NASA

National Aeronautics and
Space Administration

Budget Estimates

FISCAL YEAR **1981**

Volume I

Agency Summary

Research and Development

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

VOLUME I

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AGENCY
SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 BUDGET ESTIMATES

GENERAL STATEMENT

The 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 it's 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, while minimizing their environmental effects and energy consumption;
- Disseminate pertinent findings to potential users; and
- Promote international cooperation in peaceful activities in space.

The President's civil space policy announced in October 1978 emphasized a balanced strategy of applications, science and technology development designed to:

- Emphasize space applications that will bring important benefits to our understanding of Earth resources, climate, weather, pollution and agriculture;
- Emphasize space science and exploration in a manner that retains challenge and excitement and permits the Nation to retain the vitality of its space technology base;
- Take advantage of the flexibility of the Space Shuttle to reduce the cost of operating in space;
- Assure American scientific and technological leadership in space;

-- Increase benefits for resources expended through closer integration of the national space programs;

-- Demonstrate advanced technological capabilities in open and imaginative ways;

-- Foster space cooperation with nations by conducting joint programs;

-- Confirm our support of the continued development of a legal regime for space that will assure its safe and peaceful use for the benefit of all.

The NASA FY 1981 budget recommendation of $5,736.7 million provides for progress toward achievement of these objectives at a pace consistent with a constrained fiscal environment.

Space program elements in the recommended budget provide for progress in development of the operational capability and use of the Shuttle and related systems; in practical application of space capabilities in remote sensing of land and ocean conditions, in atmospheric studies, in materials processing and in 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:

- Development, qualification and flight testing of the Space Shuttle and manufacture of the orbiter vehicles on a schedule consistent with the requirements of the Department of Defense. The Space Shuttle is progressing toward the initial flight tests, but the final preparations and ground testing required before these flight missions can be confidently undertaken are taking longer and requiring more effort than previously planned. The requirements of the Department of Defense and other Shuttle users, as well as the requirements of the NASA program, make it necessary to proceed as expeditiously as possible in achieving the capabilities of the Space Transportation System. Consistent with these requirements, it is necessary to recommend a Supplemental Appropriation of $300 million for FY 1980. The FY 1981 budget recommendation is based on the assumption that this Supplemental Appropriation will be approved;

- Continuation of the approved flight missions in Science and Applications, but with a revised plan for the Galileo mission to Jupiter to achieve the science objectives using separate launches of orbiter and probe spacecraft in 1984 rather than a combined spacecraft launch in 1982;

- Continuation of the basic and applied research activities essential to future capabilities and leadership in space;

- Carefully selected program enhancements and next step initiatives in the areas of practical applications of space capabilities and scientific exploration of space. Specifically, enhancements and initiatives in the area of practical applications, remote sensing and communications include the National Oceanic Satellite

System in response to both military and civil requirements for remote sensing of ocean data and advanced technical development effort on an experimental wideband communications satellite. In the area of Space Science, development will be initiated on the Gamma Ray Observatory to conduct a comprehensive sky survey of the highest energy region of the electromagnetic spectrum.

Aeronautical research and technology activities in the recommended budget are necessary to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft. The FY 1981 program continues emphasis on the fundamental research and technology base in all disciplines vital to aeronautics; on specific technology efforts directed toward major improvements in transport aircraft energy efficiency for operations and on systems technology to provide a basis €or improved performance and safety for future vehicles in each major aircraft category. The FY 1981 program also continues and extends focused efforts on aircraft energy efficiency technology to provide the basis for a major reduction in fuel requirements for transport aircraft; on design technology for future quiet, efficient, all weather rotorcraft; on variable flow propulsion technology; and, on other key areas of systems technology. Construction effort is proceeding on two major aeronautical facilities, the National Transonic Facility at the Langley Research Center and the Modification to the 40-by-80 foot Subsonic Wind Tunnel at the Ames Research Center. The facilities, which will considerably enhance the Nation's aeronautical research capability, are scheduled to come on line as operational facilities during FY 1982.

