents and predictions of how these will evolve. Localized field measurements are determining the detailed processes involved. The upper atmospheric research satellite experiment program is developing a set of instruments to provide the needed global data for a comprehensive determination of the state of the upper atmosphere. We have reassessed the severity of the threat to the ozone layer due to chlorofluorocarbons and have found it to be in the five to ten percent range for depletion of ozone over the globe. Our ability to make these projections is being improved through laboratory measurements and the development of more realistic numerical models which make use of the data obtained from *in situ* and space observations.

Research on the dynamics and radiative properties of the atroosphere is showing that the improved global observations available only from space can extend long range weather forecasts eight to ten days. Advanced numerical modeling techniques are being employed to improve our understanding of weather and severe storm phenomena. New remote sensing capabilities are being developed to provide the data needed to test our theories and extend predictive abilities. The radiative budget of the Earth which results from the flow of solar energy through the environment and back to space is fundamental in our understanding of climate. The Earth radiation budget experiment is being developed for launches beginning in *1984* and will provide virtually all of the essential observations needed to understand this phenomenon.

Data from the instruments carried in the NIMBUS, SAGE, and SEASAT satellites continue to prove valuable in understanding many aspects of the environment. Ocean observations have shown the potential for revolutionizing oceanography and providing useful new information. A major effort is underway to determine the best approach to using satellite altimeters to measure the currents flowing in the global ocean. The perspective of ocean circulation offered by space has never been available to oceanographers. Quantitative measurements of the chlorophyll concentration in the ocean surface layer have been made using the coastal zone color scanner and are being used to determine the productivity of the ocean and the best places to fish. Measurements of sea surface winds have been shown to be useful in improving weather forecasts and will be essential to determining wind driven components of the ocean circulation.

Applications Systems - This program supports space applications requirements for use of airborne facilities and provides flight support to major segments of the space applications programs as well as to other NASA programs.

Technology Transfer - The objectives of the technology transfer program have been to understand the information needs of potential users of remote sensing technology in the public and private sectors and to provide for the transfer of applicable technology to meet those needs. The functions performed by this program are being discontinued at the end of FY 1982 based on the decision to allow the private sector to assume these efforts.

Materials Processing in Space - The materials processing in space program emphasizes the basic and applied science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. The goal is to develop, test, and demonstrate the capabilities of spaceborne facilities for materials processing in the space environment, and to provide opportunities for independently funded users to exploit space flight for processing

activities related to their own needs. In accordance with guidelines formulated and published in 1979, negotiations on several joint endeavors with private companies will continue in 1982. These activities are intended to encourage early transfer of space activity in materials science to private sponsorship. Ground-based research in FY 1982 will accommodate new areas of interest in materials science and in physical and chemical sciences as well as advanced technology development to meet needs identified in the research program. Development of the program's first space transportation system payload will be completed in 1983, leading to flight in early 1984.

Communications and Information Systems - NASA efforts in communications in FY 1982 and FY 1983 will focus on completion of generic proof of concept communications technology, technical support to the United States government for the World Administrative Radio Conference/Regional Administrative Radio Conference planning efforts, and continued experiment support to the ATS 1-3-5 satellites. Information systems support will continue to emphasize development and demonstration of advanced data capabilities.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 current estimate is a net decrease of $47.1 million from the budget estimate, which results from specific adjustments made to the program by the Congress, plus a portion of the general reduction in the appropriation. Generally, reductions have been applied to all program areas in keeping with the desire to maintain program balance.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

RESOURCE OBSERVATIONS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Landsat-D	88,500	83,900	83,900	61,700	RD 7-12
Extended mission operations	2,700	2,800	2,800	1,800	RD 7-15
Magnetic field satellite	500	---	---	---	---
Shuttle/Spacelab payloads	2,000	2,000	3,300	2,800	RD 7-17
Geodynamics	23,400	30,900	22,900	26,200	RD 7-19
AgRISTARS	21,450	23,100	14,000	15,000	RD 7-22
Applied research and data analysis	12,800	22,700	19,500	24.700	RD 7-24
Total	151,350	165,400	146,400	132,200	

OBJECTIVES AND STATUS:

The broad objectives of the resource observation program are to develop and apply space observation techniques to meet national and global needs for improved management of food, fiber, water, and land resources; improve our ability to systematically evaluate the composition and geometry of the Earth's crust in order to increase the effectiveness of global assessment, exploration, and development of mineral and energy resources; and increase our understanding of the solid Earth, its interior stucture and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and the mechnanisms associated with the occurrence of earthquakes.

Principal elements of the program include the development of space and supporting ground systems and improved data processing and analysis techniques; Shuttle and aircraft support for sensor and technique development; as well as basic and applied research for identifying, monitoring, analyzing, and modeling the vegetated and geological features of the Earth.

Both Landsat-2 and -3 are currently operating and providing data, although at reduced operational levels. Both Landsat-2 on-board video tape recorders are, however, inoperative, limiting its data return mode to real time operations. Landsat-3 has one fully operational tape recorder (capable of recording both Multispectral Scanner and Return Beam Vidicon data); the second recorder has failed. The overall tape recorder status for full worldwide coverage is such that a backup plan has been implemented by installation of ground recording equipment in selected foreign stations to assure worldwide coverage for key agricultural programs. There are now ten ground receiving stations operating in nine other countries.

Landsat-D development is proceeding with the launch of Landsat-D planned for 1982. Landsat-D will incorporate both the Thematic Mapper (TM) and Multispectral Scanner (MSS). Landsat-D', the backup spacecraft, will be available for launch 12-15 months later. In addition to continuing the availability of MSS data, Landsat-D will provide imagery with the improved spectral and spatial resolution of the thematic mapper needed to expand the use of space data for agricultural, water resources, land use, and other applications.

Another aspect of the resource observation program is the research associated with understanding the physical relationship of various types of vegetation and other surface features with the radiation which they emit or reflect; the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. The scope of these activities ranges from individual scientific studies to projects such as the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS).

AgRISTARS, a research, development and test program, addresses identified U.S. Department of Agriculture information requirements by combining NASA's unique remote sensing development expertise with complementary resources from Department of Agriculture and Department of Commerce. This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. Substantial progress has been made in developing techniques for enhancing the separability of crops, particularly small grains, corn and soybeans at or near harvest. Additional research is being conducted to develop procedures for improved separability during the growing season.

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information needed to understand the processes leading to the release of crustal strain in the form of earthquakes; to improve our understanding of the formation of mineral deposits; to contribute to long-term weather and climate forecasting; and to

better understand the Earth as a planet. Space techniques (laser ranging to satellites and the Moon, very long baseline interferometry using radio stars or satellites, and satellite mapping) are the only methods which can provide the precise measurements needed for these studies. In FY **1981** and **1982,** measurements of the relative motion of several of the tectonic plates which form the Earth's crust, and of regional crustal deformation in California were conducted. Variations in the Earth's polar motion were monitored and correlated with changes in the angular momentum of the Earth's atmosphere resulting from shifts in atmospheric winds.

The Landsat-D thematic mapper (TM) and multispectral scanner (MSS) instruments have been delivered by the contractor, Hughes Aircraft Company, and are currently in the test phase following spacecraft integration at the mission contractor, General Electric. During FY **1982,** the Landsat-D' subsystems will be delivered.

The Landsat-D ground segment development has made significant progress during the past year. All data processing hardware elements required for the Landsat-D launch have been delivered and integrated with the facilities needed to operate the spacecraft, process the MSS data, and control the entire ground complex. Software development is nearing completion; facility acceptance tests are scheduled for **1982** and will be followed by an operational readiness test. The TM processing system design is nearing completion.

The focus of the Multispectral Linear Array (MLA) advanced technology development is on the development of technology for a future high performance MLA instrument for use as a diagnostic tool for fundamental research in remote sensing. The MLA solid state sensor has a number of significant advantages over existing mechanically-scanned sensors including electronic scan, inherent geometric and spectral registration and programmable high spatial and spectral resolution. The critical technology development and support research initiated in FY **1981** on the linear array instrument and the Shuttle Imaging Spectrometer will continue in FY **1982.**

The objective of the Shuttle/Spacelab Payload Development project is to develop, test, and evaluate earth-viewing remote sensing instruments and systems to obtain data for resource observations research. The instruments which were flown on the second Shuttle orbital test flight in November **1981,** the Shuttle Imaging Radar, for evaluation of the utility of spaceborne imaging radar for geologic exploration, and the Shuttle Multispectral Infrared Radiometer, which is used to determine the optimum spectral bands for surface materials classification, operated successfully. In FY **1982,** these instruments will undergo post flight calibration and evaluation, and the data from the flight will be processed and analyzed. The Large Format Camera, required for high resolution mapping applications, will be removed from storage and prepared for flight on the Shuttle.

MAJOR FY 1983 ACTIVITIES:

Remotely-sensed multispectral and high resolution panchromatic imagery of the Earth's surface will continue to be supplied by Landsat-2 and -3 to research and development and operational users for application to agriculture, forestry, range, water and land resource management; for geological studies; and for mapping. The onvrbit check-out of Landsat-D, planned to be launched in 1982 will be completed. Operation of the spacecraft, the multispectral scanner (MSS), and the MSS ground system will be turned over to the National Oceanic and Atmospheric Administration (NOAA) following checkout and verification of the performance of the space and ground segments. Landsat-2 and -3 will provide MSS overlap/backup to Landsat-D until mid-FY 1983. Both Landsat-2 and -3 will then be placed in a "standby storage" mode allowing rapid reactivation if needed.

The Landsat-D' spacecraft and payload will be integrated and environmental tests performed in preparation for standby launch readiness in the event of a Landsat-D failure. Development of the thematic mapper (TM) ground system hardware and software will be completed in FY 1983 with an initial data production capability of 12 scenes/day by July 1983. Landsat-D TM multispectral data with improved spatial resolution, additional spectral bands extending into the middle and thermal infrared range, and improved radiometric sensitivity will then be provided to research and development users.

Critical technology development will be continued for a multispectral linear array (MLA) solid state sensor to meet evolving research requirements of the late 1980's for improved spatial and spectral resolution, improved radiometric sensitivity, and in-flight programmability. The emphasis in FY 1983 will be on the development and evaluation of the detector modules for the short wave infrared bands in order to develop the technology ultimately required for a series of onvrbit scientific experiments. Development of the short wave infrared focal plane, visible wavelength charge coupled device modules, and an optical subsystem will continue. In addition, long-range technology developments, directed towards an evolving capability to support a broader-based fundamental research program in land remote sensing experiments will be continued. Experiments will be conducted in the laboratory and aboard the Space Shuttle to test the advanced technology and apply it to basic research objectives.

The large format camera, completed in 1981, will be removed from storage and calibrated in prepartion for flight on the first available Shuttle. The attitude reference system, which will provide precise pointing accuracy information, will be developed and flown in conjunction with the large format camera. A digital data system for the Shuttle imaging radar-A (SIR-A) will be developed and the SIR-A antenna modified to incorporate a fold mechanism for more efficient utilization of the available volume in the Shuttle payload bay. A tilt mechanism will be added for variation in antenna angle during data acquisition.

AgRISTARS activities conducted in conjunction with Department of Agriculture (USDA), NOAA, Department of the Interior, and the Agency for International Development to meet the information needs established by the USDA--early warning/crop condition assessment, foreign commodity production forecasting, supporting research, soil moisture, domestic crops and land cover, and conservation--will be continued. In **FY 1983** research will continue on automated procedures for crop classification which significantly reduce analyst involvement while maintaining accuracy. Techniques will be developed for classifying large geographic areas, soil mapping, domestic land use and crop statistics improvements. Conservation practice identification activities will also be continued. This research will utilize simulated thematic mapper data from aircraft and spacecraft, when available, to assess improvements over MSS-based procedures.

In the applied research and data analysis program, the emphasis in **FY 1983** will be on the development of techniques for information extraction from remotely-sensed data in the visible, short wave, and thermal infrared regions, and from active and passive microwave sensors. In renewable resources, simulated aircraft TM data and TM spacecraft data, when available, over urban, rural, and degraded land areas will be analyzed to quantify the improvement in classification accuracy of TM data over MSS data. Synthetic aperture radar imagery from aircraft, Seasat, and SIR-A will be analyzed to determine its unique and complementary information content. Fundamental research activities in scene radiation and pattern recognition will be conducted and research topics in electromagnetic measurements and data handling and in information utilization and evaluation will be identified for future implementation. The joint program with the Japanese on snow and evapotranspiration monitoring will be completed.

In nonrenewable resources, laboratory and field experiments will be conducted to evaluate the utility of narrow band multispectral imagery and combinations of imagery from divergent regions of the spectrum (visible/infrared/microwave) for geological mapping. In **FY 1983,** special emphasis will be placed on the data collected by SIR-A and the shuttle multispectral infrared radiometer flown on the second Shuttle orbital test flight. Analysis of Magsat vector data will continue with emphasis on the crustal magnetism of higher latitude regions (e.g., the Arctic Basin and Greenland) where aircraft and ground-based measurements are hampered by external magnetic field effects. The airborne multiband thermal infrared scanner will be calibrated and tested in aircraft flights. Passive microwave sensors and scatterometers will be upgraded for field and aircraft use.

In **FY 1983** seven new technique tests--cooperative projects between NASA and a user to develop and test remote sensing technology--will be initiated, emphasizing use of simulated aircraft TM data and spacecraft TM data, when available to delineate hydrologic features, model wetlands productive

capacity; and aid in facility site selection for waste disposal, transmission line corridor siting, crop mensuration, crop condition assessment, and timber inventory.

The geodynamics program is conducted jointly with NOAA, United States Geological Survey, National Science Foundation, and Defense Mapping Agency through an interagency agreement. During the past several years, measurements (baselines) have been made at regional, continental and intercontinental scales using laser ranging to satellites and to the moon, and very long baseline microwave interferometric techniques have been used to study the rotational dynamics of the Earth and to model the Earth's gravity and magnetic fields. In FY 1983, the focus will be on continuation of studies of the western United States regional deformation and the relative motion of the North American and Pacific plates. Plans will be continued for a future joint United States/Japan Pacific plate motion study. The training of NOAA personnel for operation of mobile very long baseline interofermetry systems will be completed, and operations phaseover to NOAA will be initiated. A consortium of European countries and United States scientists will initiate a program of measurement of crustal deformation in Europe and the eastern Mediterranean using the techniques pioneered by NASA. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling of geopotential fields will be continued. Development of a geodetic receiver, which uses signals from the global positioning system to measure crustal strain accurately within a few hundred kilometers of a fault, and laboratory development of a three-axis cryogenic gravity gradiometer sensor for Earth gravity field surveys from space will be completed.

Earth Resources Technology Satellite (Landsat-D)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spacecraft systems and sensors.....	72,200	44,400	44,400	19,800
Ground system.....	15,100	27,600	27,600	28,300
Ground operations.....	---	8,500	8,500	10,400
Investigations.....	1,200	3,400	3,400	3,200
Total.....	88,500	83,900	83,900	61,700
Delta (expendable launch vehicles program)	(8,500)	(3,300)	(9,100)	(3,000)

OBJECTIVES AND STATUS:

The objective of the Landsat-D project is to develop, launch, and operate an advanced land observing system and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental thematic mapper (TM) and the flight proven multispectral scanner (MSS). The Landsat-D launch is planned for 1982. The backup spacecraft will be available for launch 12-15 months after the initial launch. The major technical focus of the Landsat-D project involves a test of both the thematic mapper instrument's capabilities and an improved ground data handling system. The thematic mapper will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of Landsat data and to enhance many current uses.

The thematic mapper was delivered on schedule in October 1981 and has been integrated with the spacecraft. Its performance has exceeded specification requirements in many areas, and no significant integration problems have been encountered. The MSS was delivered in July 1981 and has also been satisfactorily integrated with the spacecraft.

All other elements needed to complete the assembly of the Landsat-D spacecraft have been delivered and integrated. These include the multimission modular spacecraft, the wideband communication system, and the global positioning system. The totally integrated spacecraft is in the systems compatibility and environmental test cycle. Activities are on schedule for a launch from the Western Space and Missile Center.

During FY 1982, the Landsat-D' thematic mapper will be integrated, tested and delivered. All other subsystems required for Landsat-D' have already been delivered, or will be delivered during FY 1982 for integration with the spacecraft.

The ground segment hardware and software development has made significant progress during the past year. All data processing hardware elements required for the Landsat-D launch have been delivered and integrated with the facilities needed to operate the spacecraft, process the MSS data, and control the entire ground complex. Software development is nearing completion. Facility acceptance tests are scheduled for 1982 and will be followed by a three-month operational readiness test.

The TM processing system design is nearing completion. At the time of the Landsat-D launch, the TM research and development data production rate will be approximately one scene per day. During the first year of operation, the sensor performance will be characterized and the necessary software will be developed to permit a production rate of 12 scenes/day by mid-1983.

BASIS OF PY 1983 ESTIMATE:

FY 1983 funds will be utilized to integrate and perform the acceptance testing of the Landsat-D′ spacecraft, and to continue the development of the TM processing system.

FY 1983 funds will also be utilized to operate the facilities required for MSS operations for about six months after the launch of Landsat-D. After that time NOAA will fund and operate the facilities necessary for spacecraft control, mission management, and MSS data processing. The funds required for training NOAA personnel to accomplish these tasks are included in this budget estimate. Using data from the on-orbit performance of the TM instrument, the ground processing system will be upgraded to process 50 scenes per day by 1985. Current planning assumes the TM processing system will be turned over to NOAA at that time.

Extended Mission Operations

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Heat capacity mapping mission.....	525	---	---	---
Landsat-2 and -3.....	1,990	2,575	2,575	1,700
Magsat	185	225	225	100
Total.....	2,700	2,800	2,800	1,800

OBJECTIVES AND STATUS:

The objective of extended mission operations is to capitalize on the continued performance of Earth resource observation satellites (including Landsats) beyond the initially planned mission duration. Data products Erom these missions are being used to support research and operational activities in agriculture, water resources, geology, and land use. In the case of Landsat, some operational requirements of federal and state agencies, plus many private interests are now being satisfied.

Both Landsat-2 and -3 are currently operating and providing data, although at reduced operational levels. Both Landsat-2 onboard video tape recorders are, however, inoperative limiting its data return mode to real-time operations. Landsat-3 has one fully operational tape recorder (capable of both multispectral scanner and return beam vidicon data). The second Landsat-3 recorder has failed, however, a backup plan has been implemented by installation of ground recording equipment in selected foreign stations to assure worldwide coverage for key agricultural programs. There are now ten ground receiving stations operating in nine other countries.

Resolution of Magsat data was completed in FY 1982. Preliminary maps of crustal magnetic anomalies have been prepared and distributed to a group of scientific investigators. A global magnetic map based on Magsat data was accepted as the worldwide standard by the International Association of geomagnetism and aeronomy.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding will support the continued acquisition of remotely-sensed multispectral and high resolution panchromatic imagery of the Earth's surface from Landsat-:! and -3 for both research and development and operational users. Landsat data will be applied to agricultural, forestry, and water and land management studies. Landsat-2 and -3 are planned to be retired from service in March 1983, subject to the satisfactory launch and operation of Landsat-D. Magsat data will be concluded in FY 1983, and a final set of magnetic field models and crustal anomaly maps will be issued.

Shuttle/Spacelab Payload Development

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Payload development.....	1,715	1,600	1,600	1,500
Large format camera.....	285	400	1,700	1,300
Total.....'.....	2,000	2,000	3, 300	2,800

OBJECTIVES AND STATUS:

The objective of this project is to develop, test, and evaluate Earthviewing remote sensing instruments and systems to obtain data for resource observations research. Instruments were completed and successfully flown on the second Shuttle orbital test flight. Development of the large format camera is complete.

The instruments flown on the second Shuttle orbital test flight were the Shuttle imaging radar which is required for evaluation of the utility of spaceborne imaging radar for geologic exploration, and the Shuttle multispectral infrared radiometer, used to determine the optimum spectral bands for surface materials classification; and the Ocean Color Experiment, which can differentiate ocean colors and identify algae concentrations for fishery applications. In FY 1982, these instruments will undergo postflight calibration and evaluation, and the data from the flight will be processed and analyzed. The large format camera will be maintained in storage, pending preparations €or flight on the Shuttle. Interface compatibility studies and integration support will be initiated, and electrical and mechanical spares will be procured. System design trade-off studies will be initiated for an advanced Shuttle radar system.

CEANGES FROM PY 1982 BUDGET ESTIMATE:

The increase in the FY 1982 funding allows for an acceleration of the initial demonstration flight of the large format camera, and the incorporation of an attitude reference system into the camera

flight package. The attitude reference system will provide precise pointing accuracy information for the large format camera necessary for the preparation of metric quality photographs, especially in regions of the world without geodetic control points.

BASIS FOR FY 1983 ESTIMATE:

During FY 1983, development of the attitude reference system will be completed, and will be delivered and integrated with the large format camera. The camera package will be shipped to the Kennedy Space Center for integration as part of a Shuttle cargo and flown on a future Shuttle mission. Feasibility and preliminary design studies will be conducted on a fold and tilt radar antenna to provide more efficient utilization of the Shuttle payload bay volume as well as selectable look angles. System design studies will be conducted for an improved imaging radar evolving from the Shuttle Imaging Radar flown on the second Shuttle orbital test flight.

Geodynamics

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Crustal dynamics project.....	11,570	16,300	14,000	16,500
Laser network operations.....	8,630	12,400	6,900	7,000
Research and technique development.....	3,200	2,200	2,000	2.700
Total.....	23,400	30,900	22,900	26,200

OBJECTIVES AND STATUS:

The geodynamics program makes use of the unique capabilities provided by space techniques to improve our understanding of the dynamic processes occurring within the Earth and at its surface. The objectives of the program are to contribute to studies of earthquake mechanisms by measuring and modeling crustal deformation at active plate boundaries; to verify and extend tectonophysical theories by measuring the contemporary motions of the plates and determining the plate-driving forces; to study causative relationships between variations in the Earth's polar motion and rotational rate with earthquake occurrences, internal core dynamics, and other physical phenomena; to map and model the global gravity fields for studies of crustal processes associated with the formation of mineral and petroleum deposits; to study mantle convection and the internal composition and structure of the Earth; and to facilitate the establishment of new geodynamic measurement services which will make use of precise position determination methods.

The principal activity under the geodynamics program is the crustal dynamics project. This project supports the development of laser ranging and very long baseline interferometry systems for measurement of plate motion, plate stability, regional crustal deformation, polar motion, and Earth rotation, and is expected to contribute to the understanding of why and how earthquakes occur, and perhaps, to the development of earthquake prediction methods. Project activity is conducted jointly with the National Oceanic and Atmospheric Administration, the United States Geological Survey, the National Science Foundation, and the Defense Mapping Agency, through an interagency agreement for the

application of space technology to crustal dynamics and earthquake research. The laser network supports the project through the acquisition and processing of laser data for sites in the United States the Pacific, South America, and Australia.

Beginning in 1981, epoch measurements (baselines) were obtained for studies of crustal deformation over a large portion of California and in other parts of the western United States. In 1982, and subsequent years, these measurements will be repeated to obtain deformation rates. A highly mobile laser system was placed in operation in 1981, and work was continued on the development of mobile very long baseline interferometry systems and laser systems. In response to an announcement of opportunity issued in 1980, 60 domestic and foreign investigators were selected to analyze data acquired by the crustal dynamics project.

Development has continued on a geodetic receiver design (SERIES), which uses signals from the Global Positioning System. SERIES will provide rapid (few days) and accurate ($\pm$ 1 cm) measurement of crustal movement within a few hundred kilometers of a fault. *Also* in 1981, an interagency plan was approved for initiation of a national crustal motion network by NOAA using NASA equipment, for completion and operation of a polar motion monitoring network (POLARIS) by NOAA, and for establishment of local crustal strain monitoring networks by U.S. Geological Survey using the Global Positioning System receivers. The feasibility of using satellite-to-satellite tracking to substantially improve gravity field surveys was demonstrated in the laboratory, and initial models of the vector components of the Earth's magnetic field were produced.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

As a result of the FY 1982 general reduction in the appropriation, geodynamics activities have been decreased. Crustal dynamics efforts will focus primarily on measurement of crustal movement and deformation associated with highly seismic areas in the western United States. The laser network operations will be scaled down to the minimum required to support the United States studies. Research and technique development will stress the development of models of plate motion, crustal deformation, Earth rotational dynamics, and conceptual studies of advanced instruments and missions. Activities in global Earth structure and dynamics have been terminated.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, the western United States regional deformation measurements and measurements of the relative motion of the North American and Pacific plates will be continued. Analysis of these data

and earlier data will provide the first maps of large-scale crustal deformation in the western United States. Planning will be continued for a joint United States/Japan Pacific plate motion study. The training of NOAA personnel for operation of mobile very long baseline interferometry systems and phaseover to NOAA operation will be completed. Operation of the laser network will be continued at the reduced level. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling of geopotential fields will be continued. Development and field tests of the SERIES unit and laboratory development of a three-axis cryogenic gravity gradiometer sensor will be completed.

AgRISTARS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Technique development (Formerly foreign commodity production forecasting)	7,400	6,000	1,700	2,800
Supporting research	8,750	11,100	7,400	7,400
Early warning, soil moisture, domestic crop and land use, conservation, pollution, and renewable resources	5,300	6,000	4,900	4,800
Total	21,450	23,100	14,000	15,000

OBJECTIVES AND STATUS:

AgRISTARS, a research, development and test program, addresses identified Department of Agriculture (USDA) information requirements by combining NASA's unique remote sensing research and development expertise with complementary resources from the USDA and Department of Commerce. Improved information on world agricultural potential production has been identified by USDA as a major need for establishing effective United States and international food and agriculture policies, and for efficient operation of United States agricultural markets. With present resource limitations and political situations in many countries, aerospace remote sensing provides the only feasible means for making significant improvements.

This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. There is no other existing research and development program that would enable this country to obtain the potential for global vegetation asssessments.

The major NASA thrust in AgRISTARS is to conduct the research, development, and test activities necessary to identify and validate basic techniques for extracting useful information from remotely-

sensed data for the purpose of inventorying vegetation types and assessing their condition. Substantial progress has been made in developing techniques for enhancing the separability of crops, particularly small grains, corn, and soybeans at or near harvest. Additional research, however, is required to develop procedures that are valid early in the growing season. Present results obtained with simulated thematic mapper data hold promise for much improved separability of corn/soybeans at earlier growth stages, and for accommodating a wider range of agricultural conditions, e.g., small fields. Major questions regarding the ability to remotely measure soil moisture have been positively answered, but the conversion of these measurements to meet information needs remains to be developed.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 budget estimate has been decreased due to the general reduction in the appropriation request. This will result in the elimination of crop identification pilot testing.

BASIS FOR FY 1983 ESTIMATE:

Major FY 1983 milestones for the technique development project include completion of a multiple crop technique development and test activity. This activity includes separation of corn and soybeans and small grains.

Major FY 1983 milestones for supporting research include research on classification techniques which emphasize use of spatial information and improved understanding of physical processes that influence the energy emitted or reflected from scene elements for improving spectral classification procedures. Research on the use of spectral data for crop condition assessment will focus on development of crop growth and yield models which accept remotely-sensed data.

Three problems encountered during the first two years of the program will be addressed in FY 1983. These include separating small grains by utilizing multispectral scanner data, developing spectral inputs to yield and crop condition models, and developing applications of statistical sampling theory for remotely-sensed data.

Emphasis will be given to development of techniques for evaluating thematic mapper data in such applications as crop identification and area measurement, identification of conservation practices, soil practices, soil mapping, and forest species identification. Research in the use of microwave techniques for improved crop identification and soil/snow moisture monitoring will be continued.

Applied Research and Data Analysis

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Renewable resources	2,850	4,400	3,700	6,000
Nonrenewable resources	3,300	5,000	4,300	6,600
Technique tests	1,050	1,500	1,300	1,100
Operational earth resources system definition	600	2,000	---	---
Advanced studies	700	1,800	1,500	---
Multispectral linear array advanced technology development	4,300	8,000	8,700	11.000
Total	12,800	22,700	19,500	24,700

OBJECTIVES AND STATUS:

The goal of the applied research and data analysis activities is to develop thorough remote sensing capabilities that aid in the management of renewable and nonrenewable resources and to monitor the impact of man on the natural environment, and to perform the advanced technology development and detailed system definition studies required prior to initiation of new space flight hardware development. This program incorporates the ground-based and aircraft-based activities for renewable and nonrenewable resource observations research; system definition studies of flight hardware sensors and missions in renewable and nonrenewable resources and in geodynamics; advanced technology development required to implement new sensors and Shuttle experiments; and feasibility and conceptual design studies of future sensors and Shuttle experiments.

The overall objectives of this effort are to improve machine-aided interpretation (classification and data handling techniques which are needed to increase efficiency in extracting useful information from space-derived data for the research community), to test this capability with researchers through technique tests; to analyze science requirements for new types of space-acquired data, to develop and test ground-based or airborne systems that are derived from space technology, to perform feasibility,

conceptual design, and detailed systems definition studies of new sensors and missions, and to perform the advanced technology development necessary to implement these new sensors and missions.

In renewable resources, the focus is on extending and strengthening our fundamental understanding of the remote sensing process, evaluating improvements to land cover inventory and monitoring resulting from use of the thematic mapper, the thermal infrared portion of the spectrum, and passive and active microwave data; developing improved ground and aircraft microwave sensors and data processors; conducting tests which determine the applicability and limitations of these techniques; and performing feasibility and conceptual design studies of future sensors and missions to ensure the conceptualization of high priority future capabilities in remote sensing of Earth resources. Techniques for combining Seasat synthetic aperture radar and Landsat multispectral scanner data have been developed and were tested in 1981. Simulated thematic mapper data was compared with multispectral scanner data, and an improvement of 20 percent in classification accuracy due to improved spatial resolution of a forest site was demonstrated. In FY 1982 the potential improvements in classification accuracy as a result of enhanced thematic mapper spectral resolution and extended spectral range will be explored.