Resources Summary

The budget for FY 1981 has been developed on the assumption that the FY 1980 Supplemental Appropriation of $300.0 million required for the Space Shuttle program will be approved on a timely basis. The total budget authority for FY 1980, including this supplemental appropriation, and a supplemental of $46.3 million requested to cover the increased salary costs that became effective in October 1979 pursuant to Executive Order 12165, totals $5,269.8 million. The budget authority recommended for FY 1981 totals $5,736.7 million with estimated outlays of $5,439.7 million. Civil service staffing levels are planned at 22,613 for the end of FY 1980 and 22,713 at the end of FY 1981.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

	Budget Plan		
	FY 1979	FY 1980	FY 1981
RESEARCH AND DEVELOPMENT			
Space Transportation Systems	2,011,600	2,403,300	2,738,200
Space shuttle	1,638,300	1,886,000 a/	1,873,000
Space flight operations	299,700	446,600	809,500
Expendable launch vehicles	73,600	70,700	55,700
Space science	505,400	600,800	668,000
Physics and astronomy	282,900	337,100	438,700
Planetary exploration	182,400	219,900	179,600
Life science	40,100	43,800	49,700
Space and Terrestrial Applications	283,900	343,900	394,800
Space applications	274,800	331,800	381,700
Technology utilization	9,100	12,100	13,100
Aeronautics and Space Technology	376,400	427,100	409,500
Aeronautical research and techn	264,100	308,300	290,300
Space research and technology	107,300	115,800	115,200
Energy technology	5,000	3,000	4,000
Tracking and Data Acquisition	299,900	332,400	359,000
TOTAL RESEARCH AND DEVELOPMENT	3,475,200	4,107,500	4,569,500
CONSTRUCTION OF FACILITIES	145,500	156,100	120,000
RESEARCH AND PROGRAM MANAGEMENT	934,069	1,006,186 b/	1,047,154
TOTAL	4,558,769	5,269,786	5,736,654
OUTLAYS	4,196,472	5,012,600	5,439,700

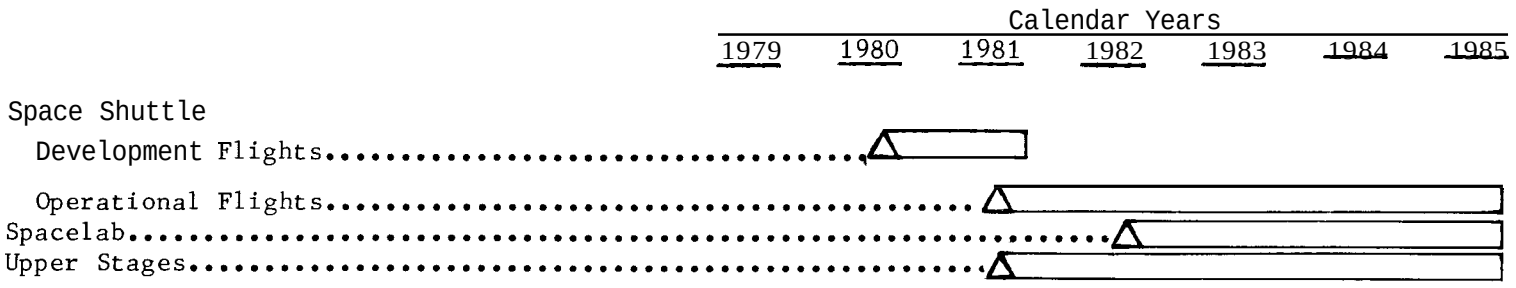
a/Includes proposed supplement 1 of $300,000,000 for Space Shuttle.
b/Includes proposed supplement 1 of $46,286,000 for October 1979 pay raise

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

A CE TRANSPORTATION SYST

- Develop 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
- Continue production to provide a national fleet of Space Shuttle orbiters
- Establish capability for Space Transportation System operations
- Conduct Shuttle orbital flight tests
- Conduct design and verification activities for Shuttle thrust augmentation
- Provide expendable launch vehicle services as required by NASA and other users during transition to Space Transportation System