The objectives of the nonrenewable resources effort are to develop techniques for extracting useful geological information from remote sensing measurements; to employ remote sensing techniques in unique and innovative ways for studies of crustal geology; to develop improved geological models which make effective use of unique types of information that can be derived from space-acquired data; and to evaluate experimentally the utility of remote sensing methods for specific geological applications. The NASA-Geosat Test Case Project, a joint research venture with private industry to assess the utility of remote sensing methods for geological mapping, was successfully completed in 1981. In FY 1982 greater emphasis will be placed on the use of thermal infrared and microwave remote sensing techniques. Development of an infrared aircraft scanner will be completed and the scanner flown during 1982 to collect six-channel multispectral data in the 8–13 micron spectral region over a series of western United States test sites. In addition, intensive analysis and interpretation of the radar imaging data obtained during the second Shuttle orbital test flight is planned in FY 1982.

In technique tests (TT's), remote sensing techniques, are developed and tested jointly with potential users in their resource management environment. Four multispectral scanner-based TT's involving the assessment of irrigated lands for water management, monitoring insect defoliation of hardwood forests, classifying crops using soil data, and digital mapping of irrigated cropland in western acquifiers will be completed in FY 1982. Also during FY 1982, planning will be initiated on seven tests designed to provide a definitive test of the thematic mapper information extraction techniques. These include hydrologic feature delineation, wetlands productive capacity modeling, facility site selection for

waste disposal, transmission line corridor siting, crop mensuration, crop condition assessment, and timber inventory.

The focus of the multispectral linear array (MLA) advanced technology development (ATD) is on the development of the technology for a future high performance MLA instrument €or use as a diagnostic tool for fundamental research in remote sensing. The MLA solid state sensor has a number of significant advantages over existing mechanically-scanned sensors including electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research initiated in FY 1981 on the linear array instrument and the Shuttle imaging spectrometer is being continued in FY 1982

CHANGES FROM PY 1982 BUDGET ESTIMATE:

Increased funding for MLA ATD reflects inclusion of technology development activities previously included in operational Earth resources system (OERS) definition. NASA will no longer conduct OERS definition studies. Reductions to other applied research and data analysis elements result from the FY 1982 general reduction.

BASIS OF PY 1983 ESTIMATE:

In renewable resources, the FY 1983 funding will support continuation of research in land resources remote sensing technique development, fundamental remote sensing investigations, processing technique development, and sensor and mission studies.

Planned nonrenewable resources research will extend into other portions of the electromagnetic spectrum concentrating on the thermal infrared and microwave regions. Measurement capabilities from aircraft platforms will be expanded and upgraded with the development of digital data recording systems for airborne radars; the six-channel multiband thermal infrared scanner will be tested from an aircraft platform. Experimental remote sensing data collected during the second orbital test flight of the Space Shuttle (i.e., shortwave infrared and radar measurments) will be analyzed in detail. The Magsat principal investigators program will be completed in FY 1982, and a set of global magnetic field maps derived from these data will be published in FY 1983.

In FY 1983 seven new thematic mapper simulated-based technique tests will be initiated dealing with delineation of hydrologic features, modeling of wetlands productive capacity, site selection of facilities for waste disposal, siting of transmission line corridors, assessing crop conditions, and timber inventorying.

The multispectral linear array advanced technology development efforts initiated in FY **1982** will be continued in FY **1983.** The visible charge-coupled device and infrared Schottky barrier array work will be completed. The shortwave infrared detector development will continue with initial modules delivered for evaluation in late **1983.** In-house test and evaluation capabilities will be upgraded at the Goddard Space Flight Center and the Jet Propulsion Laboratory to evaluate the modules. Follow-on Shuttle interface studies will be conducted to define a potential experimental multispectral linear array Shuttle mission. Technology development of the Shuttle imaging spectrometer will continue with additional optical design, onboard data processing, and focal plane development. The supporting aircraft instrument program will be continued in FY **1983** to provide high resolution spectral and spatial data for fundamental remote sensing research, and to optimize the design of the Shuttle Imaging Spectrometer.

BASIS OF FY 1983 FUNDING REOUIREMENTS:

ENVIRONMENTAL OBSERVATIONS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Upper atmospheric research program.....	13,500	15,000	13,000	16,500	RD 7-31
Applied research and data analysis.....	48,100	56,500	47,000	54,700	RD 7-34
Shuttle/Spacelab payload development....	1,700	4,100	4,100	3,700	RD 7-39
Operational satellite improvement program.....	7,200	11,800	6,000	6,000	RD 7-42
Earth radiation budget experiment.....	20,300	24,000	24,000	24,000	RD 7-43
Extended mission operations.....	8,000	11,400	11,400	10,000	RD 7-46
Upper atmospheric research satellite experiments and mission definition....	---	5,000	6,000	14,000	RD 7-47
Halogen occulation experiment.....	4,500	7,500	5,000	---	RD 7-49
National oceanic satellite system (NOSS)	800	---	---	---	---
Total.....	104,100	135,300	116,500	128,900	

OBJECTIVES AND STATUS:

NASA's environmental observations program has the goals of improving the understanding of processes in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes solely, studied from space. NASA's program includes scientific research efforts plus the development of new technology €or global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; the improvement of operational weather satellite capabilities; optimization of the use of space-derived measurements in weather forecasting; improvements in knowledge of severe storms and forecasting capabilities; a thorough understanding of large-scale open ocean currents, oceans productivity, and air-sea interactions; and an improved knowledge of seasonal climate variability leading to the long-term strategy for climate observations and prediction.

Remote sensing from space is the principal method that NASA uses to accomplish its objectives. Utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation, laboratory research of fundamental processes, development of instrumentation, flight of the instruments on Shuttle and dedicated spacecraft, collection of *in situ* ancillary or validation data, and scientific analysis of data. The approach is to develop a technological capability and a strong scientific base and then to collect appropriate data (from space and *in situ*) which, taken together, will address a particular program objective.

Our studies of the upper atmosphere have led to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone which was reported to the Congress in January 1982. The revised assessment of the predicted impact is somewhat less severe and resulted from improved measurements in our continuing program of laboratory chemical kinetics measurements. The new model predictions are being tested against our growing set of measurements of stratospheric chemical composition.

Three-dimensional models of the stratosphere are being developed to quantify our understanding of the interrelation of chemistry with dynamics and radiation. The record of satellite ozone measurements now extends for over a decade and is being used in studies to determine if there have been long term trends in the average amount of global ozone which shields the Earth's surface from harmful ultraviolet radiation.

The Upper Atmospheric Research Satellite Experiments (UARSE) activity initiated in FY 1982 will provide a set of satellite instruments capable of making a comprehensive measurement of the state of the stratosphere. Detailed definition studies of sixteen instruments have been completed and a final determination has been made to proceed with development of nine of these instruments.

The Earth Radiation Budget Experiment (ERBE) mission is proceeding on schedule toward a 1984 launch date with a Critical Design Review planned for early 1982. The flight of the Halogen Occultation Experiment (HALOE) instrument has been removed from the ERBE mission and has been selected as a UARS experiment. NASA has continued to support the National Oceanic and Atmospheric Administration (NOAA) by managing the development of the NOAA and the Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis. NOAA-C and GOES-E were launched in 1981 and preparations are proceeding to launch NOAA-E in mid-1982.

The ability to perform temperature and moisture soundings of the atmosphere from geostationary orbit has been demonstrated by the flight of the NASA-developed visible/infrared spin scan radiometer (VISSR) atmospheric sounder (VAS) instrument on GOES-D and -E. The opportunity afforded by geostationary orbits to observe a localized region continuously will permit intensive study of the evolving temperature and moisture environment of severe local storms. Low Earth orbit sounding capabilities, first implemented in 1978, are now enabling the extension of forecast reliability from three to five days. In certain special situations, reliable forecasts of 8 to 10 days duration have been achieved.

The scientific requirements for a global ocean topography mission - TOPEX - have been reported by a NASA science working group. This mission would measure the global circulation of the oceans for the first time and revolutionize man's understanding of oceanography. A conceptual definition of a space mission to meet these requirements has also been completed.

Virtually all of the data from the Seasat has been archived and much of the Nimbus-7 ocean data has been reduced. Efforts are presently underway to assess the scientific utility of the data. This information is also being used to define potential low cost approaches to using the demonstrated ocean observing techniques to address a variety of ocean research challenges.

Upper Atmospheric Research Program

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Research support.....	12,400	13,700	11,700	14,900
Upper atmospheric research balloon program.....	1,100	1,300	1,300	1,600
Total.....	13,500	15,000	13,000	16,500

OBJECTIVES AND STATUS:

The upper atmospheric research program is a comprehensive research and technology effort investigating and monitoring the phenomena of the upper atmosphere, aimed at improving basic scientific understanding of the upper atmosphere and methods needed to maintain its chemical and physical integrity.

In particular, the goal of the program is the improved prediction of man's impact upon the ozone layer and the effect of changes in the upper atmosphere upon our environment. In order to accomplish this, efforts are underway: (1) to improve upper atmospheric models, validate them, and assess their uncertainties; (2) to measure minor chemical constituents, temperature, and radiation fields; (3) to develop sensors capable of remotely sensing all aspects of the upper atmosphere from space; (4) to assemble and maintain the existing long-term data base of stratospheric ozone measurements and long time-scale natural variations in order to detect man-made ozone changes; and (5) to carry out laboratory kinetics and spectroscopy studies to support these activities.

A wide variety of in situ and remote sensing instruments which are useful in meeting the objectives related to determining and understanding the distribution of ozone and key nitrogen, hydrogen, and chlorine radical and molecular species in the upper atmosphere have been developed and utilized. These measurements have been made from the ground, from aircraft, balloons, and rockets. An extensive

workshop to assess the status of the ozone depletion problem was held in May 1981 (jointly sponsored by NASA and the World Meteorological Organization). This was attended by over 115 scientists from 12 countries.

The balloon support program provides for ~~in situ~~ and remote atmosphere measurements in the altitude range of 15-45 kilometers. It also provides partial support for improvements in balloon technology, e.g. the development of truncated duct balloons.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $2 million in FY 1982 funding from the budget estimate is a result of the general reduction in the appropriation. This reduction will be accommodated by the the elimination of a multidimensional modeling study, deferral of the development of the 600 GHz remote sensor for species measurements, a reduced level of activity in laboratory studies, and the elimination of at least one field measurement program.

BASIS FOR PY 1983 ESTIMATE:

During FY 1983, NASA will continue the assessment and evaluation of man-made and natural perturbations of the stratospheric ozone layer. The development of models (one, two, and three dimensional) which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species using multisensor platforms will be extended (simultaneous mesurements of the same species will assist in determining the quality of the data, and simultaneous measurements of different species will improve our ability to critically test our current photochemical theories of atmospheric chemical composition); improvements in the laboratory kinetics and spectroscopy data base will be sought; and improved techniques for detecting additional trace species and remotely measuring winds will be studied. There will also be increased emphasis on the analysis of satellite data sets (Nimbus -6, -7 and Solar Mesosphere Explorer), as well as a modest expansion of research into the mesosphere. Knowledge of the coupling between the mesosphere and the stratosphere is necessary for understanding the complex interactions among radiation, chemistry, and dynamics in the upper atmosphere, and the relationship between solar variations and terrestrial weather and climate.

The balloon program will be continued at a level of approximately 30-45 flights per year and will provide key measurements of the photochemically active trace species important in the stratospheric ozone balance. These balloon flights provide the principal capability to validate the photochemistry

program. Balloon flights also provide for instrument calibration and intercomparisons of different measurement techniques. Atmospheric dynamic studies using aircraft and ground-based radar facilities will be continued. Aircraft platforms provide the best method for studying stratospheric-tropospheric interchange and a major study of stratospheric-tropospheric exchange processes is planned in FY 1983. Studies of future instruments will continue our progress toward development of a spaceborne active and passive measurement capability to provide the global data on trace species, dynamic processes, and meteorological parameters needed to understand the atmosphere.

Applied Research and Data Analysis (Environmental Observations)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Applied research and data analysis in:				
Stratospheric air quality	4,800	6,200	4,400	6,000
Tropospheric air quality	4,400	5,900	3,200	5,200
Global weather (including GARP)	10,500	13,100	10,000	12,500
Severe storms	5,565	7,400	6,600	7,000
Ocean processes	14,780	16,600	17,000	17,000
Climate	8,055	7,300	5,800	7.000
Total	48,100	56,500	47,000	54,700

OBJECTIVES AND STATUS:

The applied research and data analysis (AR&DA) activities within the environmental observations program comprise a core of effort which is fundamental to the application of space technology to the Nation's pressing environmental concerns. Atmospheric programs include global weather, severe storms and local weather, and stratospheric and tropospheric air quality. Ocean processes research includes general oceanic circulation, air–sea interactions, ocean productivity studies, sea and glacier ice studies, and marine boundary layer studies. A climate program enables special formulation and study of space–derived data that will interrelate the physics, dynamics, chemistry, and radiation balance of the atmosphere and the oceans in order to understand basic climate sensitivities and to study the requirements for a space monitoring system.

Applied research and data analysis program objectives are to study tropospheric and stratospheric chemical composition and pollution; to model the radiative budget of our planet; to increase our understanding of meteorological processes in order to improve numerical weather prediction; to determine the morphology of lightning and severe storm occurrence; and to develop and demonstrate a

capability for remotely sensing near-surface properties of the ocean and to relate these properties to characteristics in both the atmosphere above and ocean below the air-sea interface. To study climate, NASA takes a long-term perspective of the phenomena of the atmosphere and oceans with the objective of defining the data requirements, and interpreting the global data sets obtained from spaceborne platforms. Such data are vital to the development of a long-term predictive capability. Each element of the program supports the development and demonstration of remote sensing technology; the development of algorithms to extract geophysical parameters from remotely acquired data; suborbital and ground-based experiments to measure fundamental properties and processes of the environment and provide a base for remote sensor development; fundamental research into the processes at work in the environment; and the development of models which express the current understanding of all or part of this system and provide a predictive capability for key environmental parameters.

Applied research and data analysis activities consist of a comprehensive, integrated program of research, technology, development, measurements, and interpretation. In the AR&DA program, concepts are developed €or advanced sensors and advanced studies are conducted for the definition of new systems and missions.

Our studies in stratospheric air quality emphasize accurate measurements and comprehensive ozone analyses. An international rocketsonde intercomparison of several different sensors measuring ozone was successfully completed, the data have been analyzed, and reports are due in early 1982. Comparison of these sensors has established their accuracy and precision for use as "ground truth" for satellite systems. The processed Nimbus-4 and Nimbus-7 backscatter ultraviolet total ozone and upper stratospheric ozone data for the periods 1970-1977 and 1978-1981, respectively, are being used to determine global ozone climatology and to complement the ground Dobson network base. These data sets are also being used to deduce whether ozone (total column content or vertical distribution) has changed between 1970 and 1979. Additional satellite data from the Nimbus-7 and Solar Mesosphere Explorer experiments continue to be collected, processed and interpreted. Stratospheric composition data from the Nimbus-7 and Nimbus-6 experiments are currently undergoing final processing and will be archived for interpretation by the scientific community during FY 1982. Chemical processes will continue to be studied to understand better the atmospheric constituents involved in catalytic cycles that destroy ozone. A hierarchy of models will be developed to explain the chemical, dynamical, and radiative processes of the stratosphere.

Over the twenty years since the launch of the first weather satellite, NASA together with the National Oceanic and Atmospheric Administration (NOAA), has continued the development of an increasingly sophisticated complement of satellite capabilities for the measurement of winds,

temperature profiles, sea surface temperature, and other meteorological parameters on a routine basis. Hurricanes and storm cells are routinely tracked by images from the Geostationary Operational Environmental Satellites (GOES), and improved forecasts now use the operational temperature soundings. Recently, a pilot centralized storm information system was established using space-related technology to receive and rapidly display weather satellite data as an aid to short-term forecasts. The global weather experiment (GWE) data have been archived and analysis continues. Over seventy forecast cases based on the GWE data confirm the value of satellite observations in numerical forecasting. An advanced vector processor, now scheduled to begin operating in FY 1983, will enhance our capabilities to assess the role of satellites in forecasting, by using the GWE data, and to provide improved model forecasts in the weather, climate, and upper atmosphere programs. Laboratory studies and modeling improvements continue in several areas such as thunderstorm and tornado prediction. New instruments designed to improve satellite observing capabilities further are already under development.

Preparations are complete for a number of activities to obtain oceanic observations needed to determine the ocean circulation. Seasat data have demonstrated that scatterometer observations enable space mapping of the detailed structure of the ocean surface wind fields, including atmospheric fronts and typhoons. Altimeter observations enable mapping of surface wave fields and circulation features such as the Gulf Stream and mesoscale eddies. Microwave radiometer observations enable all weather mapping of sea surface temperatures and of the characteristics of sea ice. Color scanner observations enable mapping of chlorophyl concentration. Taken collectively, these observations will permit the global determination of the general circulation of the oceans--both the wind-driven and geostrophic components-along with sea ice coverage, sea surface temperature, and primary biological productivity in the oceans.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $9.5 million from the FY 1982 budget estimate is a result of the general reduction in the appropriation. This reduction in global weather, severe storms and stratospheric air quality will delay the full-up capability of the high speed vector processor until FY 1983. Within the tropospheric air quality research, field measurements in support of Environmental Protection Agency will be deleted, and implementation of aircraft experiments will be delayed. Within climate research, archiving of existing Earth radiation budget data will be slowed and some NASA-university collaborative climate modeling efforts will be discontinued. Feasibility studies will be initiated to reduce risk for the global ocean topography mission.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, basic investigations in research and technology and data analysis will continue in the various discipline areas. Laboratory, field, and advanced studies will address our specific objectives which are to: (1) obtain global climatology of ozone and key nitrogen, hydrogen, and chlorine species in the upper atmosphere; (2) develop a longer-term monitoring strategy for the upper atmosphere; (3) improve our understanding of the chemistry and dynamics of the global troposphere as a crucial element in understanding the whole atmosphere, particularly the stratosphere; (4) improve weather satellite observing capabilities; (5) increase forecasting usefulness of space-derived meteorological parameters; (6) significantly improve our understanding of large scale weather processes and severe storms;, (7) improve our storm prediction capabilities; (8) support the National Climate Program (PL-95-367) through studies related to the Earth radiation budget (e.g., ERBE), climate model developments and special studies; and (9) develop an understanding of the ocean circulation and biological productivity of the oceans.

In FY 1983, the stratospheric air quality program will continue to focus on ozone perturbations. Key modeling and analysis efforts and advanced instrument and technique development for field studies will be continued. The major focus will be on: (a) improving experimental techniques which are needed to provide ground truth for satellite systems; (b) conducting a series of intercomparisons of in situ and remote balloon-borne sensors for a wide variety of key atmospheric constituents; and (c) increasing emphasis on the interpretation of Nimbus-4, Nimbus-6, Nimbus-7, and Solar Mesosphere Explorer satellite data utilizing multidimensional theoretical models.

For the tropospheric air quality program, the FY 1983 activities will emphasize development of models for the assessment of the role of the global troposphere as a chemical/dynamical "source and sink" for stratospheric species, development of satellite techniques and strategies for measuring key tropospheric trace species, and the further development of active and passive remote sensors. This funding will permit further development of aircraft instrumentation and measurements. In addition, support will be continued for laboratory studies to determine rate constants and spectroscopic parameters of key trace species and for planning a global tropospheric experiment on atmospheric chemistry and dynamics.

The activities related to weather and storms will support efforts to improve observing systems and expand uses of existing systems. In the global weather program, development and demonstration of temperature, moisture, and pressure sounders will be maintained. The global weather experiment data sets will be processed and analyzed. The data will be used in the model experiments to assess the

impact of satellite data on forecast models and to increase our understanding of atmospheric phenomena. The research program on zero-G fluid dynamic experiments will provide information on the physical processes occurring in planetary atmospheric dynamics which cannot be achieved by any other means. These funds will allow continuation of sensor studies, and supporting laboratory research, and will provide basic data on the dynamics of the atmosphere and oceans.

FY **1983** activities in the severe storms and local weather research program will support techniques to improve the understanding of and, ultimately, the ability to forecast severe weather events. Assimilation techniques for high resolution observations will be tested while new severe storm indicators such as lightning will be studied. Outstanding progress has already been made in developing doppler lidar techniques for the remote measurement of winds. Assessment of the vertica' soundings of temperature and moisture from GOES/VISSR atmospheric sounder instruments should provide an evaluation of the validity of the data, as well as an indication of its utility in severe weather forecasting. Other severe storm research will include efforts to improve the basic understanding of storm development and the specific conditions which initiate storms, tornadoes, and damaging down-drafts, and produce destructive cloud to ground lightning. Efforts in the numerical modeling of storms and their environments will be supported in order to enhance forecasting capabilities. The severe storms and local weather research program activities will include: software development for the centralized storm information system program, data analysis and modeling of forecast improvement of tropical cyclones, severe local storms and tornadoes; man-computer interactive data system technique development; storm severity indicator studies; and aircraft data analysis of doppler lidar field experiment measurements.

An advanced high speed vector processor, to be delivered in FY **1983,** will greatly improve the presently overtaxed computing capacity. This computer will make it possible to handle and assimilate satellite data more rapidly, to develop more realistic numerical weather prediction models, simulate advanced observing systems, as well as support other environmental observation programs including climate sensitivity studies and ocean models.

In FY **1983,** the oceans research program will include the processing of Seasat data records into final geophysical units and their subsequent analysis; evaluation of the performance of X/L/C-band aircraft synthetic aperture radar in conjunction with the National Science Foundation's warm gulf stream rings and coastal ocean dynamics experiments; characterization of sea ice properties by various remote sensing techniques; definition of altimetry dependence on sea state; investigation of phytoplankton productivity associated with physical and chemical ocean properties near the Grand Banks in cooperation with the National Science Foundation and the National Marine Fisheries Service;

refinement of techniques for assimilation of scatterometer winds into numerical models; and development of a shipborne lidar system for depth profile measurements of temperature, phytoplankton and zooplankton.

The NASA climate research program, an integral part of the national climate program, will conduct climate parameter sensitivity studies to help establish the requirements for global climate observations, will provide global data sets of satellite-acquired climate measurements (with initial emphasis on radiation budget parameters), and will utilize climate models in order to help define future space observing systems. Specific near-term efforts will include quantitative studies of the effects of clouds and aerosols on climate variations. Planning is underway for NASA participation in the international satellite cloud climatology project designed to produce a five-year global cloud data set needed in developing and validating climate models.

The augmented data processing capabilities at the Goddard Space Flight Center will be utilized for improving numerical climate models, incorporating the results of current theoretical and experimental studies of climate processes, in order to simulate the seasonal cycle and interannual variability of climate. A number of university scientists are participating in collaborative studies with NASA scientists aimed at improving the models needed for these studies.

Shuttle/Spacelab Payload Development (Environmental Observations)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Measurement of air pollution from satellites (MAPS)...	110	300	450	300
Atmosphere trace molecules observed by spectroscopy (ATMOS)..	683	1,900	1,900	2,100
Atmosphere cloud physics laboratory (ACPL)	700	--	--	--
Principal investigator instrument development and reflight program.....	207	1,900	1,750	1,300
Total.....	1,700	4,100	4,100	3,700

OBJECTIVES AND STATUS:

The space transportation system offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The environmental observations program has incorporated this new capability in the Shuttle/Spacelab payload development activities in these important aspects: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use will be in long duration free-flying missions; (2) short-term data gathering of atmospheric and environmental information for basic research and analysis where long-term observations are not necessary or are impractical; (3) research into processes which cannot be accomplished effectively in ground-based laboratories.

The measurement of air pollution from satellites experiment is a gas filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown on the second Shuttle orbital test flight, STS-2, in November 1981. The instrument performed as expected and obtained approximately 40 hours of data on the global distribution of carbon monoxide in the atmosphere. Long periods of continuous cloud-free data were collected from the northern to southern hemisphere. Three corroborative aircraft flights were made over the east and west coasts of the United States, in addition to a flight over Australia. The measurement of air pollution from satellites experiment has been approved for a reflight and has been assigned to OSTA-3.

The objective of the atmospheric trace molecules observed by spectroscopy experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammnonia, methane) in the Earth's atmosphere using the techniques of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument delivery is scheduled for 1982 with a planned launch in 1984 on Spacelab-3.

In response to an announcement of opportunity, a number of principal investigator class instruments were selected for definition, development and flight as part of the Shuttle/Spacelab payloads programs. Payloads under development include active cavity radiometer-I (ACR-I) designed to determine the total solar irradiance to very high accuracy and precision. This information will aid in studies of the climate and the physical behavior of the sun. The instrument is scheduled to be delivered to the Kennedy Space Center in 1982 for flight on Spacelab-1 in 1983. A program for reflights of ACR-1 is bieng developed. The experiments selected include reflights of some other instruments flown on the orbital flight test series, Spacelab-1 and Spacelab-2. These experiments are: (1) a solar

ultraviolet spectral irradiance monitor; (2) an imaging spectrometric observatory for trace constituent measurements; and *(3)* a photometric imager for lightning research. Several foreign investigations which are complementary to NASA programs have been selected; funding is provided by the foreign agency sponsoring the investigator.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY *1982* budget estimate is unchanged in total; however, the redistribution of funds within the Shuttle/Spacelab Payload Development line was required to provide for post-flight calibration and thermal vacuum activities for the MAPS instrument. Funds for these reflight-related activities were provided from the principal investigator instrument development and reflight program.

BASIS OF **FY 1983 ESTIMATE:**

FY *1983* funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities, data reduction and refurbishment for possible reflight in *1984.*

After delivery of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) instrument, a verification and familiarization program will be conducted by the experiment team to establish baseline characteristics of the instrument. Delivery of the instrument for Shuttle integration is scheduled for early *1984* with the initial flight later in *1984.*

The Principal Investigator Instrument Development and Reflight Program -- the reflights and limited activities associated with development of new principal investigator instruments will continue with research efforts in atmosphere chemistry, solar intensity and variability and upper atmospheric winds in FY *1983.* Active Cavity Radiometer-I (ACR-1) funding will provide for data processing and validation, science team activites, and refurbishment for a reflight on a future Shuttle mission.

Operational Satellite Improvement Program (OSIP)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Research and development of improvement of operational satellite systems.....	7,200	11,800	6,000	6,000

OBJECTIVES AND STATUS:

The objectives of the operational satellite improvement program have been to: **(1)** perform the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites, and (2) perform definition studies for incorporation of user-dictated changes which affect the total system configuration and capabilities. Current activities include the following: **(1)** development of the solar backscatter ultraviolet (SBUV) instrument for future operational monitoring of ozone fluctuations in the upper atmosphere; (2) assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; **(3)** implementation of improvements in the high resolution infrared sounder (HIRS); and (4) modification and improvement of direct readout equipment for operational use.

Although hampered by the early requirement for operational utilization of GOES-4 and GOES-5, limited experimental results from the VAS instrument show promise for ultimate contributions to severe storm predictions and numerical modeling of weather patterns. We are presently working with NOAA to define ground system modifications and operational time-sharing to allow more opportunities for data-gathering in an experimental mode. The SBUV and HIRS improvement contracts have been signed and are proceeding with development for initial flight on NOAA-F and NOAA-H, respectively.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The FY 1982 budget has been significantly reduced to reflect a basic policy decision to limit NASA responsiblity for instrument and spacecraft systems development to those activities that are directly related to NASA's mission and research goals in the environmental sciences. In the future, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for defining and funding

specific system improvements required for their operational missions. NASA will retain its role as system implementation agency for NOAA on a reimbursable basis. Where new or improved measurements or systems are required, NASA will accomplish these requirements on a reimbursable basis.

Under these guidelines, the FY *1982* budget content has been reduced to only those funds required to continue and complete previous commitments as appropriate. These commitments are: *(1)* continued development of the SBW; *(2)* continued improvements in HIRS resolution and sensitivity; *(3)* completion of VAS assessment activities; *(4)* final studies to define GOES modifications for launch on the Space Shuttle; *(5)* final integration of the VAS on *GOES-4;* and (6) limited continuation of real-time data receipt ground terminals. The continuation tasks represent those items that NOAA has identified as necessary to continue until they can make a transition to full responsibility.

BASIS OF PY 1983 ESTIMATE:

The FY *1983* estimate is structured to continue NASA's phase-out of this activity. FY *1983* funds to complete SBUV development and improvement of the HIRS instrument are required. NASA will also provide limited support for GOES-G, H, and I modifications required for compatibility with the revised tracking and data system and for ease of operation of VAS in its operational and experimental mode.

Earth Radiation Budget Experiment

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	*1983* Budget Estimate
	(Thousands of Dollars)			
Spacecraft	*9,200*	*17,000*	*13,300*	*15,100*
Sensors	*9,400*	*4,100*	8,200	*4,900*
Mission operations and data analysis	*1,700*	*2,900*	*2,500*	*4,000*
Total	*20,300*	*24,000*	*24,000*	*24,000*

OBJECTIVES AND STATUS:

More solar energy is absorbed by some regions of the Earth than by others. At the same time, more thermal energy is radiated into space by some regions than others. This differential heating is thought to be the driving force that sets the atmospheric winds and ocean currents into motion transferring heat from warmer to cooler areas. The excess in the amount of solar energy absorbed over the thermal energy radiated to space continually changes for any given region, depending on the time of year, degree of cloudiness, snow and ice cover, abundance of atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insight into the reason for climatic fluctuations.

Experimental Earth radiation budget instruments have flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. They also indicate the need for improved calibration of the sensors. Coincident Earth radiation budget data sets over one set of seasonal variations are needed. In order to provide concurrent observations from one sun synchronous and one mid-inclination satellite, identical Earth radiation budget instruments will be installed on two satellites of the TIROS-N series and on one dedicated NASA observatory at a mid-inclination orbit. The NASA observatory will be launched between the NOAA satellites to provide the necessary overlap. The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

The ERBE instrument contract was awarded to TRW, Inc. in September 1979, and development has proceeded satisfactorily. The preliminary design review was completed in July 1980, and the critical design review is scheduled for early 1982 after completion of engineering model testing. Delivery of the three ERBE instrument flight models is scheduled for 1983.

In addition to the ERBE instrument, the NASA observatory will carry the Stratospheric Aerosol and Gas Experiment (SAGE II). This instrument is being developed by Ball Corporation and will provide aerosol measurement data for ERBE. Both the preliminary and critical design reviews of the SAGE 11 instrument were completed in 1981. Delivery of the flight model is expected in 1982.

1981 and the critical design review is scheduled for 1982. The ERBS observatory will be launched by the Shuttle to an altitude of 300km and then will be propelled to the operational altitude of 600km by an auxiliary onboard propulsion system.