MAJOR FLIGHT ACTIVITY

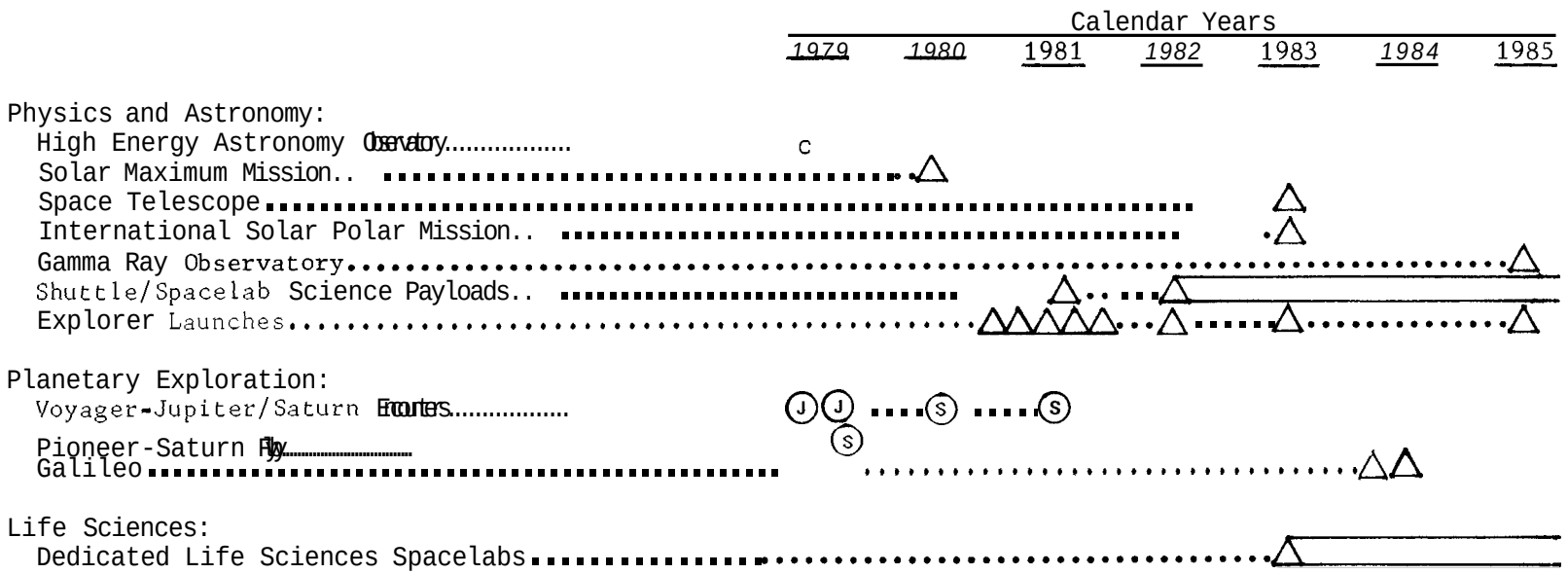


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE

- Increase our understanding of the evolution and nature of the 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