Due to Shuttle development delays and NOAA FY 1982/83 budget constraints, the planned launch dates for ERBS and for NOAA-F and G, respectively, are under review. Launch rescheduling efforts are underway by both NASA and NOAA in order to obtain the desired satellite schedule overlap for data collection. The Halogen Occultation Experiment (HALOE), which had been intended to fly as an instrument of opportunity on ERBS, is now a candidate for the Upper Atmospheric Research Satellite Experiments payload.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The FY 1982 budget estimate is unchanged in total; however, the redistribution of funds within the FY 1982 budget for ERBE was required to cover increased costs of the instruments. Certain spacecraft and mission operations and data analysis activities, are being rephased in accordance with the rescheduling of the launch.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funding will be used to complete the testing and delivery of the three ERBE flight model instruments for NOAA-F and G plus ERBS. The ERBS spacecraft will be integrated in FY 1983. Development of algorithms and simulation of data systems operations will also be continued in FY 1983. This activity is designed to insure the ability to reduce and analyze the data before the launch.

Extended Mission Operations (Environmental Observations)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Operations for the extended mission of:				
Nimbus-5, -6, and -7	6,683	8,400	8,400	8,200
Stratospheric aerosol and gas experiment (SAGE)	500	1,000	1,000	600
Solar mesosphere explorer (SME)	817	2,000	2,000	1,200
Total	8,000	11,400	11,400	10,000

OBJECTIVES AND STATUS:

Since the launching of Nimbus-5, -6, and -7 in 1972, 1975 and 1978, respectively, significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color have been gathered. Preliminary evaluation of the results has demonstrated the utility of the measurements, and the instrument techniques are starting to be used on operational satellites. Reduction and validation of these valuable data are continuing, as is the operation of the satellites themselves. There is a strong demand for historical, current and future data regarding global precipitation, soil moisture, snow and ice cover, the Earth's radiation budget, atmospheric dynamics, and trace constituent concentrations and distribution. All contribute toward global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis and Earth climate studies.

An important contributor to the ozone and aerosol data base is the Stratospheric Aerosol and Gas Experiment (SAGE) satellite launched in early 1979. The measurements by this satellite of the stratospheric aerosol loading from the Mt. Saint Helens volcano eruptions have contributed significantly to our overall understanding of natural perturbations to the stratosphere and its potential effect on weather and climate. In November 1981, the spacecraft experienced operational problems which are currently undergoing engineering assessment.

The Solar Mesosphere Explorer (SME) was launched in October 1981, and is providing major inputs into our overall atmospheric parameter data base. SME is making some of the simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere. Included in the data set are measurements of ozone, atomic oxygen, nitric oxide and temperature. The four ultraviolet instruments on board are functioning well and data is being returned from the infrared instrument. It appears likely that the mission will continue to operate beyond it one year design life. A ground truth program to verify SME data is being initiated.

BASIS OF PY 1983 ESTIMATE:

FY 1983 funding will support spacecraft operations, as well as processing and validation of data from Nimbus, SAGE, and SME satellites. These satellites will continue to produce an extremely valuable set of atmosphere and ocean observations during this time period. These observations provide a continued global data set on ozone concentrations. This is required to determine natural variations and long-term trends, sea surface temperatures for real-time operational uses, extended earth radiation budget and aerosol measurements to enhance the interpretation from the upcoming ERBE mission, and coastal zone color scanner (CZCS) measurements which will be used to better predict ocean productivity and carbon uptake. The necessary correlative ground truth activity will also be supported. These in situ observations are essential to verify the quality of the observations and improve our ability to interpret them.

Upper Atmosphere Research Satellite Experiments (UARSE)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Upper atmosphere research satellite experiments and mission definition....	--	5,000	6,000	14,000

OBJECTIVE AND STATUS:

An Upper Atmosphere Research Satellite (UARS) mission is the next logical step in the implementation of a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. The UARSE program is intended to design and develop the instruments necessary to accomplish the UARS mission and to perform mission definition

studies. UARS is planned to provide the first integrated measurements of ozone concentration, concentrations of chemical species that affect ozone, energy inputs, temperature, and winds in the stratosphere and mesosphere. It will extend the measurements of ozone, and of atmospheric parameters affecting ozone, that have been or will have been made on Nimbus and SAGE. It also goes beyond these efforts to measure key species simultaneously in all important chemical families (hydrogen, nitrogen, chlorine, etc.) of the upper atmosphere, dynamic parameters, and solar energy input. UARS is a critical element in NASA's stratospheric research and monitoring strategy. It will provide the first full data set on stratospheric composition and dynamics that will be needed when very difficult regulatory decisions must be made on future production of chlorofluorocarbons. UARS will contribute to the assessment of the impact of stratospheric changes on climate and will provide data needed for a fuller understanding of the stratosphere, which is essential for design and implementation of a long term stratospheric monitoring strategy.

In FY 1980, a tentative selection of 16 experimenters and 10 theoretical investigators was accomplished. Following a 16-month concept definition period, a final selection of 9 experimenters and 10 theoretical investigators was made in December 1981 to start experiment development. The experiments selected are: Solar Ultraviolet Spectral Irradiance Monitor, Ultraviolet Solar Spectral Irradiance Experiment, Cryogenic Limb Array Etalaon Spectrometer, Improved Stratospheric and Mesospheric Sounder, Microwave Limb Sounder, Halogen Occultation Experiment, Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere, High Resolution Doppler Imager, and the Particle Environment Monitor. The Improved Statospheric and Mesospheric Sounder instrument will be provided by Oxford University, United Kingdom, and the Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere by the Service d'Aeronomie du CNRS, France. These nine experiments draw heavily upon the experience derived from earlier satellites and satellite experiments. The experiments package includes infrared and microwave limb sounders requiring advances in cryogenics, solid-state devices and microwave antennas beyond the earlier capabilities. Final design and development of the instruments and instrument mounting module for the UARSE will proceed consistent with the potential launch of UARS in 1987-88. A launch in that time frame will provide data coverage of the minimum and ascending phases of the solar cycle to complement other data (although more limited) obtained at the maximum and descending phases and will avoid a data gap in the collection of satellite ozone measurements. A ground data handling facility, permitting interactive utilization of data by the Principal Investigators, is being studied as part of the UARSE activity, along with definition of the mission implementation concept. The overall UARS end-to-end data acquisition, processing and distribution system will provide for timely reduction of the UARS data and for their wide dissemination among the UARS investigators.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The Upper Atmospheric Research Satellite Experiment FY 1982 funding has been increased from $5 million to $6 million in response to Congressional interest. The additional funds will be used to enhance the long lead development work on the selected payloads.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds will be used to support the continued detailed design, development and breadboarding of the selected instruments; instrument module design definition and analysis; detailed mission implementation studies; and definition of concept and design requirements for the advanced ground data handling facility that will be implemented in the UARS program. The instruments are the long-lead time elements of the UARS program. Although there is considerable technological heritage for these instruments, their development and testing in time for a 1987-88 launch opportunity requires that substantial progress in instrument internal design and in interface design--thermal, mechanical, view angles, etc.--with the instrument module take place in 1983.

The ground data handling facility will enable a higher level of interaction among experimenters, and between experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that it be designed early in the UARSE effort so that individual experiment data processing subsystems, including algorithms, can be designed for maximum interaction and effectiveness.

HALOE

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
HALOE.....	4,500	7,500	5,000	---

OBJECTIVES AND STATUS:

The objective of HALOE had been to develop an infrared occultation instrument to measure hydrochloric and hydrofluoric acids and other species in the upper atmosphere and to deliver this instrument for flight on the Earth Radiation Budget Satellite (ERBS). Technical problems, schedule

delays, and cost increases have resulted in a decision to delete the instrument from the ERBS payload, and to adapt it for flight on a possible future upper atmospheric research satellite mission.

CHANGES IN THE FY 1982 ESTIMATE:

The change in the FY 1982 level of funding reflects termination of the contract activities associated with HALOE instrument development for flight on the ERBS spacecraft. The hardware will be brought in-house and modified as necessary under the UARSE project.

BASIS OF PY 1983 FUNDING REQUIREMENTS:

APPLICATIONS SYSTEMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Airborne instrumentation research program.....	18,100	14,200	13,200	11,700

OBJECTIVES AND STATUS:

The airborne instrumentation research program provides flight support to major segments of the space applications program. The aircraft fleet presently consists of two U-2C's, one ER-2, one C-130, and one CV-990. These aircraft serve as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites. The data acquired during the flights is used to refine algorithms and develop ground data handling techniques and preliminary proof of concept studies. Examples of such activities are flights over test sites to obtain crop signature data for the AgRISTARS program by the C-130 and flights in the ER-2/U-2C's to acquire simulated thematic mapper data. A principal use of the ER-2/U-2C's is to acquire stratospheric air samples and conduct ~~in situ~~ measurements at altitude ranges above the capability of more conventional aircraft and below that of orbiting spacecraft. This use is important in the environmental observation program where much interest exists regarding stratospheric transport mechanisms and where is it extremely desirable to penetrate the stratospheric region, which, in the tropical intercovergence zone, is normally found at altitudes of 60,000 feet and above.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

The applications systems budget has been reduced by $1 million below the budget estimate as a part of the general reduction in the appropriation.

BASIS OF FY 1983 ESTIMATE:

FY 1983 funds are required to provide the necessary aircraft operations support required by the space applications program.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

TECHNOLOGY TRANSFER

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
User requirements and supporting activities	5,000	---	3,000	---
Applications systems verification and test	700	---	---	---
Regional remote sensing applications	2,400	---	2,000	---
Total	8,100	---	5,000	---

OBJECTIVES AND STATUS:

The technology transfer program provides for the development, experimental test and evaluation, and transfer of remote sensing technology applications for operational use by public and private organizations.

User requirements and supporting activites have maintsined communications at the national level between NASA and the user community to determine and analyze national priorities and user needs, inform users of existing and planned technological capabilities, obtain external evaluations of technology transfer programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. Cooperative efforts have been conducted with state and local governments to evaluate proven Landsat applications in natural resource and environmental management.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The Technology Transfer FY 1982 of $5 million is in response to Congressional interest. These funds will be used to more systematically transition these efforts to the private sector.

BASIS OF FY 1983 ESTIMATE:

No funds are being requested for FY 1983 in accordance with the decision that these efforts be transferred to the private sector.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

MATERIALS PROCESSING IN SPACE

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Applied research and data analysis.....	9,233	14,000	12,000	13,100	RD 7-55
Shuttle/Spacelab payload development....	8,157	7,600	8,800	3,300	RD 7-57
Materials experiment operations....	1,310	6,100	3,000	7,200	RD 7-58
Total.....	18,700	27,700	23,800	23,600	

OBJECTIVES AND STATUS:

The materials processing in space program emphasizes the fundamental science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1982 will concentrate on three major processing areas: crystal growth and solidification, containerless processing, and fluid and chemical processing. Limited research will be supported in the areas of cloud physics, combustion science, vacuum science, and fluid dynamics. These activities will provide the scientific basis for future space applications of materials processing technology. Definition study activities will be performed for Shuttle payload candidates such as the acoustic containerless experiments system, the combustion science system, the containerless measurement system, and the floating zone experiment system.

The Shuttle/Spacelab payload development project will provide opportunities to perform materials science experiments in an extended, microgravity environment. Fabrication and testing of the fluid experiment system, vapor crystal growth (FES/VCG) system and monodisperse latex reactor (MLR) will be completed in FY 1982.

Materials experiment operations is a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the materials processing in space program. These include drop towers and aircraft and sounding rocket flights as well as the Shuttle mid-deck experiments and the material experiment assembly. These capabilities will enable users to develop experiments in a cost effective manner and allow NASA to develop a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, limited reflight of currently selected investigations on sounding rockets and on Shuttle/Spacelab missions is included in materials experiment operations.

Applied Research and Data Analysis (Materials Processing)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Ground-based investigations, analysis and studies.....	9,233	*14,000*	12,000	**13,100**

OBJECTIVES AND STATUS:

The applied research and data analysis (AR&DA) activity provides the scientific foundation for all current and future projects in the materials processing in space program. The emphasis is placed on ground-based research which is expected to develop into space investigations with potential for future applications. In addition, the AR&DA program supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities leading toward privately funded space enterprises. Most research projects in the AR&DA program are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1982 funding has been used to initiate funding of another set of new three-year research projects proposed by leading members of the materials science community; to initiate new activities in containerless science, cloud physics, and extraterrestrial materials processing; and to begin definition studies in the acoustic containerless experiments system and combustion science facility. Ongoing research concentrates on scientific investigation and technology advancement in infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processes, combustion science, crystal growth, containerless processing

techniques, and extraterrestrial materials processing. In addition, some cloud physics research will be initiated as low gravity research opportunities become available. Commercialization activities will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in materials processing in space projects, and negotiations with companies interested in undertaking joint space endeavors with NASA.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction in FY **1982** is a result of the general reduction in the appropriation. This will result in the deferral of activities including space materials systems, and of new investigations in cloud physics, bioprocessing, and fluid dynamics. In addition, several investigations in crystal growth and containerless processing will be terminated.

BASIS OF FY 1983 ESTIMATE:

Ground-based applied research and data analysis will continue in the areas of containerless processing, crystal growth, solidification, fluid behavior, biological separations, combustion, and cloud physics. Prior material processing in space research has brought three containerless processing techniques (acoustic, electrostatic, and electromagnetic) to the design and trial stage. FY **1983** efforts will include flight test preparation for the first two of these techniques. Fundamental studies of crystal growth, solidification, and fluid behavior will continue in order to define the role of gravity-driven influences (convection, sedimentation, and buoyancy) in generic processing methods, and will concentrate on materials of technological interest (infrared and nuclear detectors, magnetic alloys, and immiscible alloys). Major FY **1983** efforts will also include increasing the scope of materials studied to include superconductors, metallic glasses, and other metastable phases where enhanced or new properties may be achieved. Work will be augmented in the area of bioprocessing by expanding into new separation methods. Companies and arrangements for which space processing and manufacturing are desirable ventures will continue to be identified. A small effort in space materials systems will continue as part of our early study effort for the cost effective utilization of extraterrestrial materials.

Shuttle/Spacelab Payload Development (Materials Processing)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Payload development.....	8,157	7,600	8,800	3,300

OBJECTIVES AND STATUS:

The Shuttle/Spacelab payload development projects include the design and development of a basic set of payload equipment for space experiments on materials and processes. Experiments are planned with this equipment on space transportation system flights. The first series of experiments to use the equipment will be flown on the Spacelab-3 mission. Investigations selected for these flights cover topics in crystal growth and fluid flow effects. All of the equipment is being designed for repeated use and a long service lifetime, so that it can be used for further experiments on later missions without new development or substantial modification.

Two facility class equipment systems are under development. One of these is a multiuser facility, the fluid experiment system, a sophisticated holographic optical measurement system to determine density gradients and fluid flows during crystal growth and analogous processes. The other facility is the vapor crystal growth system which will grow large single crystals of mercuric iodide by evaporation and recondensation.

The solidification experiment system contract was cancelled in September 1981 due to technical and cost problems. The experimental capacity of the solidification experiment system will be partially recovered by updating existing government furnaces.

The Monodisperse Latex Reactor, planned for flight on a Shuttle orbital test flight, is designed to explore chemical and physical processes involved in forming 10 micron latex spheres in the nearly gravity free environment of Earth orbit.

CHANGES FROM FY 1982 BUDGET ESTIMATE

The Materials Processing in Space Shuttle/Spacelab Payload Development funding in FY 1982 has been increased from $7.6 million to $8.8 million to accommodate a cost increase in the Spacelab 3 materials processing payload development.

BASIS OF FY 1983 ESTIMATE:

The development of the fluid experiments system/vapor crystal growth apparatus will be finished in 1982. The FY 1983 activities will concentrate on ground testing by the principal investigators in preparation for a 1984 launch. Initial efforts will be directed toward the growth of infrared and nuclear detector materials in low gravity.

Materials Experiment Operations

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Materials experiment operations.....	1,310	6,100	3,000	7,200

OBJECTIVES AND STATUS:

Materials experiment operations provide a wide range of opportunities for scientific and commerical experiments in material processing in space. Investigators will gain experience in a cost-effective manner allowing NASA to better understand the technical risks associated with experimental concepts before attempting to develop more complex hardware. Facilities generally in use include drop towers, drop tubes, aircraft and sounding rocket flights. Development of Shuttle mid-deck experiments are also supported under this activity. The first materials experiment assembly hardware will be completed in 1982. In addition, reflights of existing Shuttle/Spacelab facilities and the selection of a limited number of new investigations for the fluid experiment system and vapor crystal growth are part of this activity.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease in FY 1982 is a result of the general reduction in the appropriation. This will result in the deferral of activities including development of mid-deck and materials experiment assembly hardware for electromagnetic containerless processing, combustion sciences apparatus and an advanced directionless solidification furnace.

BASIS OF PY 1983 ESTIMATE:

FY 1983 activities in materials experiment operations will be directed toward new mid-deck experiments, continued use of the materials experiment assembly (MEA-A), definition studies for MEA-C to increase experimental opportunities, and ground-based, low gravity experimentation. The mid-deck experiments will include: (1) investigations using the first version of acoustic containerless processing equipment; and, (2) the first low gravity test of a method (isoelectric focussed electrophoresis) for the separation of biological materials. Development of MEA-B will also allow interfacing to the Shuttle which will provide more energy and cooling capabilities than are possible with MEA-A. Activities in short-term, low gravity ground-based facilities will be augmented, taking particular advantage of the new, longer (91m) drop tube/tower which will become available in mid 1982. This will be used to study the solidification of metastable and deeply undercooled alloys which may possess new and attactive properties.

BASIS OF PY 1983 FUNDING REOUIREMENTS:

COMMUNICATIONS AND INFORMATION SYSTEMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Applied research and data analysis.....	16,600	15,400	10,000	5,100	RD 7-62
Search and rescue.....	4,800	1,300	2,300	3,700	RD 7-63
Technical consultation and support studies.....	3,145	2,600	2,600	2,600	RD 7-65
Experiment coordination and operations support.....	2,155	1,000	1,000	1,000	RD 7-66
Information systems.....	4,500	10,000	5,000	7,500	RD 7-67
Total.....	31,200	30,300	20,900	19,900	

OBJECTIVES AND STATUS:

The communications program provides the technology that allows the most effective use of the geosynchronous orbit and radio frequency spectrum. A major portion of the program resources are currently concentrated in the applied research and data analysis element of the program which is focused on new communications subsystem technology. In FY 1980, multiyear contracts were placed with industry to develop a technology base in advanced communications for the 1990's. These efforts, which will be completed in FY 1983, will produce laboratory models of multibeam antennas, onboard switching, signal processing, and radio frequency components. Excellent progress was made on these contracts in 1981.

The search and rescue program uses satellites to aid in the detection and location of distress beacons carried by aircraft and ships. The search and rescue demonstration and evaluation phase will begin in 1982 with the launch of the first United States spacecraft in the series, NOAA-E, and the Soviet satellite, COSPAS 1. During FY 1981, the NOAA-E spacecraft was completed. The search and rescue antennas, receivers, signal processor and transmitter were integrated and tested, completing

all necessary preparations for launch. In FY 1982, the ground station development will be completed. Three ground stations will be installed at search and rescue facilities operated by the United States Coast Guard and the United States Air Force. Experimental distress transmitters operating at 406 MHz will be completed and deployed in accordance with the demonstration and evaluation plan. This work will be done in cooperation with Canada, France, and the U.S.S.R. The search and rescue program is now planned to include payloads aboard six meteorological spacecraft operated by the National Oceanic and Atmosphere Administration, and at least two Soviet COSPAS spacecraft.

Technical consultation and support will continue to provide radio interference, propagation, and special system studies required for the growth of existing satellite services and the inclusion of new satellite applications. Support to the Department of State, Federal Communications Commission, and the National Telecommunications and Information Adminstration, in preparing for a series of World Adminstrative Radio Conferences on geostationary orbit planning for all space services is continuing, as are broadcast satellite and mobile communications planning activities.

Experiment coordination and operation support was continued for ATS-1, 3, and 5 satellites in FY 1981. The relocation of ATS-1 to enable continued operations in the Western Pacific is now in process. Current efforts are directed at developing protocol user documents to assist other agencies in the use of these satellites for public service.

Information systems will continue to provide timely development of systems capabilities to meet the needs of space science and applications flight missions. Specific examples are the ocean pilot system, high speed processor for Landsat (Thematic Mapper), and common executive software for image processing.

Applied Research and Data Analysis (Communications)

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Applied research and data analysis..	16,600	15,400	10,000	5,100

OBJECTIVES AND STATUS:

The communications applied research and data analysis program provides the advanced technology base in the field of satellite communications. Currently, there are nine United States commercial communications satellites located above the Equator in view of the United States. Applications are on file for 24 more to be launched by the mid-1980's. These satellites will exhaust the capacity of the geostationary arc at the lower frequency bands currently in use. Capacity increases beyond the mid-1980's will require systems using new technology advances that function most efficiently in higher frequency bands.

In FY 1980 and 1981, a series of technology development contracts were awarded to United States industry to produce proof-of-concept models of components and subsystems that permit satellite communications operations in the new 30/20 GHz frequency band. Contracts have been awarded in the following technology areas: multiple spot-beam spacecraft antennas, spacecraft matrix switch for trunking applications, baseband spacecraft processor, 30 GHz spacecraft receiver, 20 GHz solid state spacecraft transmitter, 20 GHz spacecraft travelingwave tube amplifier, travelingwave tube power supply, 30 and 20 GHz latching switches, switches and filters for spacecraft-switched multiple access, components for low cost ground terminals, and spacecraft transponders. Several of these contracts have been jointly funded by the Department of Defense because of their applicability to future military systems. The proof-of-concept models produced by these contractors will be delivered during FY 1982 and FY 1983 and will undergo limited end-to-end testing to evaluate their system level performance.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

FY 1982 funds have been decreased by $5.4 million consistent with the policy decision not to pursue efforts leading toward large hardware demonstrations of new technologies that are more appropriately funded by the private sector.

BASIS FOR PY 1983 ESTIMATE:

In FY 1983 the proof-of-concept model technology development program will be completed and a limited laboratory test phase conducted.

Search and Rescue

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Search and rescue.....	4,800	1,300	2,300	3,700

OBJECTIVES AND STATUS:

The search and rescue mission will demonstrate the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate distress signals from general aviation aircraft and marine vessels during an emergency. A satellite system can provide a more comprehensive coverage than the irregular coverage provided by overflying aircraft now relied upon. This permits rescue forces to arrive at the accident scene more quickly than is presently possible. Systems studies have shown that a satellite orbiting at an 850-kilometer altitude can detect the emergency beacons operating at 121.5 and 243 MHz presently carried by aircraft and ships. Systems analysis and simulations indicated that a satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers and could locate a proposed new beacon (using the recently allocated 406 MHz frequency) with its stronger and more stable signal to better than 5 kilometers accuracy.

This multiagency program is being conducted jointly with Canada, France, Norway, and the Soviet Union. The United States will provide the spacecraft, antennas, launch vehicle, and the United States ground stations. The Canadians will provide the space telecommunication equipment and a ground station in their country. France will provide an onboard processor and receiver and a ground station in France. The Soviet Union will launch and maintain in orbit two spacecraft operationally compatible with the United States, French, and Canadian systems, and will operate their own ground stations. Norway will participate in the joint project as an investigator providing additional experimental test

beacons and an interoperable ground station in Norway. In addition to NASA, United States participants include the Departments of Defense and Transportation which have purchased and will operate ground stations and will participate in the program test and evaluation phase. NOAA is providing the spacecraft for modifications.

All activities required to support the beginning of the demonstration and evaluation phase of the program in mid-1982 are proceeding on schedule. The NOAA-E spacecraft is complete; the French and Canadian search and rescue instruments have been delivered and integrated; and the spacecraft completed thermal/vacuum testing in November 1981. The three search and rescue ground stations are nearly complete and will be installed in late 1981 and early 1982. The mission control center will be ready in 1982. New experimental distress transmitters operating at 406 MHz have been developed. Excellent progress has been made in developing the detailed test plans which will be used as the basis for evaluating the effectiveness of the system during the 15-month period following launch.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase in FY 1982 is in response to Congressional request and will be used for long lead procurement and necessary spacecraft modifications to permit inclusion of French and Canadian search and rescue instruments on the follow-on NOAA spacecraft--NOAA-H, I and J.

BASIS OF FY 1983 BUDGET ESTIMATE:

FY 1983 funding will he used to evaluate the performance of the on-orbit search and rescue system to determine overall system effectiveness, location accuracy, and impact on search and rescue operations. FY 1983 funds will also be used to complete the integration and test of the search and rescue instruments on the NOAA-F and G spacecraft. In addition, work will continue on the NOAA-H, I, and J spacecraft to permit an extension of the search and rescue spacecraft coverage on an interim basis until an operational system can be deployed.

Technical Consultation and Support Studies

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Technical consultation and support studies.....	3,145	2,600	2,600	2,600

OBJECTIVES AND STATUS:

Radio interference, propagation, and system studies being conducted under this program are required to ensure the growth of existing satellite services and the inclusion of new satellite applications. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. They provide a technical basis for regulatory and policy studies and are needed to continue orderly satellite services. Emphasis is on orbit and spectrum utilization studies which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effects of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary orbit and radio spectrum. NASA's unique resources and expertise, developed over more than 15 years, are also used, on request, to support the Federal Communications Commission, National Telecommunications Information Administration, Department of State, Federal Emergency Management Agency, and other organizations.

Through this program, NASA provided key inputs in the preparation for and participation in the 1979 General World Administrative Radio Conference. More than 100 technical and position papers were provided by this program in support of the 1979 conference.

The program has made it possible to implement, on a commercial and nonexperimental basis, remote sensing, mobile communications, and broadcasting by satellite. These capabilities are essential to a broad range of public and private sector applications such as commercial mobile telephone, direct television and audio broadcast, paging, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. In a broader sense, the capabilities will be invaluable for domestic and international economic and social development.

BASIS OF FY 1983 ESTIMATE:

Major emphasis over the next three years will include continued preparations for the 1985-87 World Adminstrative Radio Conference on Geostationary Orbit Planning, the 1983 Western Hemisphere Conference on Broadcast Satellite Planning, and the 1983 General World Administration Radio Conference on Mobile Communications, and continued measurement of propagation effects on radio communications.

Experiment Coordination and Operations Support

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Experiment coordination and operations support.....	2,155	1,000	1,000	1,000

OBJECTIVES AND STATUS:

The objective of this program is to continue experiment support for ATS-1, -3, and -5; and to complete, appropriately document, and archive the wide range of user experiments and demonstrations in the application of satellite communications. Past experiments with NASA experimental satellites (ATS series and CTS) have generated great interest nationally and internationally in satellite telecommunications. Nearly *400* communication experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites to provide users with the experience necessary for making decisions regarding their communication functions. NASA's stimulus in encouraging use of these unique facilities has led to wider use of commercial satellites, which can now better meet needs for flexibility and continuity of services. ATS-1 and ATS-3 are currently used for VHF voice communication experiments in health care delivery, education, public safety, emergency communication, mobile land and maritime communications, research support and data communication. The major experiments on ATS-1 involve communications in the islands of the Pacific Basin, and for much of that region, the ATS-1 is the only source of intra-island communications.

A major accomplishment of this program was the completion of the first phase of the Pacific Basin Communications Study, partially funded by the National Telecommunications Information Administration, which assessed present telecommunication systems in the Pacific island regions, examined user needs

and services, and proposed alternative technological solutions for a regional satellite based communications system.

Other activities in this program include planning for educational and public service communication, continuing support for the management and operation of the Denver Satellite Access Facility and the coordination of ATS user experiments with other Federal agencies.

BASIS OF PY 1983 BUDGET ESTIMATE:

ATS-1, 3, and 5 operations will continue through the end of FY 1983 as will Denver Satellite Facility support. The Pacific Basin Study will conclude with an evaluation of the technical characteristics of a Pacific island satellite based telecommunication network. A study of ATS-1 follow-on options and alternative low density system concepts will be conducted.

Information Svstems

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Applications of advanced technology.....	450	2,950	1,600	1,300
Data management....	1,510	3,3 50	1,300	3,225
Distributed data systems.....	2,540	3,700	2,100	2,975
Total.....	4,500	10,000	5,000	7,500

OBJECTIVES AND STATUS:

The objectives of the information systems program are to develop and demonstrate advanced capabilities for managing, distributing, and processing data and information; to implement information systems standards and transportable common software to lower data systems costs; and to develop the basis for data services to provide improved access to, and rapid delivery of, space data and information in support of the Nation's satellite programs. Further objectives of this program include the improvement of capabilities €or analyzing, managing and exchanging data and information in support of Space Science and Applications projects.

This program provides for timely development of data systems capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a good potential of reducing ground data systems development risks and the incidence of schedule slips and late data delivery. The results of the FY 1983 efforts will provide for an earlier return on the considerable investment in data acquisition, will establish a firm basis for interagency data sharing, and will result in compatible data and data systems. Pilot data systems projects (initiated in 1981 in the atmosphere, oceans, and resouces disciplines) will demonstrate common multidisciplinary approaches for cataloging, processing, managing, and using science and applications data.

CHANGES FROM FY 982 ; ESTIMATE:

The information systems program net reduction of $5 million is the result of the general reduction in the appropriation. This reduction will be accommodated by the deferral of new applications studies and new technique development of advanced data systems.

BASIS FOR FY 1983 ESTIMATE:

The FY 1983 information systems program will provide near-term support for space applications programs. Specifically, funds will be used to complete one of the pilot projects (development of an advanced pipeline processor system that will support the Landsat Thematic Mapper); continue development of the ocean and atmospheric pilot systems at the Jet Propulsion Laboratory and the Goddard Space Flight Center; and complete implementation of online catalogs and common software for climate and oceans data to support ongoing discipline research.

The FY 1983 program includes the completion of the applications data systems (ADS) definition studies; supports the continuation of the atmosphere and oceans pilot data systems through completion; provides for the interconnection of these pilots to form the nucleus of an ADS; provides for technical support of flight projects; continues high priority data system standards and transportable software research and development activities; and allows the definition of joint pilot activities with the National Bureau of Standards and the National Oceanic and Atmospheric Administration.

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF EXTERNAL RELATIONS **TECHNOLOGY UTILIZATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Technology dissemination.....	2,594	1,500	5,700	3,200	RD 8-4
Technology applications.....	3,858	2,100	2,300	800	RD 8-5
Program evaluation and support.....	1,148	---	---	---	RD 8-5
Civil systems.....	1,200	1,000	---	---	RD 8-5
Total.....	8,800	4,600	8,000	4,000	

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION:

Johnson Space Center.....	---	---	100	---	
Kennedy Space Center.....	28	---	50	---	
Marshall Space Flight Center.....	252	195	400	195	
National Space Technology Laboratories..	134	---	---	---	
Goddard Space Flight Center.....	962	540	865	393	
Jet Propulsion Laboratory.....	1,823	265	300	50	
Ames Research Center.....	553	---	200	50	
Langley Research Center.....	859	142	450	235	
Lewis Research Center.....	158	---	200	---	
Headquarters.....	4,031	3,458	5,435	3,080	
Total.....	8,800	4,600	8,000	4,000	

OFFICE OF EXTERNAL RELATIONS **TECHNOLOGY UTILIZATION PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The NASA technology utilization program is designed to enhance national economic growth and productivity through the transfer of new technology resulting from NASA research and development programs to the nonaerospace sectors of the economy. In addition to generating use of aerospace technology in United States industry, such technological advances have found use in important public sector areas such as medicine, transportation, environment and public safety. The specific objectives of the program are:

- To accelerate and facilitate the application and use of new technology thus shortening the time between development of advanced aeronautics and space technologies and their full use in the economy;

- To encourage multiple secondary uses of NASA technology in industry, education, and Government where a wide spectrum of technological problems and needs exist;

- To understand more fully the technology transfer process and its impact on the economy, and to manage and optimze the process in a systematic way; and

- To develop applications of NASA's aerospace expertise--its technology, technologists and unique facilities--to nonaerospace needs of the Nation.

Since the program's inception in 1962, a multifaceted array of transfer mechanisms has evolved -- mechanisms designed to facilitate the use of aerospace technology in the public and private sectors of the economy. These mechanisms or project areas include: publications and announcements, industrial applications centers, the Computer Software Management and Information Center (COSMIC), State technology application centers, applications teams/applications engineering and civil systems projects.

OBJECTIVES AND STATUS:

Subscriptions to NASA Tech Briefs among engineers, scientists and businessmen in United States industry reached the administrative limit of 75,000 distributed copies during the past year, necessitating the establishment of a "waiting list" pending completion of annual circularization. Nearly 160,000 requests for additional technical information were received by NASA during the past year based on Tech Brief announcements, reflecting substantial continued industrial interest and utility of this primary NASA transfer mechanism.

Last year, the NASA dissemination center network continued to provide United States industry with technology research and assistance service based on problem-related inquiries from client firms. Companies, both large and small, found such services to be especially beneficial in the development of new and improved products and processes. In addition, use of governmentdeveloped computer programs made available through the NASA-sponsored Computer Software Management and Information Center (COSMIC) reached an all-time high with industrial income for programs reaching the $730,000 level--a 35-percent increase over the previous year. Total industrial income from NASA dissemination center activities was $4,100,000 last year, a 22-percent increase over the previous year.

Program evaluation efforts were substantially reduced last year due to the FY 1981 rescission and are now incorporated in the dissemination line which they support. Evidence of technology transfer continued to be systematically documented for use in the annual "Spinoff" report to industry and the public, a publication which has created broad awareness of NASA research and development programs and the beneficial uses thereof in the United States economy.

During 1981, applications engineering project emphasis was directed to bioengineering, rehabilitation, environment and public safety problems. Each of the 25 projects funded last year had joint participation from user agencies or industry. A major milestone was reached in bioengineering when the programmable implantable medication system was successfully implanted in a diabetic animal. Also, a mass spectrometer study was completed for the National Institute for Occupational Safety and Health and NASA and the National Institute of Handicapped Research successfully demonstrated a new wheelchair concept for possible use in commercial air travel.

During 1981, the civil systems program was brought to a conclusion. A total of 18 projects were completed during the period of 1974-1981. Of those 18, eight have already reached a successful transfer to the public sector. Projects demonstrated in this program area covered water and air pollution, undersea technology, radar archaeology, agro-environmental systems, and radar entomology.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The increase of $3.4 million in FY 1982 over the budget estimate is the result of direction by the Congress in approving the appropriation for 1982. These additional funds are being used to enhance technology dissemination efforts and to increase efforts to encourage commercialization of aerospace applications by United States industry.

BASIS OF PY 1983 ESTIMATE:

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Technology dissemination.....	2,594	1,500	5,700	3,200

In FY 1983, NASA will continue efforts to meet the requirements of the Space Act to provide for the widest practicable dissemination of technical information resulting from NASA research and development programs. Funding in FY 1983 will continue the dissemination of information concerning NASA technology but at a somewhat lower level than FY 1982. NASA will attempt to maintain price levels for technical information for United States industry so that access by small business users will not be seriously impaired.

In FY 1982, NASA will perform its evaluation and benefit analysis activities to analyze areas of United States industrial need where aerospace technology may have particular applicability. In addition, program elements will be reviewed in detail to determine the practicality of greater private sector involvement in the technology transfer process. Benefit and economic impacts resulting from NASA research and development programs will also be analyzed, documented and assessed to determine appropriate changes to make the program more effective. In FY 1983, program evaluation and benefit analysis will be phased out; however, publication inquiry support and scientific and technical information data base support for the NASA dissemination center network will be maintained at the NASA scientific and technical information facility.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Technology applications...	3,858	2,100	2,300	800

In FY 1983, NASA plans to focus its applications engineering program in the biomedical field. NASA will continue particpation to completion of several high priority biomedical projects and maintain biomedical applications team activities in support of selected feasibility studies designed to apply existing aerospace technology to biomedical problems identified in cooperation with the National Institutes of Health and other public sector medical organizations. To achieve this objective, NASA plans to reduce its level of support in the applications of aerospace technology in transportation, environment, and public safety.

Program evaluation and support..	1,148	---	---	---

Activity formerly funded under this title has been incorporated into technology dissemination which it directly supports.

Civil systems.....	1,200	1,000	---	---

The civil systems program was brought to a conclusion during FY 1981. A total of 18 projects were completed during the period of 1974–1981. Of those 18, eight have already reached a successful transfer to the public sector.

AERONAUTICS AND
SPACE TECHNOLOGY
PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1983 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

Programs	Budget Plan			
	1981	1982		1983
	Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)			
Aeronautical research and technology	271,400	264,800	233,000	232,000
Space research and technology	110,700	125,300	111,000	123,000
Energy technology	1,900	---	---	---
Total	384,000	390,100	344,000	355,000

AERONAUTICAL
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF A ... SPACE TECHNOLOGY — **AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base	133.847	157.800	162.500	182.000	RD 9-5
Systems technology programs	137.553	107.000	70.500	50.000	RD 9-29
Total	271.400	264.800	233.000	232.000	

Distribution of Program Amount by Installation:

Johnson Space Center	190	100	150	150
Marshall Space Flight Center	675	800	800	750
Jet Propulsion Laboratory	780	1.000	500	500
Goddard Space Flight Center	590	800	500	500
Ames Research Center	71.462	86.600	80.750	95.000
Langley Research Center.	100.155	97.000	80.500	76.000
Lewis Research Center	93.389	74.000	65.300	54.600
Headquarters	4.159	4.500	4.500	4.500
Total	271.400	264.800	233.000	232.000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **AERONAUTICAL RESEARCE AND TECHNOLOGY PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATIONS:

The objectives of the aeronautics program are to advance aeronautical technology to insure safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to support the military in maintaining the superiority of the Nation's military aircraft; and, to maintain the strong competitive position of the United States in the international aviation marketplace.

The FY 1983 program supports these objectives by providing for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical by in-house assessments, industry, military, and advisory groups, and other users of technology within and outside the Federal government. Emphasis will be placed on maintaining a strong discipline- and vehicle-oriented research and technology base, with focused systems technology programs in high speed and low speed aircraft in support of the military.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The total aeronautics program reflects a reduction of $31.8 million from the amended budget request submitted last year. This reduction is the result of implementation of the policy decision to emphasize fundamental research and technology while deemphasizing technology demonstration activities. This deemphasis in Systems Technology reflects the objective of reducing the Federal role in those areas which directly support industry for product development, while retaining those efforts which are related to longer range technology and to defense considerations. Specifically, the Research and Technology Base has been increased by $4.7 million to provide increased support for fundamental supersonic research, and to reflect a realignment of certain efforts, such as broad property fuels, which were to have been conducted under Systems Technology. The Systems Technology programs being reduced in FY 1982 and planned for termination prior to FY 1983 include: aeronautical systems studies, an integrated program for aerospace vehicle design, and aeroelasticity of turbine

engine, helicopter transmission technology, powered lift technology, tilt rotor systems technology, laminar flow control, energy efficient transport, composite primary aircraft structures, terminal configured vehicle program, energy efficient engine and the advanced turboprop programs.

The overall **$36.5** million decrease to the systems technology program impacts a broad range of technology efforts and reflects the policy change initiated in the FY **1983** budget.

The FY **1983** systems technology portion of the aeronautical research and technology program will contain only the high speed and low speed budget categories. These efforts have a strong direct interdependence with national aeronautical research programs of the Department of Defense and will be, beginning in FY **1983,** the only focused systems technology activities within the Aeronautics research and technology program. All other more fundamental research activities will be conducted within the research and technology base.

BASIS OF **FY** 1983 **BUDGET ESTIMATE:**

The research and technology base program will build on the substantial results of the ongoing program, utilizing the unique **NASA** experimental facilities, research aircraft, computer capabilities, and expertise now in existence. Fundamental discipline efforts will continue to lead to advances in nonintrusive experimental test techniques and the development of analytical and computational methods to better understand and predict aerodynamic characteristics associated with flow over a variety of aircraft shapes to reduce drag and improve performance; metallic, ceramic, polymer, and composite materials for high temperature engine applications and lightweight airframe structures; the development of analytical methods to improve life prediction and better understand and control the dynamic response of complex aircraft and engine structures; electronics and highly reliable, fault-tolerant aircraft control system software and architectural concepts; crew station technology and the capability of modeling pilot behavior in a multivariable environment; computational methods able to predict complex internal flow through rotating blade rows in turbomachinery and modeling of combustion processes in engines to control emissions; and a better understanding of the impact of alternative fuels on engine performance. The discipline- and vehicle-oriented research and technology base efforts in the various speed regimes will continue to pursue wind tunnel investigations on advanced aircraft and rotorcraft configurations, and to examine the effects of promising technology advances individually and in combination.

Systems technology efforts will continue on advanced rotorcraft concepts and technology for future military aircraft. The rotorcraft activity will include research on new rotor configurations and

other advances in joint programs with the United States Army. The high speed activity will investigate advanced technology and new configuration approaches in cooperative wind tunnel and flight research programs with the Air Force, Navy, and Defense Advanced Research Projects Agency.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Aerodynamics research and technology	23,800	27,200	29,200	42,300	RD 9-6
Propulsion research and technology	31,800	35,300	37,100	43,000	RD 9-8
Materials and structures research and technology	17,800	21,800	22,100	31,300	RD 9-12
Aircraft controls and guidance research and technology	5,400	7,100	7,000	12,900	RD 9-15
Human factors research and technology	6,147	8,100	8,000	9,600	RD 9-17
Multidisciplinary research	5,000	5,900	6,000	3,500	RD 9-19
General aviation and commuter research and technology	6,600	7,800	7,700	---	RD 9-20
Low speed research and technology	9,600	15,200	11,300	12,400	RD 9-21
High speed research and technology	20,600	20,700	26,000	27,000	RD 9-24
Transport research and technology	7,100	8,700	8,100	---	RD 9-27
Total	133.847	157,800	162,500	182,000	

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Aerodynamics research and technology.. ..	23,800	27,200	29,200	42,300

OBJECTIVES AND STATUS:

The objectives of the aerodynamics research and technology program are to: (1) increase the capability to predict the complex aerodynamic flow over aircraft and missile components; (2) discover new means for increasing aerodynamic performance; and, (3) provide for the development of aerodynamic facilities and measurement techniques.

Aerodynamic predictive capability continues to improve with new developments in numerical analysis and in the application of more powerful computers to aerodynamic problems. The computation of transonic flow with shock-boundary layer interaction on airfoils, which is critical in the design of advanced transport aircraft, is becoming a precise science. Substantial progress has been made in computing flows over airfoils at high angles of incidence where the flow may become oscillatory and shed vortices into the wake. New approximate methods have been developed and published for computing the flow-over-wing, body, nacelle, and winglet combinations thus permitting a substantial reduction in wind tunnel time for developmental testing.

Potentially significant discoveries are being made during FY 1982 in devices and surface treatments capable of reducing the turbulent friction drag of fuselages and wings. These experimental findings will permit total aircraft drag reductions of 10 to 15 percent if early results are confirmed.

Such devices may be retrofitted to the existing fleets of aircraft and missiles. New capabilities for testing multielement airfoils to increase maximum lift have been developed during the year. A modified wind tunnel, known as the Low Turbulence Pressure Tunnel, will be used to develop a new series of natural laminar flow airfoils which apply to general aviation and commuter aircraft. The National Transonic Facility (NTF), which will provide the Nation with the world's most advanced high Reynolds number wind tunnel, is expected to achieve operational status at the end of FY 1982.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $2.0 million reflects the increased needs of cryogenic research which provides: (1) the preliminary development, test, and evaluation of instrumentation, materials, and model construction techniques in support of the NTF; (2) construction of the unique preliminary test models and related specialized balances; and, (3) realignment of activities to emphasize fundamental supersonic aerodynamics research following cancellation of the focused supersonic cruise research systems technology effort.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, program funding will be increased to accommodate: (1) operation of the NTF, (2) continued lease of a Class VI computer at the Ames Research Center to replace the obsolete ILLIAC system; (3) continuing studies of the Numerical Aerodynamic Simulator system; and, (4) activities to investigate stall/spin and natural laminar flow phenomena for general aviation-type aircraft.

The research program during FY 1983 will emphasize the application of new computational methods and high speed computer system architectures to practical aerodynamic problems including the task of determining optimal geometries for wing sections and combinations of aircraft components. Additional work will be directed toward the generation of high-lift airfoils and wings that provide opportunities in aircraft design €or improved range and fuel economy.

A strong effort will be maintained to verify and exploit newly discovered friction drag reduction techniques for turbulent flow over wings and fuselages. The basic theory for the reduction of the transition of laminar flow into turbulent flow will be confirmed. The research will provide the fundamental technology for future design of laminar flow systems at both subsonic and supersonic speeds.

Theory and the experimental data base for achieving efficient supersonic and hypersonic flight will be augmented during FY 1983 to support national efforts to improve the range and flight performance of military aircraft and missiles.

With the NTF achieving operational status, comparisons of transonic flight and wind tunnel data will be possible in ranges of Reynolds numbers not heretofore achievable. During FY 1983, new exploratory models designed for the stringent cryogenic test environment will be tested to provide preliminary high Reynolds numbers data and to confirm model and measurement system design techniques. Further

development of cryogenic testing will address the unsteady aerodynamic problems of aileron buzz and wing flutter at flight Reynolds numbers.

Wake vortex studies will be continued and broadened to identify differences in structure between wakes that have been highly attenuated and those produced by conventional wings in landing configurations. The Wake Vortex Facility, at the Langley Research Center, will be used for tests conducted at a small fraction of the cost of flying and modifying existing large aircraft to achieve similar test conditions.

Stall/spin research will concentrate on the development of analytical prediction methods, aided by the extensive experimental data base accumulated in past years. Research on natural laminar flow phenomena will pursue practical methods for incorporating means for overcoming or avoiding adverse environmental effects (ice formation and insect contamination) and will study three-dimensional wing design requirements and limitations. Other drag reduction research will continue to study ways to reduce undesired aerodynamic surface interference effects.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Propulsion research and technology.....	31,800	35,300	37,100	43,000

OBJECTIVES AND STATUS:

The objective of the propulsion research and technology program is to provide the fundamental understanding and generic technology that will allow continued future improvements in aircraft propulsion system efficiency, engine performance, fuel flexibility, reliability, and durability as well as environmental compatibility. The potential of advanced propulsion system concepts is also evaluated within the program. Research is being performed in the areas of turbomachinery, combustion and fuels, propulsion system integration, power transfer, engine systems, controls, noise, computational methods, and instrumentation. These activities provide the fundamental understanding and technology advances that will lead to propulsion system improvements for a broad range of vehicle applications ranging from small, general aviation aircraft to commerical transports and helicopters to military aircraft of all types.

Advanced analysis codes which model internal flows in advanced gas turbine engines are receiving continued emphasis. When fully developed, these codes will have significant potential for reducing development time and cost, as well as providing for improved performance of advanced engines. In FY 1982, three-dimensional inviscid flow analysis codes are being extended from fans and compressors to include turbines. Turbomachinery research continues to explore basic fluid mechanics and heat transfer. Detailed boundary layer and secondary flow measurements are being obtained in cascades and large low speed rigs to verify existing analytical codes. Experimental evaluation of geometry and endwall effects on the performance of small turbomachinery components continues. Investigation of stall performance and recovery characteristics of highly loaded compressor stages is being conducted for dynamic modeling of compressors. Progress has been made in identifying the multiple sources of fan noise and quantifying the influence of forward velocity on fan noise generation. New emphasis is being directed toward identifying noise generation mechanisms of rotors and high speed propellers. In combustion and fuels research in FY 1982, increased emphasis is being placed on understanding fundamental processes and development of analytical models. Experimental investigations of fundamental hydrocarbon reaction rates are being conducted to determine soot formation mechanisms over a range of temperatures and pressures typical of combustor operation as a function of hydrocarbon type. The data is being used to develop multistep kinetic models of the soot formation process. Work continues toward establishing a data base on fuel effects in FY 1982 through an experimental program to relate fuel characteristics (viscosity, composition, hydrogen-carbon ratio) to combustion stability, ignition, emissions, and flame radiation. As a result of propulsion system integration research, an experimentally validated viscous, three-dimensional, patched code for the prediction of exhaust system performance will be available for industry use during FY 1982. Increased emphasis on propeller aerodynamics has resulted in improved flow analysis codes for describing propeller performance for a wide range of applications. Experimental verification of these advanced codes has been initiated in FY 1982. Research on propulsion controls is ongoing to develop a real-time steady-state and dynamic engine simulator for use in future control research. With the simulator design completed, fabrication is being initiated in FY 1982. Future research in this area may ultimately lead to a miniaturized engine-mounted simulator for onboard diagnostics and adaptive control capability. Efforts in power transfer research are focused on developing and verifying improved computational techniques for analysis of lubricated contacts, transient rotor response, gears, and high speed rolling element bearings. Lubrication analysis for high speed gear mesh lubrication and multigear mesh dynamic analysis will be completed in FY 1982. Instrumentation research is concentrated on the measurement techniques required for higher pressure and temperature environments typical of future propulsion systems. Recently developed nonintrusive techniques for gas path flow measurement and visualization are being used to verify advanced analysis codes.

Broad property fuels research focuses on evolving and evaluating combustion technology to accommodate future fuels. The initial concept definition and evaluation phase of this activity has been completed. Design refinement and optimization of multizone (double-annular) and variable geometry combustor concepts are in progress.

CHANGES FROM FY 1982 BUDGET ESTIMATE

The $1.8 million increase in propulsion research and technology is the result of internal program redirection to support additional emphasis in critical resources, supersonic cruise research, and small engine research efforts. Critical resources research and technology activity has been increased to expand research and technology base emphasis on alternative fuels research which includes completion of the broad property fuels effort. Research directed at supersonic cruise technology was increased to address high temperature turbine and high speed jet noise reduction concepts. Additionally, added effort was applied to small engine component research in support of general aviation and commuter vehicles, while turbofan noise research has been reduced.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, the scope and funding of propulsion research and technology base effort will be expanded by $3.5 million to include technologies in advanced propeller concepts, as well as rotary and reciprocating engines. The integration of noise reduction, composite structures, and increased aerodynamic efficiency technologies will be undertaken for advanced propeller concepts applicable over the broad range of general aviation and commuter transport aircraft. Engine research will continue the evolution of enabling technologies for superior rotary and reciprocating engines having multifuel capabilities. Research in computation fluid mechanics will continue the development of advanced analysis codes which model complex internal flows in advanced propulsion system components.

The Lewis Research Center computational capability will be upgraded to support the increased emphasis on fundamental computation fluid dynamics research and, more specifically, the future focus on complex, three-dimensional viscous internal flows. The capability of existing inviscid flow codes will be extended by the incorporation of viscous/inviscid interaction corrections.

Turbomachinery research will continue to focus on fundamental heat transfer and fluid mechanics experiments with emphasis on boundary layer behavior, secondary flows, scale effects, and rotational effects for flow physics modeling and code verification. Investigations of in-stall performance and recovery characteristics of advanced highly-loaded compressor stages will continue.

Combustion and fuels research will continue to be directed toward achieving a basic understanding and analytical representation of the fundamental aerodynamic and chemical kinetic phenomena governing the combustion process. Specific emphasis in FY 1983 will be given to improving and validating turbulent flow field models, droplet combustion, and kinetic computations. In FY 1983, increasing emphasis will be directed toward critical aircraft resources technology with the principal emphasis on developing the fundamental data base relating fuel chemistry to physical property variations and ultimately to effects on combustion, emissions, and component performance and durability.

In FY 1983, the focus in noise research will shift from turbofan application to the fundamental understanding of source noise of rotors and high speed propellers. This will lead to development and validation of source noise prediction models that can ultimately provide a design-for-noise capability for turboprops and rotorcraft.

Propulsion system aerodynamics research will concentrate on analytical methods and verification for supersonic inlets, diffusers, turboprop/airframe integration, and advanced propellers. In FY 1983, verification of three-dimensional nonviscous and viscous aerodynamic codes will be initiated using flow field data obtained through advanced nonintrusive measurement techniques. In FY 1983, engine systems and controls research will focus on the fundamental understanding and modeling of turbofan stall recovery. The use of advanced control modes will be examined as a method to effect recovery from turbofan hung stalls. Initial efforts will begin to prepare the hardware developed during the energy efficient engine program as testbeds for future engine systems research.

Advanced propulsion systems research will continue to pursue activities to gain an understanding of the fundamental processes associated with hypersonic propulsion. Computational methods will be developed and validated to predict the characteristics of turbulent combustion flows. The focus in FY 1983 will be on demonstrating useful levels of installed thrust and impulse for a single subscale engine module over a range of Mach numbers from 4 to 7.

Within instrumentation research, increased emphasis will be placed on combustion diagnostic techniques to acquire and process large amounts of data €or validating analytical models of physical processes.

Mechanical power transfer research will continue to advance the fundamental understanding of lubrication and wear mechanisms and the technology of bearings, gears, seals, and lubrication systems to achieve increased life, performance, and efficiency in the high speed, temperature and pressure environments of advanced gas turbine engines and mechanical transmissions. Increased emphasis will be

placed on extending the technology base of large, high speed gear and lubrication systems to improve the understanding of the effects of scale.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Materials and structures research and technology.....	17,800	21,800	22,100	31,300

OBJECTIVES AND STATUS:

The objectives of the materials and structures research and technology program are to: investigate and characterize advanced metallic, ceramic, polymer, and composite materials; develop structural concepts and design methods to exploit the use of advanced materials in aircraft; further analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and, generate research data to promote improvements in performance, safety, durability, and economy in civil and military aircraft. Areas of emphasis include high temperature engine and airframe materials and structural concepts; composite materials application, life prediction, thermal and dynamic response, and aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines. During the past year, advances were made in understanding the role of the critical strategic element, cobalt, in high temperature superalloys. Coating development work has demonstrated an increase in temperature capability of coatings and the ability to model the oxidation/corrosion environment encountered in turbine engines. Life prediction methodology continued to make advances in modeling of viscoplastic behavior of a metal subjected to cyclic high temperatures and stresses. Initial research on advanced powder aluminum alloys has demonstrated improved temperature and strength properties. Advances are also being made in the capability to predict the life of composites which will improve the efficiency and performance of aeronautical systems. In composite structural applications, concepts for improving damage tolerance by means of buffer strips, bonded stringers and translaminar stitching have been validated. Intensive studies of impact response characteristics and delamination behavior and control have been initiated. Efforts to develop tougher resins have resulted in the identification and initial assessment of promising compositions, such as rubber-toughened epoxy, novel on-phase theromsets, and modified thermoplastics.

Research has continued in the area of improved optimization and design-oriented analysis methods. A wide collection of analysis codes has been developed and assembled. The codes are being integrated into a computer application system for the evaluation and design of a wide range of aerospace vehicles. Studies of the use of microprocessors for structural calculations have resulted in a successful demonstration of a prototype hardware configuration and solution algorithms. Further research will define key components that can improve hardware and software design and efficiency.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $300,000 is the net effect of several actions taken to realign the resources to provide for increased emphasis in supersonic cruise and decreased emphasis on materials life prediction research.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, the program will be expanded to include the critical safety related research in meteorological hazards, fire safety, and landing systems previously conducted under transport research and technology, and the crash dynamics and composites materials research previously conducted under general aviation and commuter research and technology.

Research in structures will continue the evolution of design methodology for optimal crash load limiting structures for general aviation, thereby extending this effort into the realm of composite materials. Focused research in composites for light aircraft will be initiated based on previous study determinations.

Research in aircraft landing systems will continue studies of the effects of tire failures on aircraft controllability. Long-term studies of tire behavior and optimized design will begin using inputs from the tire thermal, friction, and wear studies that will have been completed. Development of advanced elastomers for tire carcasses will continue based on tire tread experience. An in-service evaluation is planned. Development of the ground handling simulator will continue based on completed research in antiskid and brake systems and aircraft performance on slippery runways. Advanced antiskid systems development will begin.

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During FY 1983, research in fiber-reinforced superalloys will be directed at improved processing techniques and modeling of material response under thermal loadings.

Research will continue to focus on obtaining a fundamental understanding of the roles of cobalt, columbium, and tantalum in superalloys. Work on advanced thermal barrier coatings of greater durability will continue. Life prediction of materials using viscoplastic modeling techniques will be continued. The powder aluminum program for high speed airframe structural applications will increase in scope to include the addition of silicon carbide particulate for increased strength and stiffness. Research on material response to cyclic loading and resultant fatigue/fracture behavior will continue to be a major thrust in airframe materials.

To predict service durability of composites, a damage growth law will be developed and validated. Research on composites will continue to emphasize the evaluation of stiff, lightweight structural materials. In FY 1983, studies will continue on low cost fabrication processes and applications of composites in fixed-wing aircraft. Study emphasis will be placed on processability improvements and methods for evaluating and increasing the durability and damage tolerance of second generation composites. Exploratory research will be continued on new resins that will result in tougher, impact-resistant, more processable composites. The fabrication and evaluation of advanced composites for high performance engine blades will continue in FY 1983.

In loads, dynamics, and aeroelastic research, the FY 1983 program will continue to validate improved unsteady aerodynamics prediction methods, with major emphasis on the transonic speed range, based on both frequency and time domain computational techniques. Aeroelastic analysis tools will be developed for application to wings and to turbine engine fans, compressors, and turbine blades, and validated by means of experimental data from wind tunnels, spin rigs, cascade rigs, and flight tests. Concepts for active and passive control or aeroelastic behavior will be investigated and validated. Investigation of active controls applications to forward swept wing design will be initiated. Methods for the prediction and control of structure-borne aircraft interior noise will also be developed. In transport crash dynamics, a crash scenario will be defined based on the various crash scenarios developed in FY 1981 and used to establish requirements for the joint NASA/Federal Aviation Administration full-scale 720 transport crash test. The evaluation of modeling techniques for crash response prediction will continue. Additional effort will define component and scaled model tests for concepts and prediction methods validation. In FY 1983, work related to integrated analysis/synthesis methods will focus on the optimization of the structural and aerodynamic configurations and the performance attributes of airframes that incorporate new technologies such as active controls and advanced composite materials. A large-scale optimization of a transport aircraft wing for fuel efficiency has been defined as a long-term task on which to focus the new methodology development. An ongoing program to demonstrate a finite element machine computation device using microprocessor components

will continue. A 36-node board system will be fabricated and used for performance evaluation of a finite element machine prototype design.

High temperature structures research will continue to develop nonlinear analysis methods for predicting the response of airframe components subjected to transient thermal loads, and for predicting the useful structural life of turbine engine hot section components. Concepts for improving the thermostructural efficiency of such structures will continue to be investigated and validated.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Aircraft controls and guidance research and technology.....	5,400	7,100	7,000	12,900

OBJECTIVES AND STATUS:

The objectives of the aircraft controls and guidance research and technology program are to: provide fundamental knowledge and understanding of information and control theory for analyzing the performance of aircraft; develop mathematical control laws and design methods for extending the performance envelope and reliability of future civil and military aircraft; devise analytical methods and techniques for assessing the performance of large-scale, complex integrated systems; and, investigate emerging technologies which offer future alternative approaches for continued aviation safety and efficiency. Major program elements are; applied control theory, flight path management, flight-crucial systems which include fault-tolerant architectural concepts, system assessment methods, and environmental effects research.

Needed advances are being made in the determination of design criteria for vehicles with highly-augmented controls. Shuttle data is being analyzed to assess the flying qualities and improve the generic design process and modeling techniques. Improvements in analytical techniques are providing the capability to determine the influence of different active control concepts on aircraft stability, performance and configuration. Experimental flight tests are being conducted to validate advanced control laws which improve aircraft performance in the presence of gusts, clear air tubulence and other disturbances without limiting the control system effectiveness in other flight regimes. A

multispectrum guidance concept using image processing and terrain matching techniques is being investigated for highly accurate approach and landing operations. This could prove to be particularly important in remote site activities.

Flight-crucial systems research is a major element in the controls and guidance program. Continued progress is being made to provide the needed technology base. In FY 1982, a technique to protect electronic systems against latent generic software errors is being evaluated. It uses dissimilar software embedded in the primary system and will potentially eliminate the requirement for costly, complicated backup hardware currently used in aircraft systems. Concern with the effects of lightning on digital electronics has increased research activity both in understanding lightning phenomena and in developing protective techniques. The effectiveness of newly developed protective schemes is being evaluated using induced voltage levels determined from prior studies. Other activites in this area have resulted in a system for random injection of lightning-induced upset transients into microprocessors to characterize the effects.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The $100,000 reduction reflects a realignment of funds within the aeronautics research and technology base in order to support other priority research activities.