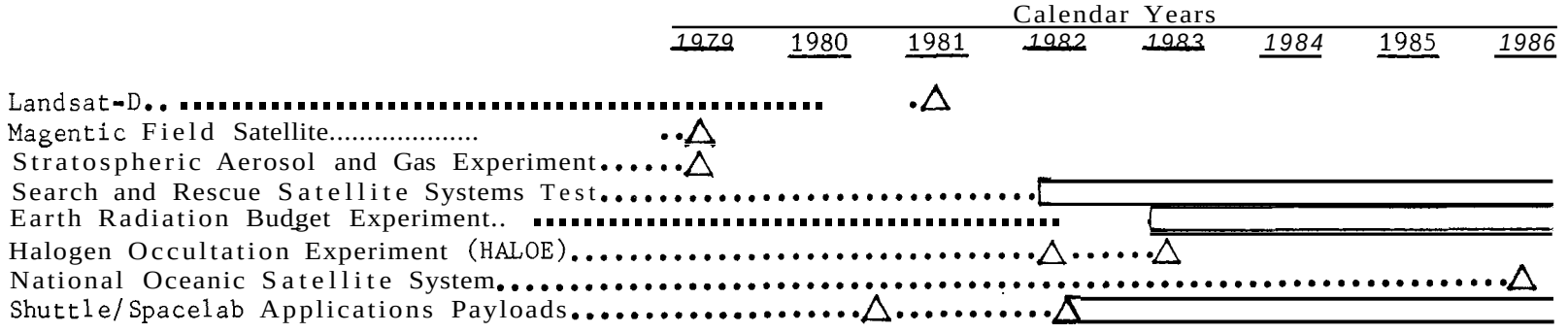


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AERONAUTICAL RESEARCH AND TECHNOLOGY

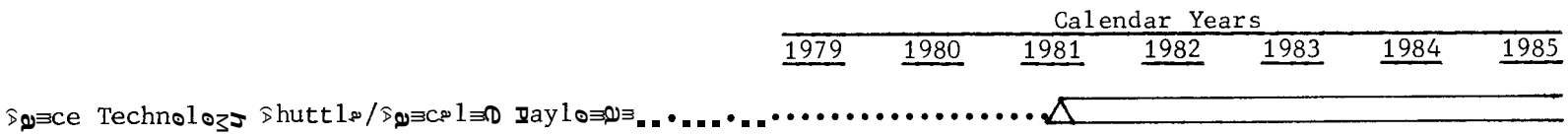
- Provide a technology base for current and future civil and military aircraft to:
  - Reduce energy requirements
  - Improve performance
  - Increase safety
  - Decrease environmental effects
  - Reduce costs
- Achieve these objectives, by means of ground and flight-based research and technology activities, through advances in the technology areas of:
  - Materials and structures
  - Propulsion
  - Avionics and flight control
  - Aerodynamics
  - Operations
  - Human-vehicle interactions
- Major technology focus:
  - Aircraft Energy Efficiency Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base to enable and enhance future space activities by:
  - Improving performance
  - Reducing cost
  - Increasing reliability
- Achieve these objectives, by means of ground and space based research and technology activities, through advances in the technology areas of:
  - Materials and structures
  - Electronics
  - Chemical and electric propulsion
  - Space power systems
  - Component standardization

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENERGY NOLOG?

- Energy technology activities to facilitate use of NASA-developed aerospace technologies, experience and facilities to meet the program needs of the Department of Energy and other agencies responsible for energy programs

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:
  - Shuttle Orbital Flight Tests
  - Automated Earth Orbiting Missions - Covering an average of approximately 40 applications and scientific spacecraft, the support workload will include Nimbus 5, 6, & 7, the Landsat missions, Heat Capacity Mapping Mission, International Ultraviolet Explorer, International Sun Earth Explorer missions, the High Energy Astronomy Observatory missions, the Applications Technology Satellite missions, Magsat, and the International Solar Maximum Mission
  - Planetary Missions - In addition to seven Pioneer spacecraft, Helios 1 & 2 and Voyager 1 & 2 will also be supported
  - Sounding Rockets
  - Aeronautical Flight Research Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	FY 1979	FY 1980	FY 1981
Research and Development	3,477,200	4,107,500	4,569,500
Basic appropriation	3,292,200	3,807,500	4,569,500
Supplemental for Space Shuttle	185,000	---	---
Proposed supplemental for Space Shuttle	---	300,000	---
Construction of Facilities	147,500	156,100	120,000
Basic appropriation	147,500	156,100	120,000
Research and Program Management	934,069	1,006,186	1,047,154
Basic appropriation	910,500	959,900	1,047,154
Rescission, PL 96-7	-2,400	---	---
Supplemental appropriation for civilian pay raises, PL 96-38	25,969	---	---
Proposed supplemental for civilian pay raises	---	46,286	---
Total	4,558,769	5,269,786	5,736,654