BASIS OF PY 1983 ESTIMATE:

In FY 1983, critical safety research previously conducted under transport research and technology will be conducted as an integral part of the aircraft controls and guidance research and technology program. Emphasis in FY 1983 will also focus on research in flight-crucial controls technology and applied control theory.

In the flight-crucial systems area, ongoing fault-tolerant control system studies will be expanded to define a candidate system architecture and to conduct laboratory simulations to assess the reliability of a fault-tolerant control system. Research on reliable flight software will continue to emphasize methods for establishing complete and consistent specifications to avoid errors. Results of these activities will be analyzed through laboratory simulation facilities to evaluate system effectiveness in FY 1984. With the opening of a new electronics research laboratory, called Avionics Integrated Research Laboratory (AIRLAB), at the Langley Research Center and the trend toward complex, highly integrated systems, increased emphasis will be placed on the development of systems validation methodology. Initial checkout of AIRLAB will utilize a well defined and tested digital system as a

baseline to conduct laboratory experiments for verification and calibration. In addition, the Langley Research Center's advanced operating system research aircraft will be used, as appropriate, as a companion facility to support this activity. Research efforts in fiber optics technology and lightning effects will continue to contribute concepts to the fault-free technology base.

Research in meteorological hazards to aviation will continue using two flight research aircraft to characterize severe storms and the effects of lightning and turbulence on future aircraft systems design and operations. Dissipation of warm fog using the charged-particle concept will be evaluated in the field. Icing research will include development and evaluation of improved icing sensors, scaling laws and the study of modern airfoils under icing conditions. Improvements in wind tunnel productivity for icing experiments are planned using improved aerodynamic measurement devices.

In FY **1983,** a more concerted effort will be initiated to establish design criteria and an optimized mechanization process for interdisciplinary active controls. Initial emphasis will be on the development of improved techniques for analyzing the functional interplay between disciplines.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Human factors research and technology...	**6,147**	**8,100**	**8,000**	**9,600**

OBJECTIVES AND STATUS:

The objective of the human factors research and technology program is to provide the supporting data base and-advanced technology for solution of human factors problems which influence the growth, efficiency, and safety of air transportation. The program has two major areas of emphasis: flight management and flight simulation technology.

In the area of flight management, the activity to assemble, analyze, and report the available practical knowledge on the effects of circadian desynchronosis has been completed. Data on actual crew rest and dietary patterns are now being collected. A number of significant experiments have now been completed under the joint NASA/Federal Aviation Administration cockpit display of traffic information (CDTI) program. The effects of sensor noise, size of display, intrail spacing stability, and various candidate procedures have been studied, and an assessment of potential advantages and

disadvantages of these and other variables will continue. Investigation of the human factors effects of increased automation in aircraft and the air transport system is being emphasized.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

A decrease of $100,000 resulted primarily from a deemphasis in the activity related to the human response to noise in order to support other priority efforts within the research and technology base.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, single pilot cockpit display technology efforts previously conducted under general aviation research and technology will be conducted as an integral part of this program. Also, the flight management research program will continue to emphasize CDTI, aircrew performance, and advanced crew station human factors. The joint NASA/FAA CDTI program encompasses multiple simulator studies of pilot ability to use the CDTI to assume certain air traffic control functions. A primary emphasis of the work will be an investigation of the interactive effects of CDTI with other planned innovations such as collision avoidance systems and automatic traffic advisory and resolution service. The FY 1983 activities will address the critical questions affecting the earliest possible implementation decision.

In the area of aircraft performance, efforts in crew resource management and circadian desynchronosis will increase the knowledge of the causes of human error in aviation, especially as it pertains to decisionmaking and problem-solving under stress. Increased emphasis will be placed on the generation of crew workload and performance measures. Circadian desynchronosis work will focus on laboratory investigations and appropriate field studies of the effects of the dietary and rest patterns of airline crews. These efforts are designed to assess the range and extent of circadian desynchronosis effects, develop methods of minimizing those effects, and determining crew tolerance limits.

Advanced crew station human factors efforts will emphasize the generation of guidelines for aircraft systems and operations tolerant to human error based on earlier exploratory work defining the proper role of automation in the cockpit. Candidate automation guidelines will be evaluated under controlled conditions in high fidelity, full-workload simulators with integrated air traffic control simulation. Conditions which lead to accidents will be recreated through simulation, and the effects of various degrees and types of automation will be studied. A corollary of this work will be an investigation of the roles of aircraft crews under conditions of increased automation.

Flight simulation research for the multicab simulation facilities being developed at Ames Research Center, (the Man–Vehicle Systems Research Facility) and at Langley Research Center, (the Mission Oriented Terminal Area Simulation), will address the development of research methodologies which can take maximum advantage of the new multicab technologies for increasing simulation fidelity will continue.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary research.....	5,000	5,900	6,000	3,500

OBJECTI I STATUS:

The objective of the ltidi ip r: s rch program is to conduct novel, on mu s .I inar r i t aeronauti l res is conducted p at i · gh (1) the Fund for p Research which supports li p and proposal received in p to announcements of r earch opportuni i n p areas such as physics of compressible flowing fl :l of tu momentum transfer coherent vertical structur in turbu enc investigation f laser beam mol cular i r lo i of pure gases, ı chemistry etc.; (2) the Graduate Program in Aeronautics l ch supports graduate studies where the th research is rforme at least in part at a NASA research er using NA facilities; (3) the Post alaureate Program, which supports graduate study at the masters level uding significant r ence t a NAS research ; *(4)* the t lui Dynamics FI Training Program initiated in FY 1980 to support CFD training programs i t universities; and, 5 th t level support for t Jo tui for Advancement of Flight Sciences and the Geor W shington t program at ey Research Center.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $100,000 reflects a modest increase in funding for the Post–Baccalaureate Program to offset cost adjustments.

BASIS OF FY 1983 ESTIMATE:

The research supported under this activity will be conducted as a broad study of innovative ideas, such as theoretical mathematics, that underlie and cut across the spectrum of disciplinary activities, and thus contribute to long-term growth in aeronautical technology.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
General aviation and commuter research and technology.....	6,600	7,800	7,700	---

OBJECTIVES AND STATUS:

The objective of the general aviation and commuter research and technology program has been to provide the technology base for achieving much needed improvements in general aviation aircraft safety, utility, and energy efficiency. Multidisciplinary in nature, the program encompasses aerodynamics (performance, stability, and control); materials and structures; propulsion and fuels; and, human factors.

The stall/spin program emphasis shifted to development of analytical techniques for predicting aircraft stall/spin characteristics and reliable design methods for achieving desired stall/spin characteristics in new aircraft. Drag reduction research emphasized natural laminar flow (NLF) airfoils suitable for general aviation. Instrumented wind tunnel and flight tests of several airfoil types demonstrated that the theoretically predicted extent of NLF could be approached closely with wing surface conditions achievable using modern manufacturing methods. Aircraft drag reductions of more than ten percent appear feasible through the eventual exploitation of NLF technology with attendant improvements in fuel economy. Propulsion research on low speed propellers and intermittent combustion engines continued. Flight tests confirmed that modifications previously demonstrated in the laboratory can achieve more than ten percent improvement in fuel consumption for certain types of existing spark-ignited reciprocating aircraft engines. Laboratory research on advanced fuel-efficient and lightweight general aviation engines, both rotary combustion and reciprocating types, proceeded with emphasis on stratified charge, multifuel combustion systems. In structures research, dynamic testing of load-limiting seats and fuselage structures proceeded with embodying the best features of

previous research. A contract study of composite structural design and fabrication techniques best suited for light aircraft use was begun to help provide a basis for planning focused research. Human factors research emphasized improvements in single pilot instrument flight rule operations. A major activity in this area was the investigation of simple visual flight path control and computer-generated cockpit display concepts. Research on agricultural aerial applications was concluded with flight test verification of computer codes for predicting liquid and solid material distribution patterns in aircraft wakes.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $100,000 reflects primarily the transfer of the interior noise research program from general aviation to the materials and structures effort within the research and technology base.

BASIS OF PY 1983 ESTIMATE:

In FY 1983, the essential elements of the program associated with generic research and technology will be pursued within the individual research and technology base discipline programs in propulsion, aerodynamics, materials and structures, and human factors.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Low speed research and technology.....	9,600	15,200	11,300	*12,400*

OBJECTIVES AND STATUS:

The objectives of the low speed research and technology program are to provide technology bases in the areas of rotorcraft structures and dynamics, aerodynamics, flight dynamics and control, man-system integration, and wind tunnel and flight experiments support. Specific objectives include: (1) long-term evaluation of flight service of composite components; (2) reduction in vibration and loads; (3) prediction of external noise; *(4)* analysis of transonic flow, blade vortex interaction and wake flow; (5) development of handling qualities criteria; and, (6) development of a technical base of human information transfer in the unique helicopter cockpit environment. These efforts are complemented by portions of the systems technology program in rotorcraft.

During the past year, static and fatigue tests of the S-76 helicopter graphite and Kevlar components were completed. The design and fabrication of an OH-6 helicopter higher harmonic control system was completed in preparation for flight tests. A NASA Structural Analysis (NASTRAN) finite-element analysis design method was developed for helicopter airframes. Unsteady aerodynamic analyses were updated to include time-domain compressibility and viscous tip vortex flow. Acoustic prediction codes were extended by adding broadband and random loading capability. Fully transonic, three-dimensional analytical codes were transferred to industry and are now being extended to include tip vortex interaction. Work was initiated for small-scale tests of main rotor/tail rotor/fuselage interactions. In the flight dynamics area, an analysis of the YAH-64 advanced attack helicopter handling qualities in nap-of-the-Earth flight was completed together with studies of sidearm 4-axis control, excess power, and engine transients. Human factors research included the completion of initial instrument position control study and a flight study of pilot performance utilizing speech recognition automated equipment.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $3.9 million reflects a $3.5 million realignment between the low speed and high speed programs within the research and technology base and reflects the transfer of budget and management responsibility of the high performance Vertical/Short Takeoff and Landing research activity to the high speed program. In addition, a reduction of $400,000 was taken in the area of rotorcraft avionics in FY 1982.

BASIS OF FY 1983 ESTIMATE:

The long-term service evaluation of composites will continue with static tests of Bell 206L helicopter components removed from the field. Support of the Army all-composite aircraft program will include laboratory tests of fabrication techniques and materials use. The proof-of-concept flight tests of higher harmonic control on the OH-6 research helicopter (jointly funded by the Army) will be completed, thus demonstrating the feasibility of meeting "jet-smooth" ride vibration levels. A second set of model rotor tests will be conducted on tip shapes to validate reduced noise and load levels. Oscillatory airfoil tests will be used to validate a time-dependent boundary layer separation analysis of dynamic stall. This work will be evaluated for the second generation aeroelastically conformable rotor blade design that is the basis for the Army's integrated technology rotor program.

In the area of aeroelastic stability, a second series of full-scale wind tunnel tests of the bearingless main rotor will be conducted in the Ames Reserch Center full-scale facilities complex. A

model test of individual blade control for flutter suppression will be completed. Several advanced hub designs will be completed.

Acoustic prediction methods will validate the broadband noise contributions using full-scale flight data from the AH-1G helicopter tests. Small-scale tests with the Army will examine noise scale effects and the problems of detectability. An acoustics specialists workshop will be held to define the remaining research tasks toward a "design-for-noise" capability.

A major effort in interactional aerodynamics will grow to include rotor wake flow effects, rotor/fuselage/tail rotor interference and related loads and noise levels. Of particular interest are the problems that arose in the Army's utility and attack helicopter development programs.

In the area of flight dynamics, math models will be refined to compare flight and simulation results in the high power/thrust conditions found in Army nap-of-the-Earth flight. The Army bailed, variable stability *CH-47* helicopter will be upgraded and, in a joint simulation exercise with the Army, the four-axis pilot stick controller will be evaluated. Under human factors research, specific instrument and control positions will be assessed for pilot performance and workload. Work on defining and evaluating the processing of auditory information from synthesized speech will continue. Advanced control work on redundant actuator and multiprocessor control will be phased into support of the Army's advanced digital optical control system program. Instrument Flight Rules rotary-wing certification criteria work will continue.

Theoretical aerodynamics work will continue with a multiyear effort to include a rotor wake model with the three-dimensional transonic code. A fast optimization routine will be developed and installed at the helicopter companies. Off-blade pressure distributions will be developed for use in high speed noise calculations. Navier-Stokes solutions of two-dimensional, unsteady stall will be tried. Experimental testing in the Ames Research Center 2 X 2-foot transonic wind tunnel will be continued on a variety of airfoils including circulation control airfoils in a cooperative effort with the United States Navy. Analysis of bladevortex interaction will continue with the modeling of noise effects.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
High speed research and technology.....	20,600	20,700	26,000	27,000

OBJECTIVES AND STATUS:

The objective of the high speed research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high speed aircraft and missiles, including powered-lift aircraft with vertical or short takeoff and landing capabilities (V/STOL), supersonic cruise and maneuver aircraft with conventional or short takeoff and landing (C/STOL) characteristics and hypersonic cruise aircraft.

In the area of high speed powered lift research and technology, emphasis continues on analytical and experimental efforts to achieve improved lift/thrust performance and vehicle control for vertical/short takeoff and landing aircraft, particularly for shipboard operations. Configuration studies and supporting research are concentrated on new concepts of integrating aerodynamics and propulsion to achieve more competitive high speed characteristics with satisfactory low speed flight performance and handling qualities in poor weather conditions. In flight dynamics, extensive analysis, simulations, wind tunnel tests, and free-flight model tests are being performed on new fighter aircraft concepts, such as the three-surface configuration, to achieve improved high angle-of-attack and stall/spin flight characteristics. In the aerodynamics and propulsion integration area, cooperative efforts with industry on high performance military supersonic airplane design concepts are being pursued in a combined analytical/experimental program. During the last year, the first hot engine altitude chamber tests of a two-dimensional convergent-divergent low-aspect-ratio exhaust nozzle were accomplished and the preliminary conceptual design of high-aspect-ratio exhaust nozzles was initiated.

High speed aircraft controls technology studies have been initiated to determine the best system architecture for highly integrated airframe and propulsion controls applicable to future high performance aircraft having very strong and significant airframe/propulsion interactions. These studies will also assess the applicability of advanced hardware elements and concepts to future integrated control systems.

Following termination of the supersonic cruise research systems technology program, the high speed aircraft structures effort was directed at the analysis of flight test data for both the longitudinal and lateral dynamic response modes of the flexible body of the B-1 aircraft at supersonic speeds. In addition, the work in supersonic aerodynamics, configurations and integration included wind tunnel model tests of advanced high speed aircraft designs; simulation studies of handling qualities and advanced flight procedures for large high speed aircraft; construction of a supersonic variable diameter centerbody inlet; and advanced nozzle integration tests in the transonic speed regime. Work continued in hypersonic airbreathing vehicle research to evaluate turbojet/ramjet integration concepts including wind tunnel tests of hypersonic vehicle concepts of off-design conditions, and development of aerodynamic prediction and performance codes.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $5.3 million reflects two changes. The powered lift research and technology activity and its associated $3.5 million was transferred from low speed aircraft research and technology to this budget category. The termination of the supersonic cruise research systems technology program resulted in a rebalancing of the FY 1982 aeronautics program with $1.8 million added to this budget category for continuing fundamental research in this area.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, the powered lift research and technology effort will concentrate on the development and verification of analytical prediction methods essential to the future development of efficient and effective military V/STOL aircraft. The results of extensive large- and small-scale wind tunnel model tests on the promising tilt-nacelle Navy configuration performed in FY 1981 and FY 1982 will be collated and correlated with theoretical predictions. Experimental activities will be extended to encompass the combination of the ejector thrust deflector and swept forward wing concepts potentially applicable to satisfying the performance requirements of V/STOL fighters.

The flight dynamics effort will emphasize three areas of fundamental concern to tactical military aircraft: basic analyses of nonlinear high angle-of-attack flight characteristics, stall/spin behavior, and improved high altitude, low speed combat maneuverability. Piloted simulation studies will be extended to investigate in more detail the best concepts for integrating thrust vectoring with aerodynamic controls and for utilizing thrust vectoring throughout the complete flight envelope. Wind tunnel tests will supply the static and dynamic data needed for the simulation studies.

In **FY 1983,** the aerodynamics and propulsion integration activites will concentrate on research for short-takeoff-and-landing, stealth, and supersonic persistence capability for future tactical military airplanes and advanced high speed concepts for future missiles. Supersonic aerodynamic analysis methods will be extended to include combined linear/nonlinear conical solutions and will be applied to promising unconventional configurations. Extensive nonaxisymmetric vectoring exhaust nozzle testing on afterburning engines in an altitude chamber and selected high speed wind tunnel testing of advanced fighter concepts will be performed to verify prediction methods and help establish a valid data base.

The high speed aircraft controls research effort in **FY 1983** will transition from the current studies activities to initial experimental research in ground facilities to validate advanced integrated airframelpropulsion control system architecture concepts. Emphasis will continue on potential applications for future military aircraft concepts having strong airframe/propulsion dynamic coupling and will address key systems reliability factors.

High temperature structures technology will be directed to high temperature, low conductivity titanium structural/fabrication concepts applicable to high speed cruise aircraft configurations.

The area of supersonic aerodynamics, configurations, and integration will address advanced multibody configuration concepts for supersonic cruise and high speed fighters; initiation of tests on the variable diameter centerbody inlet; completion of tests and analysis of the nozzle-wing supersonic flow field interactions; continuation of the handling quality/advanced procedures simulation; and fabrication of a supersonic fan.

Hypersonic cruise aircraft research activities will continue to be directed at the complex vehicle/propulsion system integration problems; advanced inlet and nozzle concepts; and unconventional passively-cooled structural integration for advanced aircraft and missile application.

Propulsion technology will address the performance/integration problems of advanced variable cycle engines in high performance airplanes including future supersonic cruise and maneuver and supersonic VTOL fighter aircraft configurations.

In **FY 1983,** the interagency and industrial assistance and testing effort will use the technical expertise, computational facilities, wind tunnels, simulators and specialized test aircraft at all NASA aeronautics research centers to directly support Department of Defense agencies and the airplane/missile industry. This development and advanced research assistance program will respond directly to specific requests and will involve a wide range of military airplane and missile developments.

Support operations activities will concentrate on high speed wind tunnels. The transonic and supersonic wind tunnel operations in FY 1983 will generate extensive experimental data for a range of vehicle configurations and classes with emphasis on high performance military aircraft.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Transport research and technology.....	7,100	8,700	8,100	---

OBJECTIVES AND STATUS:

The objectives of the transport research and technology program have been to provide a broad base of safety oriented technology and to enhance the data base in transport propulsionairframe integration. The safety research emphasized the understanding of aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment. The safety research program had been organized into three major categories: aviation meterology, aviation operations safety technology, and aircraft systems operating efficiency improvement.

In meteorological research, significant progress continues to be made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented F-106 research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds, and turbulence. The test results will provide a basis for establishing design and lightning protection criteria for advanced digital avionics systems and nonmetallic structures. This unique, high quality data is being provided to industry and the Federal Aviation Administration (FAA) for use in design and standards establishment, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research continues in the development of a computer code for the prediction of severe storms. In-flight remote sensing of hazardous clear air turbulence continues based on microwave radiometer technology. The expanded icing research and technology requirements were developed from a cross section of the aviation community and the FAA. Analytical methods were initated for predicting ice accumulation and associated aerodynamic penalties. Ice protection systems for modern airfoils were evaluated using fluids, icephobics, and advanced pneumatic boots. In-flight icing research was initiated to correlate wind tunnel and analytical prediction research. Several cooperative icing research agreements were finalized with the

Department of Defense and FAA. Flight research was initiated to measure the aircraft wing span-wize structural loadings due to atmospheric turbulence. An FAA, NASA, National Science Foundation (NSF) cooperative research program was initiated to accurately quantify real time hazards of low level wind shear and turbulence. The results of the cooperative meteorology hazards research will also be used in advanced pilot training simulators to reinforce pilot awareness and improve procedures.

Advances were made to increase occupant survivability in post-crash fires by breaking the fire chain through the use of safety fuel, antimisting kerosene, and fire resistant aircraft seat cushions, interior wall panels and fuselage windows. Advanced technology materials continue to be demonstrated in full-scale fuselage fire tests and evaluations of antimisting kerosene in jet engines using FAA, NASA and industry facilities.

The in-flight airframe operation measurement effort which utilizes digital data from widebody aircraft continues. It was expanded to cover ground operations to define the performance of landing gear system components during actual operating conditions. Advanced technology landing gear, anti-skid brake systems, and tires will evolve from this knowledge.

In landing gear systems research, analytical tire modeling and a taxiing tire thermal study were verified. Research was initiated on tire and wheel failures and their consequences on aircraft control and loads transmitted to the landing gear. Based on initial successes of active control landing gear research to reduce structural loading and improve ride qualities, cooperative research was completed with the military to test this concept on fighter aircraft. The results of the brake dynamic studies were incorporated into antiskid braking simulations. Expansion began on the loads test track facility to match the aircraft speed and landing systems loads of current and future aircraft weights and speeds.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The $600,000 reduction primarily reflects a reduction in scope in the analyses of transport aircraft recorder data.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, reduced elements of the transport aircraft safety program applicable to generic research will be carried out under the materials and structures and the aircraft controls and guidance research and technology base programs.

BASIS OF PY 1983 FUNDING REQUIREMENTS::

SYSTEMS TECHNOLOGY PROGRAMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Aeronautical systems studies.....	3,125	3,800	---	---	RD 9-30
Materials and structures systems technology.....	8,715	7,100	6,600	---	RD 9-31
Propulsion systems technology.....	4,400	3,000	500	---	RD 9-32
Avionics and flight control systems technology.....	1,200	1,300	1,300	---	RD 9-33
General aviation systems technology.. ...	1,045	---	---	---	---
Low speed aircraft systems technology...	23,511	30,900	25,600	30,000	RD 9-33
High speed aircraft systems technology..	16,615	7,700	7,700	20,000	RD 9-36
Transport aircraft systems technology...	32,746	27.400	13,400	---	RD 9-38
Advanced propulsion systems technology..	46,196	25,800	15,400	---	RD 9-40
Total.....	137,553	107,000	70,500	50,000	

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Aeronautical systems studies.....	3,125	3,800	---	---

OBJECTIVES AND STATUS:

Aeronautical systems studies have been conducted as a means of identifying the need for, and assessing the impact of, technology advances. The objectives of aeronautical systems studies were to determine the feasibilities, technology requirements, costs, benefits, and impacts of advanced civil and military aeronautical systems through mission, system, and conceptual design studies. The studies assessed the integrated effects of advances in the several technology disciplines and a wide range of related factors.

Significant recent results include an update of the analysis evaluating the fuel savings benefits of aircraft energy efficiency advances, an evaluation of alternative general aviation/commuter configuration approaches incorporating advanced propeller technology, and initial preliminary studies on the application of supersonic cruise technology to advanced fighter aircraft. The benefits of electromechanical systems in the design of large transport aircraft have also been assessed.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction from $3.8 million to zero reflects a decision to eliminate aeronautical systems studies as an independent line item. FY 1982 studies will be conducted at reduced levels within the associated research and technology base or systems technology programs.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, such system studies as may be required will be performed within the research and technology base or systems technology programs which they support.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology.....	8,715	7,100	6,600	---

OBJECTIVES AND STATUS:

The objective of the materials and structures systems technology program is to concentrate research effort in the structures and materials technology areas which have high payoff for application in the design of future aircraft and engine systems.

The integrated program for aerospace vehicle design will achieve a major program milestone in FY 1982 with the release of an engineering data management software for evaluation by industry and NASA.

The objective of the turbine engine hot section activity is to provide the technology base for improved life of hot section components of advanced turbine aircraft engines. Major tasks are to develop analytical and design methods which will enhance hot section component durability. These methods will provide environment definition, thermal and mechanical load prediction, structural analysis, and local response and failure mode characterization. Combined use of these methods will increase the capability for hot section component life prediction. This systems technology program is an outgrowth of past basic research and fundamental technology development, such as combustor and turbine blade durability analyses and laboratory experiments.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The $.5 million decrease reflects an internal realignment of emphasis within the materials and structures systems technology activity. The turbine engine hot section technology effort was increased to include critical engine resources research (+$1.0 million), and the integrated program for aerospace vehicle design and the aeroelasticity of turbine engines efforts were decreased in emphasis $1.3 and $.2 million, respectively.

BASIS OF PY 1983 ESTIMATE:

In FY 1983, the integrated program for aerospace vehicle design and aeroelasticity of turbine engine program will be discontinued. Due to the close association of turbine engine hot section technology to high speed aircraft performance, this program will be transferred as a line item to high speed aircraft systems technology.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Propulsion systems technology.....	*4,400*	3,000	500	---

OBJECTIVES AND STATUS:

The objective of the propulsion systems technology program has been to provide focused systems research to achieve improved performance, fuel efficiency, reliability and durability; fuel flexibility; and, reduced environmental impact for advanced propulsion systems applicable to a broad range of vehicle systems.

The helicopter transmission system technology effort is addressing key technology requirements to improve the life and reliability and reduce the size, weight, and noise of transmissions for military and commercial helicopters through the application of advanced concepts, analytical techniques, and other technology advances stemming from research and technology base efforts. Initial testing and analysis of the hybrid traction drive transmissions have been completed. Testing of an advanced technology conventional gear transmission is progressing.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The $2.5 million reduction reflects: (1) the deletion of the broad property fuels systems technology program and the transfer of these funds to the research and technology base propulsion discipline to support critical aircraft resources technology and completions of the broad property fuels effort; and, (2) a phase down of the helicopter transmission technology activity which will be terminated during FY 1982.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, funding for support of helicopter transmission technology has been deleted.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Avionics and flight controls systems technology.....	1,200	1,300	1,300	---

OBJECTIVES AND STATUS:

The objectives of the avionics and flight controls systems technology program have been to apply fundamental knowledge gained in the research and technology base, to demonstrate technology readiness, and to promote the transfer of advanced systems techniques to the aircraft industry through experimental testing and verification in a realistic environment. Techniques for protecting redundant flight control systems from generic software faults have been evaluated. These concepts have been coupled with experimental "fault-free" computer designs to provide candidate system architectures for fault-tolerant active control systems. Laboratory analysis and testing of these configurations are being initiated. Development of simulation techniques as a flight control system validation process is continuing.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, reduced elements of the advanced guidance and controls program applicable to generic research will be carried out under aircraft controls and guidance research and technology in the research and technology base program.

Low speed aircraft systems technology...	23,511	30,900	25,600	30,000

OBJECTIVES AND STATUS:

The objective of the low speed aircraft systems technology program is to provide ground-based and flight research on integrated systems which hold promise for future civil and military rotorcraft and short takeoff and landing concepts. The program covers the broad technology areas of: configuration aerodynamics; propulsion; integrated flight systems, including controls and guidance; and, structural systems, including advanced materials applications, aeroelasticity, vibration and acoustics. The experimental ground-based and flight testing is closely coupled with collocated Army laboratory

efforts and complements the research and technology base program activities. Specific objectives include: improvement of the rotorcraft operational capability in instrument meteorological conditions; technology advancements for self-contained, low cost, low complexity guidance systems for all-weather operations to remote sites; validation of simulations and wind tunnel tests; and development of a wind tunnel data base in aeroacoustics, vibration, performance and rotor stability and determination of the initial feasibility of high risk rotor design approaches. Other objectives are the assessment and documentation of quiet propulsive lift concepts and the feasibility and merits of the tilt rotor concept, and the enhancement of propulsion system durability, reliability, and efficiency through advanced fabrication suited to rotorcraft applications.

During FY 1981, the low speed systems technology program accomplishments included a wide variety of activities. The quiet propulsive lift research effort included completion of downwash flow measurements on the quiet short-haul research aircraft (QSRA) and completion of extensive QSRA flight tests to determine the trade-off between take-off distance and payload made possible by the upper-surface-blowing lift augmentation capability which will have important application to improved transport aircraft. Rotorcraft systems technology research progress included completion of airborne radar simulation capability and flight test of automatic tracking and passive ground-link techniques for radar approaches to remote sites and flight tests of a highly instrumented AH-1G helicopter for simultaneous airloads and external noise measurements. Both of the rotor systems research aircraft (RSRA) configurations (helicopter and compound) are now operational, and flight research continues following the completion of the helicopter load measurement systems. Vertical drag was measured in hover and low speed forward flight for the first time using capability of the RSRA. Analysis and documentation of the bearinglcss main rotor, advancing blade concept and X-wing, full-scale, wind tunnel test data were completed. Small-scale tests of innovative rotor concepts were conducted to explore their feasibility. Two XV-15 tilt rotor research aircraft were successfully flown in proof-of-concept flights demonstrating safe flight envelopes at limited weight and center of gravity points. Hover noise flight tests were documented, and demonstration and pilot evaluations were continued including a tilt rotor flight demonstration at the 1981 Paris Air Show. Planning is progressing for the procurement of a modern Army 4-bladed rotor for flight test on the RSRA. A rotor and controller are being procured for higher harmonic control parametric testing at full-scale in the Ames Research Center full-scale facilities complex.

Preparations are underway for flight tests with the Army of a blade deicing boot to determine effects on rotor performance. Preliminary design of test-bed engine modifications to explore the technology options for a convertible engine concept was completed. A large Army transmission (XCH-62) was tested for a 50-hour period to provide the data base for improved spiral bevel gear analytical

methods. A long-term study of helicopter internal noise diagnostics and control was initiated to look at the system aspects of noise generation and transmission. Preparations are underway to conduct a ground shake test to obtain vibration data on an Army CH-47 airframe for correlation with an analytical prediction method which was recently completed.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of **$5.3** million reflects a decision to phase down the powered lift and tilt rotor systems technology activities in FY **1982**, and to stretch out portions of the advanced rotorcraft project.

BASIS OF FY 1983 ESTIMATE:

The rotorcraft operating systems advanced technology activity will continue with emphasis on all-weather rotorcraft capability for instrument flight in remote-site operation. Increased emphasis will be placed on support of the Federal Aviation Administration's helicopter operations research and development program with specific emphasis on instrument flight, icing, and noise technology and certification requirements.

Advanced rotor systems technology will continue with completion of flight tests of the Army/NASA RSRA with the present S-61 rotor. This will be followed by preparation for installation of an existing Army 4-bladed rotor. Calibration of the second RSRA aircraft will be completed. Analysis of higher harmonic control flight test results will be completed and compared with analytical prediction methods. Additional full-scale wind tunnel tests of the bearingless main rotor will be conducted for comparison with predicted performance and aeroelastic stability methods. Small-scale model tests will be conducted to explore the feasibility of incorporating free tips on rotor blades for improved performance and reduced noise.

Other advanced rotorcraft technology efforts will continue including full-scale rotor/fuselage interference tests, fabrication of composite tilt rotor blades for wind tunnel testing, and initiation of small-scale tests of advanced research rotor configurations in a joint effort with the Army. In the area of vibration, full-scale wind tunnel tests of higher harmonic control concepts will be conducted to establish a parametric data base for the design of future systems. Dynamic calibration of the RSRA load measurement systems will be initiated to provide a capability to measure vibratory hub loads in addition to the static loads capability. Documentation of the deicing boot installation performance will be completed. Human factors research specific to rotorcraft will be conducted

addressing the influence of display systems on military pilot workload. An evaluation will be conducted of the needs and performance of zero-zero meteorological conditions operation of externally slung cargo loads in a simulation effort. An effort to assess the trade-offs of a blade radar installation for remote-site, allweather operations will be initiated.

The development and validation of the finite-element analytical methodology for large spiral bevel gears will be completed. Convertible engine test hardware modifications will be fabricated and assembled, and steady-state testing will be initiated.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
High speed aircraft systems technology..... ...	16,615	7,700	7,700	20,000

OBJECTIVES AND STATUS:

The objective of the high speed aircraft systems technology program is to generate validated engineering and design data applicable to the development of advanced high performance, high speed aircraft for military and civil applications. The program objective is accomplished by analyses, ground-based simulations, and wind tunnel experimental research and flight research tests.

During the past year, the high performance flight research program effort included the successful validation of a NASA-conceived aileron-to-rudder interconnect control system on an F-14 aircraft as part of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Major progress was made on two elements of the joint NASA/Air Force advanced fighter technology integration project involving integrated fire/flight controls in an F-16 aircraft and a mission adaptive wing on a F-111 aircraft.

Both highly maneuverable aircraft technology vehicles were successfully flown during the past year. Flight test data have been acquired in areas of stability and controls, structures, flutter, and propulsion. In FY 1982, the vehicles will be flown to acquire flight environmental experiment data on the aeroelastically tailored graphite composite wing/canard structure at design conditions. Both vehicles will be used to complete the flight assessment of the aerodynamic performance and the

stability and control of the closely coupled wing/canard design configuration. Tests will include flight maneuvers at different altitudes and speeds with reduced and negative static stability to assess the vehicle performance.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding level reflects an increased emphasis on high performance flight research in support of defense-oriented research and development. The high performance flight research activity in FY 1983 will involve a variety of high performance aircraft to investigate advanced concepts. Two joint NASA/Air Force projects will enter the flight test phase during this period. The advanced fighter technology integration F-111 aircraft will investigate the performance of the variable camber mission adaptive wing. Advanced fighter technology integration/F-16 aircraft will evaluate an advanced digital flight control system and an advanced fire control system. Both advanced fighter technology integration flight test activities will be performed by the joint NASA/Air Force test teams.

In FY 1983, the joint NASA/Defense Advanced Research Projects Agency X-29A forward swept wing flight demonstration program will be undergoing extensive wind tunnel tests, computational analysis, and ground tests in preparation for the flight test in FY 1984. In FY 1983, the highly maneuverable aircraft technology flight test program will be completed and data will be reduced, analyzed, and reported, at which time the program is scheduled for completion.

In FY 1983 flight research operations support will include chase operations, airspeed calibration pacer flights, remotely piloted research vehicle air drops, and crew flight-readiness operations.

Commencing with FY 1983, the turbine engine hot section program will be transfered from materials and structures systems technology to high speed systems technology. During FY 1983, the emphasis of the turbine engine hot section activity will be on defining the turbine environment through the conduct of "benchmark" component simulation tests and the development of associated instrumentation. In these tests, relatively simple hardware elements containing stress concentrations will be subjected to high temperature, low cycle, creep fatigue conditions. Simultaneously, analytical solutions for stresses and strains of the stress discontinuity will be obtained from available three-dimensional, finite-element, elasto-plastic computer programs. Direct measurements of the local strains in the high temperature testing activity will provide the desired check on the ability of the structural analysis to accurately calculate the stress/strain conditions and provide insight for future improvements that may be needed. In addition to the "benchmark" tests, a broad range of component simulation

tests will be designed and conducted for defining static and cyclic thermal and mechanical loadings, the materials and structural responses, as well as failure locations, modes, and lifetimes for combustor liners, turbine vanes, blades, and disks, gas path seals, and static structures. These simulations will provide documentation test conditions and durability data for use in model formulation and subsequent predictive methods evaluation. Research on high temperature materials will emphasize the physical effects of alloying constituents on material behavior.

High speed system studies will address military applications of supersonic cruise technology. The ongoing studies of the potential for supersonic persistence of tactical military aircraft using advanced technology will be extended to assess overall effectiveness of the systems for various tactical and strategic mission scenarios.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Transport aircraft systems technology...	32,746	27,400	13,400	---

OBJECTIVES AND STATUS:

The objective of the transport aircraft systems technology program has been to develop and demonstrate, in a realistic environment, advanced subsonic transport aircraft technology for enhancing aircraft energy efficiency and providing operational compatibility with the future National Airspace System.

The laminar flow control program has entered the fabrication phase to provide verification of promising structural concepts, operational experience with leading edge systems, and suitability of advanced airfoils for laminar flow control. New materials methodology and manufacturing techniques are being utilized to develop and demonstrate a practical, reliable, maintainable laminar flow control system for future transport aircraft and to convince the air transport industry that laminar flow control technology is ready €or exploitation in 1990's transports for significant fuel economy.

The energy efficient transport activity has included the evaluation and development of advanced aerodynamics, propulsion/airframe integration, and active controls technology for both near-term and future application to civil and military transport aircraft. In FY 1982, in-house activities are focused on active control system definition and component development. Fabrication and assembly of

the high-aspect-ratio aeroelastic research wing will continue through FY 1982. Evaluation of engineering models of fault-tolerant computer concepts will continue in FY 1982. Also continuing in FY 1982 is in-house research focused on the integration of engine nacelle configurations (emerging from the advanced engine programs) with advanced high-aspect-ratio supercritical wings to obtain the maximum benefit from these technologies. Major contract activities with Boeing, Douglas, and Lockheed have involved the evaluation of selected near-term concepts for increasing fuel efficiency. In FY 1982, emphasis will continue on the integrated application of active controls and relaxed static stability to the design of energy efficient transports.

Advanced composite airframe components can reduce weight by 20-25 percent and can reduce manufacturing costs. The composite primary aircraft structures efforts are developing composites technology to permit future transport aircraft to safely and economically attain predicted weight and cost benefits in secondary and medium primary structures. The approach has been to design, fabricate, and certificate six representative composite components. All three secondary structure components have been certificated by the Federal Aviation Administration and, in FY 1982, twenty-two sets of these components will be in flight service. These programs were a major influence on the Boeing 767 transport aircraft now flying with over 3,000 pounds of composite secondary structures. Certification of the Boeing 737 composite horizontal stabilizer first flight in September 1981 has been delayed until April 1982 to resolve questions on environmental effects, birdstrike problems, and an early failure in damage tolerance tests. The Lockheed L-1011 composite vertical fin, which failed at 98 percent of ultimate load in ground tests, will be repaired and testing continued in FY 1982.

The Douglas DC-10 vertical stabilizer has just begun structural tests, and a flight checkout is planned for March 1982. Key technology programs for fuel containment, critical joints, durability, and damage tolerance for large primary structures are continuing in FY 1982 with design work and small element tests.

The composite primary aircraft structures program will complete all ground tests to meet certification requirements in FY 1982 on medium primary structures. The 737 horizontal and the DC-10 vertical stabilizers will begin flight service evaluation. The L-1011 fin will complete certification tests in FY 1982. Programs focused on critical design technology will be phased down during FY 1982.

The terminal configured vehicle program is an intensive research and technology activity to define functional requirements and performance criteria for flight systems and displays of the future with which the pilot can safely and effectively integrate with an advanced air traffic system environment. Research is being conducted in performing more efficient flight with respect to fuel, airspace,

and time; increasing traffic flow capacity; improving the operational capability in adverse weather; and reducing noise impact on the ground.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

A total net reduction of $14.0 million has been made to this program area during FY 1982 as follows: $.5 million was added to the composite primary aircraft structures program to enhance composite structures activities; the laminar flow program was reduced by $2.5 million; the energy efficient transport program has been reduced by $5.4 million; and the terminal configured vehicle program was reduced by $6.6 million. The reductions in these three program areas reflect the planned phaseout of these activities during FY 1982.

BASIS OF FY 1983 ESTIMATE:

All elements of the transport aircraft systems technology program are being terminated.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology..	46,196	25,800	15,400	---

OBJECTIVES AND STATUS:

The objectives of the advanced propulsion systems technology program are to achieve improved performance and lower fuel consumption and to reduce noise and emissions from future aircraft engines through the integration of improved propulsion components.

The component development and integration phase of the energy efficient engine program continues. Full-scale component rig testing is nearing completion. Tests have been completed on the exhaust gas mixers and the combustor sector rigs at both contractors: the 23:1 pressure ratio compressor, the low pressure turbine and the fan at General Electric; and the 14:1 pressure ratio compressor at Pratt & Whitney. The performance demonstrated in each of the component tests has met or exceeded pretest goals, indicating the high probability of achieving the overall program goals. In FY 1982, the

remaining component tests will be completed at both contractors, and the gas generator core test initiated at General Electric.

The advanced turboprop program continues to hold promise of 15–20 percent fuel savings at Mach 0.7–0.8 cruise speed. Initial subscale propeller (prop–fan) model tests have verified potential efficiency of 80 percent at Mach 0.8. Measurements of noise generation and attenuation have confirmed analytical predictions in small–scale experiments. Installation aerodynamics wind tunnel investigations are underway, exploring the drag reduction potential of wing and nacelle contouring. Design studies of largescale propfans, inlets and turboshaft engines are underway. Studies of testbed aircraft and drive–engine options will be completed in FY 1982.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

The $10.4 million decrease reflects the descoping of the energy efficient engine program funding which was decreased by $7.9 million and the advanced turboprop funding which was reduced by $2.5 million. The reductions in these two program areas reflect the phaseout of these activities during FY 1982.

BASIS OF PY 1983 ESTIMATE:

All advanced propulsion systems technology activity in this area has been deleted.

SPACE
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **SPACE RESEARCH AND TECHNOLOGY PROGRAM**

SUMMARY OF RESOURCES REOUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base	100.380	115.300	105.200	115.600	RD 10-4
Systems technology programs	8.220	7.000	2.800	4.400	RD 10-25
Standards and practices	2.100	3.000	3.000	3.000	RD 10-28
Total	110.700	125.300	111.000	123.000	
Distribution of Program Amount by Installation:					
Johnson Space Center	7.600	8.400	8.000	9.700	
Marshall Space Flight Center	9.450	10.100	9.500	14.400	
Goddard Space Flight Center	8.900	9.600	9.000	10.600	
Jet Propulsion Laboratory	19.600	23.000	20.000	23.000	
Ames Research Center	10.150	11,700	10.250	10.700	
Langley Research Center	27.200	32.600	28.000	28.300	
Lewis Research Center	24.900	26.000	23.550	22.100	
Headquarters	2.900	3.900	2.700	4.200	
Total	110.700	125.300	111.000	123.000	

OFFICE OF AERONAUTICS AND SPACE TECENOLOGY **SPACE RESEARCH AND TECHNOLOGY**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Research and Technology program is to provide the technology base upon which all future national space activities depend. This advanced technology has direct applications to both current and future space .missions and, in large part, provides technology options which will enable missions that will not otherwise be possible.

It is not difficult to quantify the value of investment in advanced space research and technology. Without prior advancements in technology, the United States would not occupy its present position of leadership in the space arena. The future maintenance of this position depends on the achievement of the objectives of this program. The FY **1983** program continues to pursue these objectives by stressing those technology areas judged to be most critical by external advisory groups, by in-house program assessment, and by the future users of the technology. Emphasis will be placed on advancements in disciplinary technologies required for the enhancement of planned missions and the enabling of future missions which are beyond current capabilities.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of *$14.3* million reflects this program's portion of the directed agencywide FY **1982** reduction. Of the total reduction, **$10.1** million was absorbed by decreasing research and technology activites across the spectrum of research and technology base disciplines and programs. The balance of the reduction was implemented by reducing systems technology efforts by *$4.2* million. Details of program reductions and realignments follow in the program narratives.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, activities will focus on maintaining a strong research and technology base in the disciplinary areas of aerothermodynamics, chemical propulsion, materials and structures, electronics and automation, and space power and electric propulsion. These are the only NASA advanced research and technology programs designed to support and extend these critical aerospace disciplines.

Activities in information, spacecraft, and transportation systems research and technology are designed to study the interrelationships of discipline technology from an integrated systems point of view, and are critical to the successful transition of technology from the laboratory to useful application. In addition, systems-level studies conducted within the research and technology base will continue to focus the discipline and system research and technology activities in directions which will lead to maximum benefits from available resources. Finally, systems technology programs involving the extension of ground-based research and technology activities to space using Shuttle, Spacelab, and free-flying vehicles will be continued. During FY 1983, a number of space technology experiments will be performed aboard the Shuttle/Spacelab.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

KESEARCH AND TECHNOLOGY BASE

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Aerothermodynamics research and technology	7,800	8,700	7,900	8,800	RD 10-4
Chemical propulsion research and technology	12,400	14,500	13,700	15,500	RD 10-7
Materials and structures research and technology	14,000	15,500	14,100	15,100	RD 10-9
Electronics and automation research and technology	7,700	9,000	8,100	9,500	RD 10-11
Space power and electric propulsion research and technology	18,900	21,000	18,500	20,000	RD 10-14
Multidisciplinary research	2,680	3,700	2,700	3,500	RD 10-15
Information systems research and technology	21,100	24,400	22,900	24,000	RD 10-16
Spacecraft systems research and technology	8,900	10,300	9,100	10,400	RD 10-19
Transportation systems research and technology	6,900	8,200	8,200	8,800	RD 10-21
Total	100,380	115,300	105,200	115,600	
Aerothermodynamics research and technology	7,800	8,700	7,900	8,800	

OBJECTI AND STATUS:

The objective of this effort is to expan the understanding or the aerothermodynamics, gas dynamics, and flight mechanics associated with atmospheric entry and atmospheric maneuvers of aerospace vehicles

designed for Earth orbital and planetary missions. Knowledge, developed through both analytical and experimental investigations of phenomena in the viscous to noncontinuum flow regimes, is applied to the improvement of the safety, economy, reliability, and efficiency of such vehicles. The experimental investigations make maximum use of the Shuttle, which provides a unique opportunity both on the orbiter and through the orbiter experiments, to perform aerothermodynamic research in the true reentry environment.

In the area of vehicle aerothermodynamics, the technology base for potential configuration concepts from single-stage to orbit to orbital transfer vehicles is being expanded by experimental and analytical investigations of aerodynamics performance and flow field phenomena, including real-gas effects, viscous interactions, heat transfer, etc. Technology assessment studies have indicated that the payload capability of reusable transfer vehicles to geosynchronous orbit can be substantially increased by employing the technique of aero-assisted, rather than propulsive, maneuvering to return to low Earth orbit. Investigations of rarefied flows aid in characterizing the interaction of the flow field phenomena with aero-assisted transfer vehicle concepts.

The focus of entry research is on the development of computational and experimental techniques for analysis and prediction of the fundamental thermodynamic and transport properties of aerothermodynamic environments characteristic of various planetary atmospheres, including Earth, and the interaction of those atmospheres with the vehicle materials and configuration. Aerobraking, which is economically advantageous for some entries, may operate completely in the noncontinuum flow regime, requiring statistical treatment of molecular collision processes at rarefied flow conditions. A direct computer simulation technique is being used to analyze these phenomena and characterize the aerothermodynamic environments.

In the flight data analysis effort, Shuttle orbiter experiments, such as the aerodynamic coefficient identification package, are being conducted on each flight; additional experiments, such as Shuttle infrared leeside temperature sensing and Shuttle upper atmospheric mass spectrometer, will be retrofitted to the current orbiter and flown on STS-9. These experiments provide research-quality data for use in evaluating and improving theoretical and ground-based experimental methods, as well as an increased data base for improving future vehicle designs.

CHANGES FROM PY 1982 BUDGET ESTIMATE:

The reduction of *$800,000* represents this activity's portion of the directed agencywide reduction in the FY 1982 program.

BASIS OF FY 1983 ESTIMATE:

In the area of space vehicle aerothermodynamics and configurations, efforts will continue in improving vehicle performance and reliability and reducing costs for a variety of potential missions. In FY 1983, continued emphasis will be placed on development and verification of theory, advanced computational methods, and computer codes for predicting vehicle flow fields.and performance, development of improved ground-based experimental techniques, instrumentation and simulation capability, provision of advanced vehicle design integration capability, and development of a data base from ground facility and flight investigations for support of future vehicle design.

The entry effort provides the base for characterization of the fundamental aerothermodynamic environments of vehicles entering or re-entering planetary atmospheres, including Earth's atmosphere. This technology base is used in the design, development, and verification of various potential configurations, and provides the flight mechanics data in support of atmospheric reconstruction experiments. In FY 1983, theoretical and experimental efforts will be pursued in the areas of shock-layer radiation, ablation product radiation and absorption, lightly-blown shock-layers, configuration flight mechanics, and mass loss and shape change. In addition, studies of the aerothermodynamics and aerobraking vehicle concepts will be further developed, with emphasis and analytical investigations of rarefied and transitional gas flows. These studies will be pursued to develop a data base to be used to minimize Earth orbital and planetary mission costs, to maximize the scientific returns, and to insure a high probability of mission success.

The flight data analysis effort will use the orbiter experiment flight data to study phenomena, which cannot be simulated in ground facilities, to develop and refine techniques for extrapolating ground facility results to flight conditions, to evaluate and resolve anomalous ground-flight results, and to verify analytical and computational prediction techniques. In FY 1983, development of analytical techniques will continue in preparation for analysis of subsequent orbiter and orbiter experiment flight data.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Chemical propulsion research and technology....	12,400	*14,500*	13,700	15,500

OBJECTIVES AND STATUS:

The objective of the chemical propulsion research and technology program is to develop technology to improve the life, performance, versatility, and reliability of chemical rocket propulsion systems for future space transportation and spacecraft systems. The program involves technology for reusable propulsion for lower cost operations; high performance, variable thrust, and low thrust propulsion for more versatile operations; autonomous propulsion for higher reliability; and, efficient, long-life position control and station keeping propulsion for large space systems.

In FY 1982, work on advance high pressure, oxygen-hydrogen propulsion is being expanded to increase the emphasis on technology advances that will allow the future upgrading of the life and performance of large, high performance propulsion systems including the Space Shuttle main engine. Technology barriers have been identified and programs initiated in appropriate areas. Work on advanced orbital transfer propulsion has been directed toward high performance, variable thrust engines which offer greater versatility in operating between low Earth orbit and geosynchronous orbit. Conceptual design studies were initiated to evaluate feasibility and to identify critical technologies. Significant technical activities in FY 1982 include demonstrating regenerative cooling of high pressure rocket combustors using liquid oxygen as the coolant as opposed to the currently used hydrogen or hydrocarbon fuel, and experimentally determining heat transfer rates generated by highly efficient, high pressure oxygen-hydrocarbon combustors. In addition, small hybrid bearings which had previously demonstrated long life under steady-state operating conditions in liquid hydrogen, are being successfully operated over a wide range of simulated start/stop transients. Finally, the higher performance of solid propellant formulations derived by blending high energy oxidizers is being demonstrated in experimental motor firings.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $800,000 represents the chemical propulsion portion of the directed agencywide reduction to the FY 1982 program and realignment of management responsibilities in the space research

and technology program. The funding and management responsibility for in-space cryogenic fluid management technology was transferred to the transportation systems research and technology program and represents $500,000 of this $800,000 reduction.

BASIS OF FY 1983 ESTIMATE:

An expanded effort in advanced high pressure, oxygen-hydrogen engines is directed towards developing a better understanding of component operating environments and, through analysis and experimentation, establishing the capability of designing for long life and repeated use. Improved modeling in the areas of bearing and seal design, rotor dynamics, structural dynamics, combustion, ignition, and fluid and gas dynamics will enhance future design capability for critical life-limiting components. Advanced nonintrusive sensor designs will be explored that could provide in-place engine diagnostic and automated inspections and checkout capability. A comprehensive effort in materials development and evaluation, as well as advanced fabrication and manufacturing techniques, support this technology area.

Research and technology for reusable, high performance oxygen-hydrocarbon propulsion will continue to focus on fundamental work in the areas of combustion, stability, heat transfer and cooling for both primary and auxiliary propulsion systems. Experimental research will be used to upgrade our analytical modeling capability to much higher combustion pressures and provide the basis for optimizing engine designs for performance, life, reliability, and maintainability.

Work on orbital transfer propulsion will encompass critical component technology for variable thrust engines identified in ongoing conceptual design studies. Highly efficient turbomachinery and combustor operation over a very wide range of flow conditions are examples of technologies that need attention. In low thrust propulsion, efforts will continue toward characterizing small combustor performance, cooling and life, and in demonstrating efficient hydrodynamic operation of very small pumps. This technology will provide the basis for propulsion system selection for a broad range of orbital transfer missions.

Autonomous propulsion research and technology will continue to focus on sensors and sensing techniques that will be capable of detecting off-design operation and incipient failures. This information will be relayed to an engine controller that, in turn, will be capable of taking instantaneous corrective actions to maintain acceptable system performance and operations actions which would be impossible to take from the ground due to communication lag times.

Earth-orbiting large space systems will require onboard propulsion systems capable of maintaining precise position control as well as performing other functions such as drag makeup and station-keeping. Studies are being conducted to identify candidate chemical propulsion systems for this application and critical technologies that need to be addressed. Research and technology will be conducted in FY 1983 in the identified critical areas.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Materials and structures research and technology	14,000	15,500	14,100	15,100

OBJECTIVES AND STATUS:

This activity will develop the technology in advanced materials and structures for improving the performance, efficiency, durability and economy required for large area space structures for antennas and platforms, advanced space power generation, advanced space transportation systems, orbiting spacecraft, planetary probes, and payloads. Areas of emphasis include: (1) basic understanding of material science, including advanced metallics and intermetallics, long duration environmental effects of space, tribology, computational chemistry and surface physics, and bearings, lubricants, and seals technology; (2) development of composites, including both polymeric and metal matrices and the identification of environmental effects and damage mechanisms; (3) development of metallic and nonmetallic thermal protection systems; (4) definition of loads, dynamics and aeroelasticity of aerospace vehicles, payloads and spacecraft systems; and, (5) development of advanced structural concepts, integrated analysis, and synthesis techniques for design and qualification procedures involved in new systems with operational requirements well beyond the current state of technology.

A major research effort is being directed at determining the durability of polymeric materials in space, including structural composites, thermal control coatings, films, adhesives, and seals. The current emphasis is on identification of damage mechanisms and the development of methodology for accelerated tests to be able to predict long-term performance. Basic research in the fundamentals of tribology (friction and wear) of bearing systems and long-life space environment lubricants and seals continues to provide the technology for advances for future space transportation systems. Research on new ceramic fibers and coatings for advanced thermal protection remains a major thrust in this space

activity. A ceramic tile exhibiting improved toughness and higher temperature characteristics has been demonstrated. The new fibrous refractory composite insulation developed in this program will be used on the next Shuttle orbiter, as well as a lightweight blanket-type insulation with greater durability than the existing system. In FY **1982,** the instrumentation on STS-2 obtained detailed temperature distributions over a tile surface and the gaps between tiles. The measured data will be used to validate new thermal analysis methods under development. A new, more efficient algorithm €or nonlinear analysis and synthesis for dynamic and thermal response was derived and verified against existing solutions. Research on stability and control, integrated thermal-structural analysis, and structural design optimization are continuing for advanced space transportation systems, payloads, large space structures, and spacecraft. Initial analysis methods for damping of space structures were verified by test in FY **1981.** Erectable and deployable platform configuration concepts have been developed, and a ground test program to verify deployment dynamics and assembly techniques is in progress.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of **$1.4** million represents this activity's portion of the directed agencywide reduction to the FY **1982** program. This results in reductions of effort in materials science, thermal protection systems, lightweight materials for space station applications, and analysis techniques.

BASIS OF FY 1983 ESTIMATE:

Basic research activities in FY **1983** will include pulsed radiolysis and determination of reaction rate kinetics to develop a radiation interaction model and investigation of optical reflectance and dielectric property changes as a consequence of radiation damage to chemical structures. Increased attention will be focused on identifying/developing structural materials that fulfill dimensional stability requirements of large space antennas and space stations. Aluminum matrix composites will be evaluated for feasibility as a lightweight, thermal, conductive, structural material for spacecraft. Enhanced properties, made possible with new fibers such as aluminum, silicon carbide, and graphite, will also be explored. Stable high temperature liquid and solid lubricants will be studied. Studies will be accelerated to examine the characteristics of intermetallic aluminides for applications such as advanced turbopumps for the Shuttle main engine. Although such aluminides are presently very brittle materials, research is directed toward solutions to that problem to allow significant performance improvements. Thermal protection concepts and materials will continue to be evaluated for the protection of reentry vehicles. In addition to ongoing work in advanced metallic and ceramic materials, this activity will be expanded to include advanced carbon-carbon composites. A better

understanding of fundamental material surface behavior through the application of computational chemistry will continue to be a thrust in the program.

In FY 1983, research on truss structural concepts for deployable and erectable space systems and the indentification of design and qualification procedures required to meet possible future mission requirements will be emphasized. Simultaneous and sequential deployment concepts will be evaluated for potential application to platform configurations. In the area of integrated analysis and synthesis methods, emphasis will be on improved thermostructural modeling and analysis methods to include thermal radiation and convection effects on structural response.

Research will continue on: (1) nonlinear behavior due to large deformations and nonisotropic composite material application; (2) fatigue life of advanced metallic and composite materials; (3) structural controls; (4) dynamic interactions; and, (5) integrated thermal-structural analysis.

Payload analysis methods will focus on the adaptation of predictive methods to include coupled Shuttle loads and vibroacoustic response. The development of analyses and concepts for control of structural dynamic modes of space systems will emphasize methods to identify vibration modes and active damping control to reduce associated adverse effects.

The high temperature structures effort will continue research on: (1) metallic and advanced carbon-carbon structures for Earth entry vehicles capable of withstanding temperatures of 1500°F or more; (2) metallic multiwall thermal protection systems; and, (3) validated thermal stress prediction methods.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Electronics and automation research and technology.....	7,700	9,000	8,100	9,500

OBJECTIVES AND STATUS:

The electronics and automation program consists of three discipline areas: electronics, automation, and guidance and controls. The objective of the electronics discipline is to advance the technology

employ electronic sensing, detecting, and data processing systems. Areas of emphasis in this discipline include quantum electronics (laser research), signal detection and processing, and solid state research. Advances have been made in perfecting a tunable visible/ultraviolet laser which would be capable of ranging and detecting hydroxyl ions, nitrous oxide, ozone, and sulfur dioxide in the troposphere from an airborne platform for active remote sensing, the latter species being an important constituent of global acid rain. The concept of a fourier electronic transform device has been validated and efforts are underway to implement this technology in silicon for eventual use as a smart star tracker and on a chip image comparator. The microscopic properties of the silicon-silicon dioxide interface, an integral part of integrated electronic circuits, and its role in the space radiation degradation of electronic components is being unraveled. The physics and chemistry of this interface should eventually point to a method to rectify, by fabrication, the radiation susceptibility of these electronic devices.

The objective of the automation activity is to provide the theoretical and technological base needed to increase the productivity and effectiveness of humans, spacecraft, space operations, and facilities. The program is focused on automation technology for: (1) raising the level of autonomy of spacecraft; (2) performing effective in-orbit satellite servicing; (3) improving ground-based mission operations; and, (4) decreasing the overall cost of space transportation. This is accomplished through basic research and adaptation of nonaerospace automation technology to space oriented problems. Basic theories of automated problem solving are being developed to the stage that they can treat realistic space situations. Techniques for automatic experiment sequence generation were recently demonstrated which could be utilized in the Galileo mission in place of the manual logic that was utilized in earlier missions such as Voyager. These and similar techniques are being developed to manage spacecraft subsystems and provide automated fault diagnosis and isolation. A robotics research capability is being built up to provide technology for satellite servicing, and ultimately, for space assembly and construction. This part of the program is currently addressing supervisory control.

The thrust of future spacecraft is toward larger, loosely coupled structural systems which may be highly flexible because of the cost of delivering mass to orbit. Such spacecraft present formidable and as yet unsolved problems in control system design and advanced components. One objective of the space controls program is to develop the design concepts and techniques required to enable precise pointing and control of future spacecraft including space platforms, large antennas, and advanced space transportation systems. Related developments involve innovative guidance and control system components required for higher performance, longer life, and lower life cycle cost. Emphasis continues in distributed control concepts for active shape and vibration control, advanced modeling techniques for control system design, adaptivellearning system development to increase performance and

fault tolerance, and high performance and long life control sensors such as the fiber optics gyro and the three dimensional optical sensor.

CHANGES FROM FP 1982 BUDGET ESTIMATE:

The reduction of *$900,000* is in research on remote sensing and represents this activity's portion of the directed agencywide reduction to the FY 1982 program.

BASIS OF PY 1983 ESTIMATE:

The electronics program will continue to perform research in laser technology concepts, models, and components in order to provide significant advances in the parameters necessary for passive and active remote sensing and optical communication. Emphasis will be on new data processing techniques employing optical and integrated optical technology that will enable new computational capabilities for the control of large space structures from real-time image recognition. Research into new devices grown by a technique called molecular beam epitaxy will enable new solid state devices that will extend detection capability with real-time processing capability.