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

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

Fiscal Year 1979	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 95-392	4,350,200	3,292,200	147,500	910,500
Rescission, PL 96-7	-2,400	---	---	-2,400
Supplemental Appropriation, PL 96-38	210,969	185,000	---	25,969
Unobligated balance lapsing	-261	---	---	-261
Total Budget Plan	4,558,508	3,477,200	147,500	933,808
Fiscal Year 1980				
Appropriation, PL 95-392	4,923,500	3,807,500	156,100	959,900
Proposed supplemental for Space Shuttle	300,000	300,000	---	---
Proposed supplemental for civilian pay raises	46,286	---	---	46,286
Total Budget Plan	5,269,786	4,107,500	156,100	1,006,186
Fiscal Year 1981				
Appropriation request/budget plan	5,736,654	4,569,500	120,000	1,047,154

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

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

	TOTAL			Research and Development			Construction of Facilities			Research and Program Management		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Johnson Space Center.....	1,306.3	1,470.9	1,575.7	1,151.2	1,302.6	1,400.0	2.2	5.4	5.0	152.9	162.9	170.7
Kennedy Space Center.....	373.1	457.2	488.4	233.5	300.3	342.0	16.3	25.0	5.0	123.3	131.9	141.4
Marshall Space Flight Center..	914.2	1,031.2	1,233.9	747.8	853.0	1,056.8	*17.4	*20.6	*17.2	149.0	157.6	160.4
National Space Technology Laboratories.....	21.2	23.0	22.4	15.4	16.1	14.5	1.3	2.0	2.8	4.5	4.9	5.1
Goddard Space Flight Center...	656.1	699.2	774.5	519.3	560.4	631.0	8.9	3.0	4.2	127.9	135.8	139.3
Jet Propulsion Laboratory	241.2	314.0	313.2	235.1	310.4	306.1	6.1	3.6	7.1	---	---	---
Wallops Flight Center..	33.2	37.4	44.5	16.6	17.0	21.9	.8	3.3	3.6	15.8	17.1	19.0
Ames Research Center.....	248.0	251.6	222.5	141.5	139.7	135.8	43.8	42.1	15.3	62.7	69.8	71.4
Dryden Flight Research Center.	33.9	41.6	41.1	13.1	18.2	17.8	1.7	1.7	1.6	19.1	21.7	21.7
Langley Research Center.....	279.4	304.0	301.9	138.8	164.4	156.0	34.0	23.6	26.7	106.6	116.0	119.2
Lewis Research Center.....	243.7	276.0	273.9	149.2	170.2	156.8	7.0	8.0	15.7	87.5	97.8	101.4
Headquarters	202.0	345.9	428.9	115.7	255.2	331.3	1.8	---	---	84.5	90.7	97.6
Undistributed Construction of Facilities:												
Various Locations.....	---	3.8	3.1				---	3.8	3.1			
Space Shuttle Facilities....	1.9	---	2.7				1.9	---	2.7			
Rehabilitation and Modification.....	1.5	---	---				1.5	---	---			
Facility Planning and Design	2.8	14.0	10.0				2.8	14.0	10.0			
Total Budget Plan.....	4,558.5	5,269.8	5,736.7	3,477.2	4,107.5	4,569.5	147.5	156.1	120.0	933.8	1,006.2	1,047.2

*Includes Michoud Assembly Facility.. ..... (14.9) (13.2) (13.2)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