During FY 1983, the automation effort will be expanded to include those aspects of machine intelligence and robotics needed to increase autonomy of space systems. In particular, automatic sequence generation for orbital missions will be expanded and a systems architecture formulated for autonomous spacecraft and telerobots. Increased emphasis in computer science research and technology will address NASA's unique and broadly based needs in computer technology.

In FY 1983, the controls program will continue development of advanced concepts and techniques required for effective control of flexible space structures. Simulations and experimental investigations will be carried out on decoupling control concepts and adaptive/learning techniques, and extended to applications of these approaches to lightweight, space-like structures. Techniques will be studied and compared for the design of effective control systems for large, highly flexible space structures including multiobjective insensitive designs and reduced order control models. Development will continue on a continuum model for a parabolic dish antenna with a boom support feed. Extensive studies will be conducted and a government, university, and industrywide seminar held on applications to distribute parameter system theory to large space system control. Continued development of analytical techniques for onboard model error estimation will lead to adaptive controller designs. In the advanced component area demonstrations will begin on a version of an all-waveguide, integrated optics, fiber-optic gyro. An advanced three-dimensional sensor concept for

determination of shape and vibration motion of large space structures will be carried to a preliminary design. Increased emphasis will be placed on advanced space transportation system guidance and control development during FY 1983 directed toward greater performance capabilities to reduce uncertainties and associated costs.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Space power and electric propulsion research and technology.....	18,900	21,000	18,500	20,000

OBJECTI AND STATUS:

The objective of this research and technology program is to support, enhance, and enable current and future activities in the exploration and exploitation of space. The thrust areas are carefully selected to make the power subsystem more efficient, usable, and affordable in view of mission needs and to preserve and enhance a unique national capability in electric propulsion.

Significant progress has been made toward the development of a breadboard demonstration of a fuel cell/electrolysis cell energy storage system. A major thrust toward developing advanced, high capacity nickel-hydrogen batteries was started. Both of these technologies are designed to enable high power level missions in space. In the area of photovoltaics, researchers identified the failure mechanisms leading to the loss of power occurring in solar cells under deep space (low temperature, low intensity) conditions. The first gaseous solar pumped laser was demonstrated in the advanced energetics program. To provide an alternate source of high power (>100 kW) and enable operations independent of sunlight, critical technologies related to a future, nuclear reactor based power subsystem have been identified.

The ion thruster technology program was focused on the development of inert gas thrusters for on-orbit propulsion of large space structures and space stations. An effort to develop the high voltage, high power components and circuits that will be required for future low Earth applications will continue.

CEANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $2.5 million is in advanced energetics storage and electric propulsion research and represents this activity's portion of the directed agencywide reduction to the FY 1982 program.

BASIS OF FY 1983 ESTIMATE:

Major emphasis will be placed on evaluating and advancing the development of the fuel cell/electrolysis cell energy storage system. Efforts will continue toward development of safe, long-life, high energy density lithium batteries. Nuclear reactor power system technology will be enhanced by performing critical experiments to aid evolution of practical design options. Activities will continue in photovoltaics to improve conversion efficiency, reduce mass, increase operating life and reduce the cost of photovoltaic converters and arrays. Research and technology will focus on thin, high efficiency cells, solar array welding, and advanced blankets. The assessment of advanced concepts for space energy generation, conversion, storage, and distribution will continue under advanced energetics with emphasis on research on solar-pumped lasers and laser receivers.

In the area of electric propulsion, emphasis will be on increasing the thrust-to-power ratio of Mercury thrusters by a factor of two. Additional emphasis will be placed on the development of inert gas thrusters, specifically reducing the energy required to create ions and increase propellant utilization efficiency.

In the area of power management, work will continue to be directed toward high voltage, high power electrical components, power transfer devices, and analytical modeling of space plasma interactions. A thermal management program will focus on developing technologies related to constructable radiator systems and to thermal transfer technology.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary research.....	2,680	3,700	2,700	3,500

OBJECTIVES AND STATUS:

The objective of the multidisciplinary research program is to conduct long-range, basic research in the engineering and physical sciences focusing on high risk areas with revolutionary high potential payoff for space application and technology. A majority of the research is conducted at universities through either the Fund for Independent Research (FIR) or the Physics and Chemistry Experiments in Space (PACE) programs. The former program supports research across a broad spectrum of basic sciences and engineering fields such as atomic and molecular theory and spectroscopy, solid state and condensed matter physics, quantum electronics, theoretical and experimental fluid mechanics and dynamics, materials and structural sciences,?and mathematics. The latter program supports studies for the design of basic science and engineering experiments that will resolve fundamental scientific questions and discover new phenomena in which conditions of zero or near zero gravity are prerequisite. Some of the studies include experiments on the vibrational modes of liquids, behavior of quantum fluids, combustion, and the dynamics of convection.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $1.0 million represents this activity's portion of the directed agencywide reduction to the FY *1982* program.

BASIS OF FY 1983 ESTIMATE:

The research supported under this activity, such as theoretical mathematics, will be maintained as a broad study of innovative ideas that underlie and cut across the established disciplinary structure and thus contribute to long-term growth in space technology.

	1981 Actual	*1982* Budget Estimate	*1982* Current Estimate	*1983* Budget Estimate
		(Thousands of Dollars)		
Information systems research and technology...	*21,100*	*24,400*	*22,900*	*24,000*

OBJECTIVES AND STATUS:

The objectives of the information systems research and technology are to provide advanced sensor, data and communications technology options that will enable and enhance future Earth resources,

environmental observations, and space science missions, as well as a thrust toward the future of permanent occupancy in space. These technology options focus on efficient and timely acquisition, processing, reduction, and distribution of space acquired information.

Linear and area detector array technology covering wavelength ranges from 2 to 100 micrometers for infrared images of terrestrial, planetary, and astronomy scenes are being developed. A 2 x 64-foot linear charge injection device array was coupled with the 120-inch telescope at Lick Observatory for the first successful demonstration of infrared imaging with this resolution for astronomy. Quasioptical submillimeter receiver systems, with frequency capabilities in the 0.5 to 20 terahertz (THz) range and active laser sensors, are being developed for detection of the relative abundance of atmospheric trace gases. The 600 gigahertz (GHz) microwave radiometer was flown on a NASA aircraft mission to demonstrate its ability to measure atmospheric gases in the stratosphere. Cooling systems technology is being advanced in the area of long mission life refrigerators, dewars and ultralow systems for cooling sensors and experiments in space.' The first noncontacting bearing mechanical cooler has been fabricated and tested meeting its design goals of 70°K with a 5-watt cooling load.

In satellite communications technology, the 20 GHz traveling wave tube (TWT) development effort has produced an experimental model TWT employing dispenser cathode and multistage depressed collector technologies. In the 30/20 GHz solid state component area, a program was initiated to develop monolithic transmit/receive modules for a monolithic phased array antenna. A configuration study for the monolithic transmit array antenna will be completed in FY 1982.

The narrowband communications program completed a conceptual design of a large multibeam satellite antenna for land mobile satellite service. Analysis and tradeoff studies in conjunction with the antenna aperture and reflector were also completed. Development of power amplifiers, diplexers, and the antenna beam forming network were initiated.

Advances in communications technology to support NASA missions included the development of a spacecraft flight Ku-band modulator/exciter. This device is capable of transmitting data at rates as high as 2.5 gigabits per second and represents the state-of-the-art in microwave integrated circuit design. A breadboard scaled version of this technology was demonstrated at 60 GHz, a candiate intersatellite frequency. A low noise, solid state receiver development produced performance beyond the state-of-the-art at both Ku and Ka bands. This uncooled receiver will be targeted toward future NASA data communication applications. In the development of high efficiency, solid state x-band technology for deep space missions a high efficiency 10-watt transmitter was demonstrated.

In support of efficient data processing concepts, onboard data processing capability is being advanced. Technology was demonstrated to enable onboard radiometric correction and computation of geometric distortion coefficients of satellite image data. Also, a working engineering model of an onboard automated attitude determination system was completed. This technology will allow future missions to integrate auxiliary information with sensor data packets onboard.

The feature identification and location experiment was part of OSTA-1 and was a successful experiment. Sufficient experimental data was gathered to demonstrate onboard feature classification. The superfluid helium experiment has completed system integration and is targeted to evaluate the properties of superfluid helium in low gravity aboard the Spacelab-2 mission.

CHA F FY 1982 BUDGET ESTIMATE

The reduction of $1.5 million reflects two actions: (1) a **$3.1** million decrease as this activity's portion of the directed agencywide reduction to the FY **1982** program, and **(2)** an increase of $1.6 million representing the consolidation of the remaining elements of the information systems technology program into the research and technology base program.

BASIS OF PY **1983 ESTIMATE:**

During FY **1983,** the two-channel tunable diode laser heterodyne spectrometer will be flown on several NASA **CV-990** flights to demonstrate high resolution measurements of atmospheric constituent solar absorption spectra. The initial target gases are ozone and nitrous oxide The six-channel airborne subnanosecond laser ranging system for measuring regional crustal deformation will be test flown. A state-of-the-art advancement in quasi-optical components for submillimeter wavelength regions will enable the measurement of hydroxyl free radical and atomic oxygen during the flight test of the **1.8-**THz microwave radiometer. In the spring and summer of **1983,** the L-band multibeam push broom microwave radiometer will be field tested as a part of the AgRISTARS program. During the growing season of **1983** and two subsequent years, the brightness temperature will be processed to give day-by-day data on field soil moisture content. During FY **1983,** the mechanical cooler will continue in its life test. New solid state refrigeration concepts will be investigated. These systems will be used to evaluate the optical properties of typical infrared optical elements at cryogenic temperatures.

In FY **1983,** OAST will continue the development of the multistage depressed collector utilizing pyrolytic graphite a low secondary electron yield material. The pyrolytic graphite multistage depressed collector will be installed in the experimental model (TWT) and tested. Initial delivery of

transmit and receive monolithic modules will be made. Design and fabrication of 20 GHz monolithic array antenna will be completed. A technology activity to apply tunneladder circuit technology to low cost 30 GHz TWT transmitters will be initiated this fiscal year.

Aperture tradeoff studies and feed element development for the land mobile satellite service will be concluded. Breadboards of the beams forming network and power amplifier will be completed. Integration of the beams forming network into a full-scale feed structure will begin, as well as testing of a scale model antenna system (feed and reflector). Design of a mobile antenna will also commence.

During FY 1983, efforts will continue to develop 60-GHz communications components with a multi-gigabit capability, and an integrated low noise receiver for intersatellite link applications. The Ka-band work will continue in an effort to produce a high performance receiver. The communications technology work in support of deep space missions will continue with efforts to produce a flight model x-band 20/40 watt solid state transmitter.

The massively parallel processor, a major achievement in NASA's data systems technology program, will be completed during FY 1983. It features a six billion instruction/second processing rate for certain classes of problems. The technology, which enables on-line access to large volumes of space data products by geographically diverse investigators, will be demonstrated. It features 50 megabit/second data ingest and retrieval rates with data available within minutes after receipt from a spacecraft. A functional engineering model of an onboard orbit determination system using a global positioning system receiver and microprocessor will be completed. This will provide low cost operational onboard orbit determination capability €or future missions.

The superfluid helium experiment will be flown on Spacelab-2. The feature identification and location experiment will be reflown on OSTA-3 to gather additional statistical data on a wide variety of scenes.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Spacecraft systems research and technology.....	8,900	10,300	9,100	10,400

OBJECTI AND STATUS:

The objective of this program is to develop and demonstrate technology for large space systems, advanced planetary spacecraft, and advanced Earth-orbiting spacecraft to enable current and future space missions. The program extends the accomplishments of the research and technology programs in the fundamental discipline areas to integrated activites such that the transfer of a complete capability is possible. Research and technology activities are conducted in areas where a multi-disciplinary approach is essential to accomplish stated objectives. These activities share the common goal of eventual transfer and use of the technology in future spacecraft. This goal requires establishment of technical feasibility and verification of acceptable levels of risk and cost.

In the large space systems technology program, effort is directed toward spacecraft systems research and technology for application to large antennas, large space platforms, and manned space systems. The technology supports spacecraft development for missions in communications, astrophysics, radiometry, science and applications, space power generation, and operations in space. The objectives of the large space systems technology program are to define, develop, and demonstrate system level technologies for space missions which require large spacecraft structures and advanced discipline and subsystem technologies.

In FY 1982, new antenna concepts utilizing membrane reflectors and truss structures are being developed, advanced distributed control systems were configured for large flexible antennas, and full-scale ground development hardware was fabricated and assembled for the 50-meter hoop column and 55-meter wrap rib antennas. Structural assembly tests in the Neutral Buoyancy Facility have been completed utilizing man and machine-assisted techniques.

The advanced Earth-orbiting spacecraft program focuses on the systems and discipline technologies for Earth-observing spacecraft required for operational land monitors, meteorological instruments, and future scientific observations. In FY 1982, the instrument requirements document, which will guide development of future Earth-looking sensors and instruments, was completed; a power systems automation task was initated, functional requirements were identified, and the development of the large deployable solar array continues on schedule toward a test in FY 1983 as a method to understand the dynamics and control characteristics of large structures. The planetary spacecraft systems activity emphasizes the development on advanced systems and subsystems concepts which enable future lower cost planetary exploration. The primary efforts are in the area of advanced mission and spacecraft concepts and spacecraft automation concepts to reduce cost of mission operations and increase mission reliability.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The reduction of $1.2 million represents this activity's portion of the directed agencywide reduction to the FY 1982 program.

BASIS OF FY 1983 ESTIMATE:

In the large structures program, the full-scale hoop column and offset wrap rib antennas will be utilized for ground tests to determine and understand mesh management techniques, structural characterization, reflector surface precision, and the effects of surface distortions on RF performance. The electrostatic membrane antenna concept for curved and flatback electrodes will be evaluated. Deployable platforms will transition to a ground development program with activities in analysis, design, and fabrication and subsystem integration. Space assembly technology concepts will be developed through analysis and ground simulations. In addition, the structural assembly deployment experiment will be developed to correlate flight operations to ground simulations.

The fabrication and ground testing of the large solar array experiment will be completed in preparation for a late FY 1983 flight test aboard the Shuttle.

Conceptual development of an autonomous spacecraft system will be initiated leading to breadboard systems development and test in FY 1985. In power systems, automation systems requirements will be identified, trade-off assessments of options will be conducted, and system selection for subsequent demonstrations will be completed.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Transportation systems research and technology.....	6,900	8,200	8,200	8,800

OBJECTIVES AND STATUS:

The objectives of this program are to identify the technology requirements for advanced transportation vehicles to satisfy national needs and integrate these requirements into a

comprehensive plan that results in transfer-ready technology to support projected development schedules; to develop technology programs which satisfy these requirements; and, to support the development, enhancement, and improvement of the space transportation system in areas of technical competence. These objectives are accomplished through system level studies, analyses, and requirement definition efforts, as well as system and discipline research and technology efforts utilizing ground-based facilities, in-space hardware, and instrumentation which permits the Shuttle orbiter to be used as an advanced research vehicle.

During FY 1981, the analytic and ground-based test programs which established the aerodynamic/aero-thermodynamic performance envelopes for the early Shuttle flights and supported the certification of the thermal protection system pnior to the first flight were completed. First flight data from both the orbiter development flight instrumentation and the orbiter experiments (OEX) program were correlated with preflight, analytical predictions, and ground test data. No significant anomalies were discovered.

On the first Shuttle flight, instrumentation developed by the OEX program for the calculation of the actual aerodynamic coefficients of the orbiter during re-entry was flown. It provided essential data to support the above analysis. This hardware and instrumentation which validated tile gap heating predictions and the noncatalyticity of the orbiter's thermal protection system's surface during entry heating were flown on the second Shuttle flight. Sensors which measured the payload environment in the cargo bay were also flown on the second flight. The data collected from the flight will be used to calibrate the environmental, structural, and acoustical load models used to test subsequent payloads configurations. Instrumentation packages which will provide data on other aerodynamic1 aerothermodynamics and static/dynamic load characteristics are being developed for subsequent Shuttle flights.

Two significant orbit transfer vehicle studies were completed in FY 1981. The first addressed technology for a mid-1990's vehicle, and the second addressed propulsion options for a post-2000 vehicle. The first study emphasized the merits of aero-assisted recovery and space-basing of reusable vehicles, and technology programs to address critical issues were initiated. The second study identified the critical technology drivers for a post-2000 Shuttle replacement vehicle. It was limited to an assessment of the thermal structure requirements for a totally reusable, integral tankage vehicle.

BASIS FOR FY 1983 ESTIMATE:

System analysis efforts will be conducted to define the scope and direction of technology programs needed to reduce the cost or improve the performance of future space transportation vehicles. The efforts initiated in FY 1981 are to address the implications of advanced propulsion systems and thus significantly increase the comprehensive data base on advanced vehicle technology requirements. The study to identify the system levels requirements for the use of aero-assist to recover reusable orbital transfer vehicles will be expanded to define specific technology implications of manufacturing orbit transfer vehicle propellants in space, conceptual definition of large plane-change vehicles to permit an assessment of competing options, and program development for automated rendezvous and docking.

In addition to the aerodynamic coefficient and thermal protection system packages noted above, other instrumentation packages developed under the OEX program will be flown on FY 1983 Shuttle flights. These include low and high altitude research-quality air data systems, a leeside temperature sensing system, and a more accurate vehicle coefficient determination package. These will be integrated into Orbiter-102 during the refurbishment effort after Shuttle flight eight.

An OEX program package to quantify the aerodynamic heating (and thus the requirements of the thermal protection system and its limitation) on the windward side of the orbiter during reentry will be flown in conjunction with some FY 1983 flights. The instrumentation is mounted on the C–141 Kuiper Aircraft Laboratory and produces an infrared image of the orbiter at a selected reentry condition.

All Shuttle flights flown in FY 1983 will provide flight data which will be analyzed to validate analytical and test techniques. This data will provide a validation, research-quality data base which describes critical vehicle characteristics, thus permitting advanced vehicle concepts and design to be analyzed with reduced uncertainty and increased confidence.

Two flight control experiments will be integrated into the orbiter in FY 1983. The first experiment will quantify the actual effect of orbiter actuators on vehicle altitude. The second experiment will provide flight data on an advanced, adaptive, semiautonomous autopilot. These data will permit the supporting technology programs to be responsive to actual flight conditions.

Several advanced thermal protection system test panels will be in development for flight opportunities in FY 1984/1985. These panels will provide actual flight data on more durable, higher performance concepts which could become options for retrofit on the current orbiter fleet, as well as

candidates for subsequent orbiters. The panels will provide a validated data base for the thermal protection system for advanced post-Shuttle vehicles.

The design of the in-space facility to support technology advancement essential €or the management (efficient storage and low-loss transfer) of cryogenic fluids in space will be completed and the development of facility hardware will be initiated. Data from this facility will be first obtained during the FY 198811989 Shuttle flights.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAM

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space systems studies.....	2,083	500	---	---	RD 10-25
Information systems technology	4,062	4,900	---	---	RD 10-26
Spacecraft systems technology	2,075	1,600	2,800	4,400	RD 10-26
Total.....	8,220	7,000	2,800	4,400	
Space systems studies.....	2,083	500	---	---	

OBJECTIVES AND STATUS:

The objectives of the space systems studies program have been to identify and evaluate the technology requirements of advanced system candidates, to investigate future space mission alternatives, to assess the effects of technology advances, and to provide a data base to support technology program selection and program planning.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The deletion of the $500,000 estimate reflects a decision to eliminate space systems studies as an independent line item and to conduct necessary studies within the research and technology base or specific systems technology program as appropriate.

BASIS OF FY 1983 ESTIMATE:

In FY 1983 this program element will be eliminated. Such systems studies as may be required will be performed within the research and technology base or specific systems technology program.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Information systems technology.....	4,062	4,900	---	---

OBJECTIVES AND STATUS:

The ective of 1 activity is to elo the generic satellite ommuni techno which opens spectral ls s tion of the electromagnet spectrum and geostationary t d facili the d of innovative low cost satellite services to the public. Research n technology effort in te ommuni a cover ly two ctivities (1) 30/ GH: omm nd (2) narrowband communica wi the objective of providing technologies to enabl ffordable communication p lons for ssi in the s During FY 1982, this ctivity was descoped as part of the wid reduction, and the remaining elements wer funded thin the infor tio systems program in the research and base.

CHANGES FROM FY 1982 BUDGET ESTIMATES:

The deletion of the $4.9 million estimate reflects a decision to delete this program as an independent line item and to consolidate the remaining elements into the information systems program in the research and technology base.

BASIS OF FY 1983 ESTIMATE:

In FY 1983, essential elements of this program will be carried out within the information systems program in the research and technology base.

Spacecraft systems technology.....	2,075	1,600	2,800	4,400

OBJECTIVES AND STATUS:

The ob f this ff is to provide the capability to extend research and activities into th environment of space using the Shuttle th Spacela an flying vehicles. l and technology programs are so ended when tque space environment i

essential to the progress of the effort, when an in-space test is cost effective, or when an in-space verification will accelerate the utilization of advanced technology. This effort provides an effective means to demonstrate technology readiness so that the advanced technology capability can be used for important space missions at an acceptable cost and risk.

The activity includes the development, integration, and flight operations of experiments to be conducted in the Spacelab, the development of the Long Duration Exposure Facility (LDEF), the development and integration of experiments for the first LDEF missions, and a flight demonstration of an Ion Auxiliary Propulsion System on a free-flying Air Force satellite.

The Spacelab experiments are proceeding on schedule to meet currently defined launch dates. In FY 1982, the LDEF was removed from storage as the first in a lengthy sequence of activities in preparation for an FY 1984 launch. The 8-cm Ion Auxiliary Propulsion System demonstration on the USAF P80-1 spacecraft is scheduled for FY 1984. During FY 1982, systems qualification tests will be performed. Following these tests, the hardware will be shipped to the P80-1 contractor for integration into the spacecraft.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $1.2 million in FY 1982 supports increased priority funding requirements to continue the Ion Auxiliary Propulsion System flight experiment ($700,000) and additional FY 1982 requirements for the Long Duration Exposure Facility ($500,000).

BASIS OF FY 1983 ESTIMATE:

In FY 1983, considering current Shuttle launch scheduling, the following experiments will be launched: (1) solar array flight experiment; (2) solar cell calibration facility; and (3) the tribology experiment. Other experiments will be in various stages of completion for launch in FY 1984 and FY 1985.

During FY 1983, final thermal and structural analysis of the LDEF will be completed, experiments will be completed and integrated into the facility, and the facility will undergo final integration and test before integration into the Shuttle bay.

Integration of the 8-cm ion auxiliary propulsion system to the USAF P80-1 spacecraft and integration testing will be completed in preparation for a FY 1984 launch.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

STANDARDS AND PRACTICES

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Standards and practices	2,100	3,000	3,000	3,000

OBJECTIVES AND STATUS:

The objective of the standards and practices program is to provide an agency focal point for all program assessment functions relative to program assurance, safety, standards, practices, and special project activities to insure mission integrity. This includes responsibility for overall review of the technical execution of all NASA programs to assure that the development efforts and mission operations are being planned and conducted on a sound engineering basis with proper programmatic controls. Specifically, the objectives are to: maintain an overview of the technical execution of NASA programs; address technical problems highlighted in reviews; review program plans/project execution; conduct surveys and special investigations related to program execution, reliability, quality assurance, including parts and materials assurance, and aviation and systems safety; develop policies; monitor compliance; issue experience bulletins on program assurance related issues; develop handbooks and guidelines governing reliability, quality assurance, software, safety, and other practices; and, to participate with the interagency and industry groups in activities fostering better cooperation on programs and issues of mutual interest.

During FY 1981, the major effort was the completion of an independent review and assessment of the adequacy of the STS-1 flight verification certification program. Reliability and quality assurance activities included continued emphasis on materials integrity; integrated circuit product assurance; software assurance; and increasing attention to materials and parts assurance. The National Bureau of Standards investigation of reliable nondestructive test methods for aluminum alloys 2219 and 2024 is nearing completion, as is the handbook on microcircuit radiation effects. Program practices activities included a program evaluation effort to explore development of an index of risks related to spacecraft design and development, and the completion of a computer data bank pilot project, a listing

of current flight-qualified NASA equipment and similar equipment available from industry. Use of the data bank was insufficient to warrant continuation of the effort. Design and manufacturing standards activities emphasized workmanship standards, environmental engineering standards for Space Shuttle payloads, support to the measurement of the Shuttle payload bay dynamic, acoustic and thermal environment, and an assessment of industry practices to minimize damage or loss of electronic microcircuit parts due to electrostatic discharges. In the area of safety, the development of a NASA/Department of Defense ground safety document was successfully completed, and the characterization of hazardous aerospace materials continued. In response to Congressional direction, a contractual relationship was established with the National Academy of Sciences/National Academy of Engineering to provide an independent capability to review major NASA program changes at the requests of the Committees on Appropriations.

BASIS OF FY 1983 ESTIMATE:

In support of the objectives of the Agency, the FY **1983** standards and practices program will continue to conduct activities related to reliability and quality assurance, systems and aviation safety, software assurance, and program practices to reduce program risks, improve product confidence, and encourage good program practices in the technical execution of NASA programs. The FY **1983** standards and practices program principally provides for continuity in addressing engineering and technical concerns related to the NASA space program activities. For this budget year, the funding estimates do not project any major departures from the prior year activities. Standards and practices will continue to maintain an overview of the technical execution of NASA programs, address technical problems highlighted in reviews, review program plans and project execution, evaluate technical readiness of systems to perform missions, and conduct surveys and special investigations related to program execution, reliability, quality assurance, and systems safety. In each of the cognizant areas, activities are anticipated and programs will be conducted which assist the rapid identification and solution of technical problems that surface at technical reviews or are encountered in test or operational program activites, or which will contribute to the long-range goal of increased confidence in the ability of the programs to meet their mission goals. Increased emphasis is planned in FY **1982** and FY **1983** in systems and aviation safety related activities, and in support of improved management of software in NASA programs.

ENERGY
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

ENERGY TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Energy technology	1,900	---	---	---
Distribution of Program Amount by Installation:				
Johnson Space Center	150	---	---	---
Kennedy Space Center	4	---	---	---
Marshall Space Flight Center	170	---	---	---
Jet Propulsion Laboratory	1,149	---	---	---
Lewis Research Center	400	---	---	---
Headquarters	27	---	---	---
Total	1,900	---	---	---

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **ENERGY TECHNOLOGY PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major goal of the Energy Technology program has been to apply NASA aeronautics and space technologies, experience, and facilities to the energy research and development needs of the Nation, and to understand, evaluate and define how NASA capabilities can be applied to exploit the unique characteristics of the space environment to help solve energy-related problems on Earth. These objectives have been accomplished through NASA-funded exploratory programs in energy technology areas that have had close affinities to established NASA expertise. The efforts have subsequently been converted into reimbursable programs that exploit unique NASA capabilities.

BASIS OF PY 1983 ESTIMATE:

The deletion of funds in FY 1982 and FY 1983 reflects the decision to phase out the NASA directly-funded energy technology identification program.

TRACKING AND DATA ACQUISITION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1983 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS | **TRACKING AND DATA ACQUISITION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Operations	266,495	305,500	300,500	338,200	RD 12-5
Systems implementation	62,105	97,200	89,100	96,000	RD 12-16
Advanced systems	11,300	12,500	12,500	13,400	RD 12-25
Tracking and data relay satellite system	---	---	---	61,300	RD 12-27
Total	339,900	415,200	402,100	508,900	

Distribution of Program Amounts by Installation:

Marshall Space Flight Center	200	200	700	500
Goddard Space Flight Center	250,080	288,000	281,500	380,200
Jet Propulsion Laboratory	72,598	100,900	96,600	107,100
Ames Research Center	3,070	3,200	2,900	3,900
Headquarters	13,952	22,900	20,400	17,200
Total	339,900	415,200	402,100	508,900

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide vital tracking, command, telemetry, and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided for projects of the Department of Defense, and on a reimbursable basis to other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for sounding rockets, research aircraft, Earth orbital and suborbital missions, planetary spacecraft, and deep space probes. The program also includes the support of all phases of the Space Shuttle flight program. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communication with astronauts; (f) transfer of information between the various ground facilities and central control centers; (g) processing of data acquired from the launch vehicles and spacecraft; and (h) reception of television transmission from space vehicles. 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 Shuttle missions, to insure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations. When the Tracking and Data Relay Satellite System becomes operational, tracking support will be provided by a system of tracking and data relay satellites in geosynchronous orbit. Ground facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational. The STDN will remain the primary Earth orbital support network until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to insure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of STDN ground stations will be initiated. Certain facilities of the STDN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS. These remaining facilities are planned to be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory. The consolidation is keyed to providing a single network in the mid-1980's to support synchronous, highly elliptical, and planetary missions while reducing operations and maintenance costs.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) operations 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; (c) the investigation and development of advanced tracking and data acquisition systems and techniques; and (d) the cost of the TDRSS services beginning in FY 1983.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The current estimate for FY 1982 is $13.1 million below the budget estimate. This level reflects the general Congressional reduction of the FY 1982 appropriation and FY 1983 budget decisions. Actions taken to achieve the $13.1 million decrease, and FY 1983 budget decreases, include the closing of the Quito and Tula Peak tracking stations; the closure of the deep space 26-meter antenna sub-network; a reduction in staffing at a number of STDN tracking stations; an adjustment in the deep space systems implementation program based upon current requirements for the DSN reconfiguration; a

reprogramming to the Construction of Facilities appropriation for two 34-meter antenna facilities; the decisions to lease major computer replacement systems; and the rephasing of the Space Telescope data capture system.

These reductions will decrease the amount, timeliness, and reliability of support to approved missions, both to on-orbit spacecraft and to upcoming launches.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

OPERATIONS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spaceflight tracking and data network...	130,652	149,100	143,600	184,500	RD 12-6
Deep space network.....	54,427	64,400	63,400	61,300	RD 12-8
Aeronautics and sounding rocket support	6,025	6,800	6,600	6,900	RD 12-10
Communications operations.....	37,531	40,500	39,800	45,600	RD 12-11
Data processing.....	37,860	44,700	47,100	39,900	RD 12-13
Total.....	266,495	305,500	300,500	338,200	

Funds requested for operations provide for manpower and services needed to operate the worldwide network of NASA ground facilities including tracking stations, mission control centers, computation and data processing facilities, and support instrumentation for sounding rocket and aeronautics programs, and to provide the communications required in support of NASA programs. The FY 1983 funding request provides support to approximately 50 automated Earth orbiting and planetary missions. The funds requested for operations also provide for support of Space Shuttle flights and for the pre-launch support activity required for upcoming approved programs such as Spacelab, Gamma Ray Observatory, Galileo, Tracking and Data Relay Satellite System (TDRSS).

The FY 1983 request includes funding for test, checkout, and the initial operation of the TDKSS related ground systems as well as the continued operation of the Spaceflight Tracking and Data Network. To minimize the funding requirements during this transition to TDRSS operations, along with minimal provision for escalation, the actions described earlier concerning station and facility closures and staffing reductions have been taken.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network operations	130,652	149,100	143,600	184,500

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network System (STDN) is to support all NASA Earth orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer missions. In addition, the network provides launch support to NASA automated planetary missions, the Department of Defense and on a reimbursable basis, spaceflight missions of other nations, commercial firms, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of eleven geographically dispersed ground stations. The Tracking and Data Relay Satellite System (TDRSS) will consist of four spacecraft; two for NASA service, and one for commercial service, and an on-orbit spare, a single ground station at White Sands, New Mexico, and associated control, communications, and computational support facilities. Control centers for the STDN and TDRSS, the operations support computing facility, and a mission control center complex are located at the Goddard Space Flight Center (GSFC) which has the field center management responsibility for these programs.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew safety and other project related purposes.

In addition to the station and operations facilities at GSFC, ten STDN land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension

Island; Canberra, Australia; Bermuda; Santiago, Chile; and Madrid, Spain. Separate operations contracts exist for the Australian, Chilean, and Spanish sites with the balance of network operations and maintenance covered in a single procurement. A separate contract exists for network logistics support. A transportable station is located near NASA's Dryden Flight Research Facility (DFRF), California, for support of the Shuttle program. An additional small transportable station is located at New Smyrna Beach, Florida, for support of Shuttle missions. Also, four UHF/voice air-to-ground stations were established for additional Shuttle support, with one augmented for S-band operations. An engineering test and network system training facility at GSFC is also maintained and operated as part of the STDN.

The STDN has provided support to approximately 45 automated applications and space science spacecraft during the past year. Examples of significant missions being supported include Shuttle, Landsat-2 and -3, three Applications Technology Satellites (ATS-1, -3, and -5); Solar Maximum Mission; two Dynamics Explorer missions (DE-1 and -2); Solar Mesosphere Explorer (SME); Nimbus-5, -6, and -7; the International Sun-Earth Explorers (ISEE-1, -2, and -3); and the International Ultraviolet Explorer (IUE). Upcoming missions to be supported include the Space Telescope, Landsat-D, the Gamma Ray Observatory, and the Space Shuttle operational missions. The overall spacecraft support workload of the STDN is projected to total approximately 45 missions during 1982.

CHANGES PROM THE PY 1982 BUDGET ESTIMATE:

The decrease of $5.5 million resulted from a Congressional general reduction and FY 1983 budget decisions which required the closure of the Quito, Ecuador station, the Tula Peak, New Mexico facility, and a reduction of one shift at the Merritt Island, Florida and Kauai, Hawaii stations. The facility closures and shift reduction will impact support being given to several flight projects. Additionally, staffing buildups have been delayed for the Network Control Center and the NASA Ground Terminal due to changes in the space transportation system launch schedule for TDRSS.

BASIS OF PY 1983 ESTIMATE:

The FY 1983 funding requirements provide for the maintenance and operation of the STDN and mission facilities required for the command and control of automated spacecraft. The request also includes funds for the staffing, software development, and test and training activities necessary for the initiation of TDRSS operations in FY 1983. Also provided are the related logistics, supplies and network planning, scheduling, engineering, documentation, and software programming costs associated with the around-the-clock operation of the network.

The request for **FY** 1983 is based upon a substantial STDN support workload along with other program activities, including the initiation of TDRSS services, commencement of Shuttle operational flights, support of the Landsat-D, and implementation of network consolidation.

The increase from **FY** 1982 to **FY** 1983 reflects the funding required to provide ongoing support to the TDRSS such as data flow testing of the TDRSS related ground systems and to complete the basic software capabilities of the Network Control Center. The request also contains funding for achieving the staffing levels necessary for operating the TDRSS related ground systems including initial operation of the Network Control Center. The functions performed by ground systems, such as the scheduling and monitoring of the TDRSS service, is required for support to user missions during the latter part of **FY** 1983. In addition funds are required to provide for cost escalation, and a transfer of the orbit determination and computation function from the data processing operations budget line item to the STDN operations budget. This transfer is being undertaken to achieve greater consistency between the budget and program management responsibilities in the Office of Space Tracking and Data Systems as the transition is made to TDRSS operations.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Deep space network operations..	54,427	64,400	63,400	61,300

OBJECTIVES AND STATUS:

The primary function of the Deep Space Network (DSN) is to support planetary and interplanetary spaceflight missions. The DSN provides the vital two-way communication link by which distant spacecraft are controlled and scientific data is acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems software and operational techniques that push the state-of-the-art in telecommunications.

The DSN stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The three DSN station locations are approximately 120 degrees apart in longitude and permit continuous viewing of the planetary spacecraft. The stations consist of one 64-meter and one 34-meter diameter antenna at each location. As an economy measure, and with the Voyager II in a cruise phase to Uranus (requiring minimal support), a decision was made to close the 26-meter antenna subnetwork. A

centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field management responsibility for the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operation of the network control center at JPL.

The current workload in the Deep Space Network consists of seven ongoing Pioneer spacecraft (Pioneer 6–11 and Pioneer Venus), the Viking 1 Mars Lander, one Helios mission, and two Voyager spacecraft. Support of these missions will continue during FY 1983.

The Deep Space Network provided excellent support to the August 1981 encounter of Saturn by Voyager 11. This encounter returned some 12,000 images through the Deep Space Network utilizing an arrayed antenna technique. Voyager 1 is now about 1.8 billion kilometers from Earth on a trajectory that will take it out of the Solar System.

Of the older Pioneer spacecraft, Pioneer 10 is over 3.7 billion kilometers from Earth, and along with Pioneer 11 is proceeding on a path that will take them beyond the solar system. Pioneer 10 continues to be the most distant man–made object communicated with and each time data is received by the deep space network, a new communications record is established. It now takes nearly seven hours for a radio signal traveling at the speed of light to make the round trip between Earth and Pioneer 10. The Pioneer 11 spacecraft, some 1.8 billion kilometers from Earth, continues to be tracked. The Pioneer 6–9 spacecraft are provided support during solar conjunctions and during gravity wave experiments. The Helios 1 mission is continuing its orbit about the Sun and the Viking Lander continues to gather scientific data from Mars.

The Deep Space Network facilities are also used on a noninterference basis for ground–based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar phenomena.

In addition to the activities associated with the network modifications and the support cited above, the DSN workload includes preparation for several future missions including the International Solar Polar spacecraft, the Galileo spacecraft (orbiter and probe), and the reimbursable European Space Agency (ESA) mission to Halley's Comet (Giotto). This support preparation requires thorough and complex testing, training, and engineering (both hardware and software). These activities must be

carried out simultaneously with the extensive and continuous ongoing DSN support workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $1.0 million in the FY 1982 level is due primarily to the general reduction by Congress and FY 1983 budget decisions resulting in the closure of the 26-meter subnet.

BASIS OF FY 1983 ESTIMATE:

The DSN operations funding provides €or the maintenance and operation of the network facilities, control center, and the support and engineering effort associated with the operations of the network. Separate contracts have been established under international agreements for operation of the tracking facilities in Spain and Australia. The funds requested for FY 1983 are based upon the ongoing workload, including the Voyager missions, the Pioneer 6–11 missions, the Pioneer–Venus extended mission, the Helios mission, and the Viking Lander mission. The decrease from FY 1982 to FY 1983 is due principally to the closure of the 26-meter subnet, which is largely offset by escalation.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and sounding rocket support operations.....	6,025	6,800	6,600	6,900

OBJECTIVES AND STATUS:

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautical programs conducted by the Wallops Flight Center (WFC) and the aeronautical flight research programs of the Dryden Flight Research Facility. (DFRF). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The sounding rocket program continues to be an active program with approximately 135 launches in 1981, the majority of which were conducted at WFC. In addition, there were over 40 balloon flights during the same period. At WFC, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and noise studies. Approximately 200 missions were conducted during 1981. In addition to support of sounding rocket, balloon, and aeronautical programs, instrumentation at WFC will continue to be utilized to support the Shuttle orbital flight tests (OFT).

Dryden Flight Research Facility operates the aeronautical test range which provides radar, telemetry and communications support for the p'erformance of aircraft research and development programs. A variety of programs are conducted involving high performance aircraft, such as the F-111, F-14, F-16, F-104, F-8, and research vehicles such as the tilt rotor research aircraft, highly maneuverable aircraft technology, drones for aerodynamic and structural testing, and other remotely controlled spacecraft. Over 200 aeronautical research missions were supported at DFRF during CY 1981. Dryden Flight Research Facility is the prime landing site for STS-3 and STS-4 and tracking and data acquistion support of the Shuttle orbital flight tests will continue.

CHANGES FROM FY 1982 BU ESTIMATE:

The decrease of $.2 millio r m an adjustment in the estimate €or operati n E the por s c accommo the genera reduction by Congress.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, communications, data handling, and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Communications operations..	37,531	40,500	39,800	45,600

OBJECTIVES AND S

NASA's global communications network (NASCOM) interconnects, by means of leased voice data and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations.

The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real-time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditiously to users for analysis.

In order to meet high data transfer rate requirements, NASA has made and will continue to use digital techniques in providing communications support. The availability of this technology allows greater amounts of data to be sent over conventional communication circuits. Circuits capable of transferring data at increasingly higher rates continue to become available from the common carriers at reasonable costs. Consequently, the techniques of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center have become economically attractive and are used extensively in NASA's global communications network. This approach simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $.7 million was due to the congressional reduction and the FY 1983 constrained budget level which resulted in the closure of both the Quito tracking station and the 26-meter antenna sites of the Deep Space Network in Australia and Spain. The deferral of the 50 megabit wideband service from White Sands also contributed to the reduction. These reductions are largely offset by increased communication circuit tariffs approved in 1981.

BASIS OF FY 1983 ESTIMATE:

The F 1983 f equir for ommuni ti p io will r fo ne ircuits and service j to te and maintain th 1 global ini network. erna onal communicati satellites and bl wi nue to be used to ovi digital wideband er to

all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

The major increases in FY 1983 are due to the activation and test of the 50 megabit digital wideband service from the Tracking and Data Relay Satellite System facility at White Sands to both the Goddard Space Flight Center and the Johnson Space Center in support of Spacelab and Landsat-D Thematic Mapper high data rate requirements, a 4.0 megabit baseline capability from White Sands to handle the lower data rates required for Shuttle and Landsat-D support and escalation.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Data processing operations	37,860	44,700	47,100	39,900

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is 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 for each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft. Examples of these activities are: (1) the final checkout and acceptance of the operational orbit support software for the first Tracking and Data Relay Satellite launch early in 1983, and (2) the analysis and development of the operational software for the bilateration ranging transponder system for the support of the Tracking and Data Relay Satellite System and (3) final checkout of operational orbit software for the Landsat-D launch in mid-1982.

As part of the data processing activities, there is a significant effort required to process original or raw information received from the on-board experiments. Two facilities, the Imaging Processing Facility (IPF) and the Telemetry On-line Processing System (TELOPS) have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF initially established to handle imagery data from the Landsat-1, continues to support the second and third Landsat spacecraft as well as Nimbus missions. These spacecraft are supported with an all digital system using high density and computer compatible tapes which have reduced the time required to provide data to users.

The Telemetry Processing Facility which handles the conventional, nonimagery data was reconfigured in FY 1978 as the TELOPS. This reconfiguration resulted in a change from a tape-oriented system to an automated on-line electronic mass storage system. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Maintenance and operations support for the image and nonimage data processing facilities is provided by a single contractor. There are two other contracts under which software development and maintenance is provided for new systems along with software for attitude determination, flight maneuvers, support scheduling, and mission simulations.

CHANGES FROM TEE Y 1982 BUDGET ESTIMATE:

The increase of $2.4 million is due to phase-in costs for a new contractor for maintenance and operation of the data processing facilities to meet the total workload.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 budget request includes funds to operate the Image Processing Facility and the Telemetry On-line Processing System to process data from currently orbiting satellites and from missions scheduled to be launched through FY 1983. The requirements for the acquisition and processing of data from the older satellites are under continual review as support for older missions is terminated or curtailed, as mission objectives are achieved, or when the experiment data is no longer useful or cost effective to acquire and process. A facility to support Spacelab missions will be completed during mid-1983 and prelaunch operations and training will begin. The maintenance and operation of the Image Processing Facility, Telemetry On-line Processing System, and the Spacelab facility will be under a single contract.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Landsat-D, Earth Radiation Budget Satellite, Cosmic Background Explorer, and the Gamma Ray Observatory. Complex software is required €or spacecraft on-orbit and attitude control maneuvers and for the related data processing activities. Software effort is also required to develop the necessary programs to accommodate spacecraft which will operate with the Tracking and Data Relay Satellite System.

The funding request in FY 1983 reflects the transfer of the orbit determination and computation functions to the space tracking and data network operations discussed under that section.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

SYSTEMS IMPLEMENTATION

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate	Page Number
	(Thousands of Dollars)				
Spaceflight tracking and data network...	22,775	22,900	26,000	22,400	RD 12-17
Deep space network.....	20,165	41,800	36,900	44,800	RD 12-19
Aeronautics and sounding rocket support	3,345	6,400	6,200	3,800	RD 12-21
Communications.....	3,100	4,400	4,400	5,600	RD 12-22
Data processing....	12,720	21,700	15,600	19,400	RD 12-23
Total.....	62,105	97,200	89,100	96,000	

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 support needs of the many and varied space missions, and to provide augmentation of 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 support 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 basic software, the purchase of large module spares, and the acceptance testing, integration, and checkout of equipment.

FY 1983 funding is needed to maintain the operational proficiency and reliability of network systems through the replacement of obsolete and worn out equipment. Modification and augmentation of existing systems are also necessary to maintain compatibility with changes in associated on-board spacecraft communications systems and to improve the utilization and efficiency of network systems. In addition, FY 1983 funds are required to continue the implementation of new capabilities for upcoming missions, including Galileo, Space Telescope, and Spacelab. Implementation activities continue at the Network

Control Center and the NASA ground terminal at White Sands, New Mexico, and with other Tracking and Data Relay Satellite System (TDRSS) related systems for the initiation of TDRSS service in FY 1983.

Funds are included as part of a phased program for the consolidation of the remaining Space Tracking and Data Network stations with the Deep Space Network stations after the tracking and data relay satellite system is operational and to provide an imaging capability for the Voyager Uranus encounter in January 1986.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation.	22,775	22,900	26,000	22,400

OBJECTIVES AND STATUS:

The Spaceflight Tracking and Data Network systems implementation program encompasses the procurement and implementation of systems and services to: (1) sustain network facilities and equipment to insure reliable support of ongoing scientific and applications satellite missions, (2) to provide the necessary network and control center capabilities to perform the required control, tracking, command, and data acquisition functions in support of all NASA Earth orbital missions, including new support requirements for spacecraft to be launched in the near future. Implementation of these capabilities is vital to the success of NASA's spaceflight missions.

Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control. Software development is continuing for the Network Control Center (NCC) in preparation for the upcoming TDRSS launches and initiations of service. Plans and procurements are also underway to meet support requirements for upcoming missions such as Spacelab and Space Telescope. Compatibility testing and checkout activities for the Tracking and Data Relay Satellite System related ground systems will be completed in accordance with the plan to initiate Tracking and Data Relay Satellite System service during FY 1983.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The increase of $3.1 million is primarily associated with procurement of software for the Tracking and Data Relay Satellite System Network Control Center which serves as the interface between user missions and the Tracking and Data Relay Satellite System. Due to the complexity of this software task, it has required an extended development period as well as more costly, higher skilled personnel to solve development problems.

BASIS OF FY 1983 ESTIMATE:

Equipment modifications are required in the network and control centers in FY 1983 to maintain the required level of proficiency to support a diverse and demanding workload and to assure the reliability of the major systems. Accordingly, funds are required to replace portions of aging systems, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major 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.

Funds are requested to complete the implementation activities for an operational Tracking and Data Relay Satellite System including integration and compatibility testing for the bilateration tracking system, the NASA Ground Terminal, the interconnecting communications devices and other portions of the Tracking and Data Relay Satellite System. User oriented analysis on transponder power, communications margins, and interference effects are conducted on a continuing basis to ensure appropriate user support with the Tracking and Data Relay Satellite System.

In FY 1983, effort will continue on implementation of the control center for the Space Telescope mission. The funds requested provide for the control center hardware, for software used in telescope pointing, generation of command sequences for the spacecraft computer, and calculation of spacecraft attitude. Test and verification of the in-place portions of the control center and ground control tests of the spacecraft experiments will take place in FY 1983.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Deep space network systems implementation	20,165	41,800	36,900	44,800

OBJECTIVES AND STATUS:

The role of the Deep Space Network is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The Deep Space Network is responsible for receiving science data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging out to over 3.7 billion kilometers from Earth, (an ever-increasing range). In addition, after the Tracking and Data Relay Satellite System becomes operational, the Deep Space Network will also support spacecraft much closer to Earth. This new set of spacecraft will include highly elliptical Earth orbiters and synchronous Earth orbital missions which will be in orbits higher than those supportable by the Tracking and Data Relay Satellite System.

The systems and facilities required to accomplish this unique support are highly specialized and include the use of large aperture antennas configured in a phased array for optimum reception of the extremely weak radio signals, ultrasensitive, cryogenically cooled receivers and highly powered transmitters. Extremely stable cryogenic hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the deep space network complexes and the Network Control Center.

The four major objectives for the Deep Space Network in the 1980's can be summarized as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive clear images at these great distances; (2) to consolidate the activities of the residual Spaceflight Tracking and Data Network with the Deep Space Network after the Tracking and Data Relay Satellite System becomes fully operational in 1984 to increase operational flexibility and reduce overall operating costs; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits above the area supported by the Tracking and Data Relay Satellite System); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the Deep Space Network, as it will be supporting many more spacecraft than in the past, and it will be working at incredibly great distances (4.5 billion kilometers - three times the distance to Saturn) by the end of the decade.

Following the Voyager II Saturn Encounter in August 1981, the next major planetary encounter will be of Uranus by Voyager II in 1986. This encounter will occur some 4.5 billion kilometers from Earth. At that time, Voyager IT is expected to transmit the first images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of multiple antenna arraying (more than two antennas) during this Uranus encounter. In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support near-Earth missions that cannot be supported by the Tracking and Data Relay Satellite.

New deep space missions which will be supported by the network in the 1980's include a Jupiter orbiter and probe (Galileo) and the International Solar Polar Mission. One or more of Halley's Comet rendezvous missions will also be supported for the international community on a reimbursable basis.

CHANGES FROM FY 1982 BUDGET ESTIMATE

The decrease of $4.9 million in the FY 982 budget stmate is due 1 to the Congressional general reductio resulting in adjustments in th D Space Network econfiguration plan and the reprogramming to the Construction of Fac riation for the two new 3 ma
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BASIS OF PY 1983 BUDGET:

Funding in the FY 1983 request provides for continuing the reconfiguration of the ground network facilities into a consolidated, modern, and highly reliable, automated network. The capabilities planned in the reconfiguration will provide for enhanced spacecraft-ground telecommunications and navigation precision while reducing overall maintenance and operations costs.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager II at Uranus. (As the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for increased antenna aperture at Uranus, which is twice the distance that Saturn is from Earth.) Thus, this design provides for an

improved flight project support capability and also allows for a reduction in operations and maintenance costs. Equipment required for this capability includes antenna monitor and control, receiving, and data handling systems, along with the necessary engineering and fabrication.

In addition, funds are included for implementing a central signal processing center at each Deep Space Network complex. Instead of having independent support facilities for each antenna, it will be possible to control all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized and shared maintenance facilities will also be provided.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement in flight navigation accuracy and for replacement of obsolete frequency and timing equipment.

Concurrent with these important engineering changes, FY 1983 funds will be required to maintain the high level of reliability for support of time critical spacecraft maneuvers as well as routine ongoing support. This will be accomplished through a continuing program of equipment and facility refurbishment, and modifications to assure compatibility of existing equipment with the new systems being implemented in the network.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and sounding rocket support systems implementation.....	3,345	6,400	6,200	3,800

OBJECTIVES AND STATUS:

The objective of the aeronautics and sounding rocket support system implementation program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition, and range safety requirements of the aeronautical research conducted at the Wallops Flight Center (WFC) in

Virginia, the Dryden Flight Research Facility (DFRF) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops and other selected sites around the world. The WFC and DFRF provide the fixed ground instrumentation systems to support aeronautical research. In addition, WFC provides both fixed and mobile instrumentation to support the sounding rocket program.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $.2 million in the FY 1982 estimate is due to a deferral in the procurement of equipment for a planned dual mission support capability at DFRF.

BASIS OF FY 1983 ESTIMATE:

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which require generally the same level of support from year to year. To support these programs, Wallops Flight Center provides fixed and mobile instrumentation systems; namely, radar, telemetry, communications, command, data handling and processing systems. To maintain these facilities, spare and replacement parts must be acquired and test and calibration equipment routinely replaced. Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased program of necessary replacement is underway in order to sustain and improve the tracking and data systems support for these programs. To insure reliable real-time data collection and handling support to meet current and future requirements, an orderly plan to replace obsolete equipment is also underway. Funds are included in the request for the periodic refurbishment and modifications of mobile equipment to meet remote site sounding rocket and balloon support requirements.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation...	3,100	*4,400*	*4,400*	5,600

OBJECTIVE AND STATUS:

The objective of the communications systems implementation program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in the NASCOM are the procurement of a control and status system that can remotely control the configuration of the Tracking and Data Relay Satellite System (TDRSS) multiplexing system at White Sands and the implementation of a 50 megabit per second transmission capability connecting the White Sands, Johnson Space Center, and Goddard Space Flight Center for support of Spacelab and Landsat-D missions. Funding is also provided to replace equipment in the message switching system at the Goddard Space Flight Center.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and to complete the replacement of the message switching system at the Goddard Space Flight Center to coincide with the TDRSS communications system which will operate at very high data rates. Efforts will begin to test digital techniques on the wideband data system and to continue efforts on the use of fiber optic cables for distribution of very high data rates from the TDRSS.

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation..	12,720	21,700	15,600	19,400

OBJECTIVES AND STATUS:

The data processing systems implementation program provides for the procurement of equipment and related services for the large computer complexes at the Goddard Space Flight Center which support

both the operational and payload requirements of space missions. To meet operational requirements, these computer complexes determine spacecraft attitude and orbit, and generate commands to the spacecraft that provide the status of on-board subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large complexes viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth orbiting spacecraft. The Image Processing Facility is generating products for Landsat, Heat Capacity Mapping Mission, and Nimbus 7. The program to replace many of the old computers continues. The new Metric Data Facility will be on line in mid-1982 and the existing system retired. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

CHANGES FROM FY 1982 BUDGET ESTIMATE:

The decrease of $6.1 million is due primarily to the Congressional reduction, resulting in the decision to lease the Flight Dynamics and Command Management computer replacement systems. A rephasing of the data capture system for Space Telescope also contributed to the reduction. Due to the increasing age of the existing computation systems, additional costs are being incurred to maintain and operate these systems.

BASIS OF FY 1983 ESTIMATE:

The FY 1983 budget request will provide continued funding for phased replacement of the existing computer complex at the Goddard Space Flight Center which provides real-time support to the many NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control. This computer complex is approximately 16 years old. Not only is hardware and software maintenance becoming more difficult and expensive, but the more frequent outages are becoming a threat to spacecraft support. Further, system architecture of the existing systems requires more extensive software development to adapt to new missions.

The FY 1983 funding request provides for continuation of the phased computer replacement program for the flight dynamics and command management systems and initial funding for replacement of the orbit computation system at the Goddard Space Flight Center. The orbit computation replacement system will

have a complex task of not only supporting free-flyer spacecraft, but also the Shuttle and the Tracking and Data Relay Satellite System. Maintaining the Tracking and Data Relay Satellite System position accuracy will impose a significant demand on the orbit computation system resources.

While the major portion of the Spacelab Data Processing Facility implementation activity has been accomplished with prior years appropriations, funds are also required in FY 1983 to complete the implementation. This capability is being provided by new equipment as well as augmenting and sharing the existing free-flyer data processing capability. The Univac 1108 computers which are about 15 years old have been replaced with faster central processor units and additional memory; thereby, providing the additional capability required to handle the Spacelab data rates. Funds are requested for upgrading the facility to provide for a more reliable operation for both Spacelab and free-flyer support.

In addition, funds are required for the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is required for the planned packaged telemetry requirement and the long mission lifetime of the Space Telescope. The packaged telemetry concept allows the scientific data of an experiment to be accompanied by the associated ancillary data (spacecraft orbit, attitude, time, etc.) in the downlinked telemetry stream from the spacecraft. This procedure minimizes ground data processing time and complexity as well as insuring faster delivery of data to the experimenters.

There is a continuing requirement to procure and maintain adequate supply of spare parts to replace failure prone and high maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

ADVANCED SYSTEMS

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
		(Thousands of Dollars)		
Advanced systems.....	11,300	12,500	12,500	13,400

OBJECTIVES AND STATUS:

The overall objective of the advanced systems program is to perform studies and conduct the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions and near term new starts, and (2) improve the cost effectiveness and obtain the reliability needed for overall support of the total mix of spaceflight missions. This effort also includes investigations of upcoming missions and trade-off studies of ground systems and telecommunications links to determine design approaches and overall trade-offs for the lowest life-cycle costs to support future space missions.

BASIS OF FY 1983 ESTIMATE:

This program remains a vital element in the space tracking and data acquisition program. It is through this program that the dramatic changes taking place in the state-of-the-art in telecommunications and computer technology are assessed and applied to future support capabilities. The type of activity undertaken in this program provides the foundation for future planning and for advances in support capabilities that are cost effective and reliable. This is accomplished mainly through contracts at the Goddard Space Flight Center for Earth satellite missions and data systems and by in-house personnel at the Jet Propulsion Laboratory for the deep space missions.

The following are examples of the type of activity for FY 1983. Extremely precise tracking techniques will be investigated for determining planetary mission angular direction and measuring time with accuracy sufficient to track and guide future planetary flybys, orbiters, landers and probe releases, and in the process, to make possible new ground-based science experiments, e.g., search for gravity waves.

New techniques in radio telecommunications will continue to be investigated, especially those that will make more effective use of existing ground facilities. The addition of a K-band reception capability will be investigated. Developments include a cryogenically cooled telemetry receiving system and antenna improvements capable of operating in each of three frequency bands (X, S, and K-bands). Application of K-band technology promises a factor of ten improvement in telecommunications with the option of trade-offs on future missions between spacecraft power and weight and the amount of scientific data returned. Effort will also continue on an X-band uplink transmitting system to increase the Deep Space Network command capability for ground-based navigation and radio science. The use of optical telecommunications in a space relay mode will be investigated for its mission trade-off advantages and its potential for direct link video from the outer most planets.

Earth orbital missions during the Tracking and Data Relay Satellite System era will acquire and process telemetry data at rates up to 300 million bits per second, an increase over current requirements (for Landsat-3) by a factor of 20. These future requirments result from high resolution sensors such as multispectral scanners and synthetic aperature radars. New techniques and systems must be developed for the ground transfer and processing of such large volumes of data. These include computer assisted operations, digital processing of high volume data, improved man-machine interfaces and wide band satellite communications to distribute data to processing centers and the users. Optical disc data storage and automated quality control of data will be investigated in order to meet the increased image data processing requirements anticipated for future Earth observations missions.

BASIS OF FY 1983 FUNDING REQUIREMENTS:

TRACKING AND DATA RELAY SATELLITE SYSTEM

	1981 Actual	1982 Budget Estimate	1982 Current Estimate	1983 Budget Estimate
	(Thousands of Dollars)			
Tracking and data relay satellite system.....	---	---	---	61,300

OBJECTIVES AND STATUS:

The objective of the Tracking and Data Relay Satellite System (TDRSS) is to provide tracking, command, and telemetry services to all low-Earth orbital missions. TDRSS will consist of a four satellite constellation in geosynchronous orbit and a single ground station located at White Sands, New Mexico. Of the four satellites on-orbit, two will be dedicated to NASA use, one will provide Space Communications Company commercial service, and the fourth will serve as an on-orbit spare to assure the reliability of both NASA and commercial services.

The NASA service will provide both increased high data rate capability and greatly expanded mission coverage over that currently provided via traditional ground stations. When TDRSS becomes fully operational, a number of manpower intensive ground stations servicing low-Earth orbital missions will be phased out.

The first TDRSS spacecraft has completed its integration and environmental testing and is undergoing disassembly to incorporate modifications to provide improved security and Shuttle safety features. All essential ground terminal equipment for initial operations has been delivered and installed at the White Sands station. Software test and checkout, service level testing, and initial data flow and compatibility testing with other NASA systems have been initiated. The launch of the first TDRSS is scheduled for January 1983.

BASIS OF FY 1983 ESTIMATE:

Tracking and Data Relay Satellite System services are being procured through a long-term service contract from Space Communications Company (SCC). SCC is a partnership of subsidiaries of Western Union, Continental Telephone, and Fairchild Industries. TRW and Harris Electronic Systems Division are major development subcontractors to Space Communications Company. Under the terms of the service contract, SCC will provide the Tracking and Data Relay Satellite System services to NASA for a ten-year period.

The program development phase is being financed through loans from the Federal Financing Bank (FFB). FFB loans are extended to SCC under the terms of a SCC-FFB loan agreement and note. NASA, as an assignee to the FFB note, is responsible for making loan repayments directly to the FFB when the funds are authorized and appropriated by the Congress.

Funds requested for FY 1983 are to initiate repayment of the construction period FFB loan. In addition, funds are requested to make operations and award fee payments to Space Communications Company for the Tracking and Data Relay Satellite System provided, and to provide support to the NASA Tracking and Data Relay Satellite System project management staff in the areas of systems engineering and operations planning.

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FISCAL YEAR 1983 BUDGET ESTIMATES