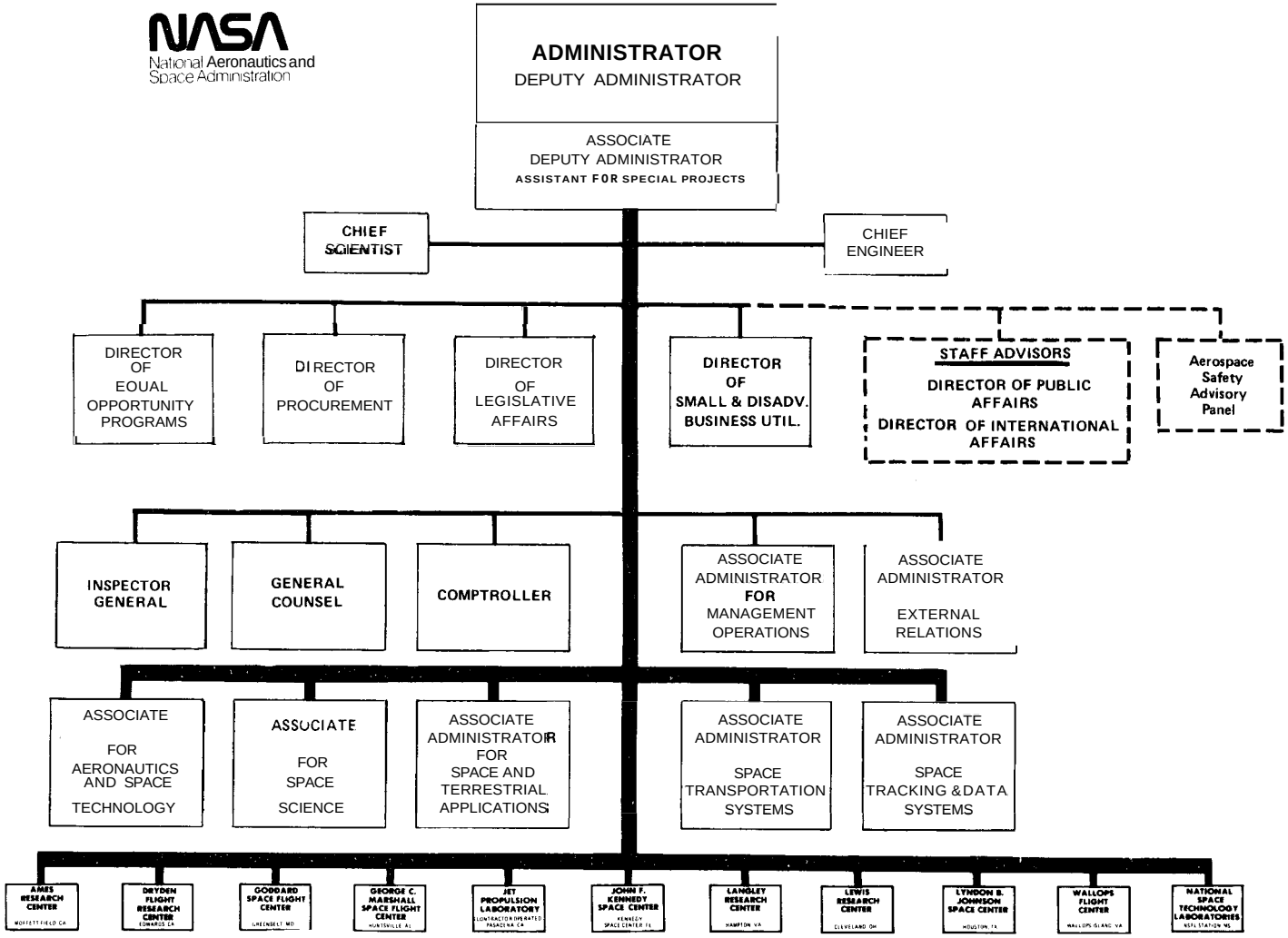
RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1981 ESTIMATES

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

Installation	FY 1979 Actual	FY 1980 Estimate	FY 1981 Estimate
Johnson Space Center	3. 504	3. 469	3. 494
Kennedy Space Center	2. 193	2. 191	2. 201
Marshall Space Flight Center	3. 636	3. 561	3. 561
National Space Technology Laboratories	104	103	103
Goddard Space Flight Center	3. 482	3. 440	3. 440
Wallops Flight Center	398	395	395
Ames Research Center	1.666	1.658	1,658
Dryden Flight Research Center	480	461	461
Langley Research Center	3. 005	2. 980	2. 980
Lewis Research Center	2. 858	2. 835	2. 835
Headquarters	1.505	1,520	1.585
Total. Permanent Positions	22,831	22. 613	22. 713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National Aeronautics and Space Administration
ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSOCIATE DEPUTY ADMINISTRATOR
ASSISTANT FOR SPECIAL PROJECTS
CHIEF SCIENTIST
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DIRECTOR OF EOUAL OPPORTUNITY PROGRAMS
DIRECTOR OF PROCUREMENT
DIRECTOR OF LEGISLATIVE AFFAIRS
DIRECTOR OF SMALL & DISADV. BUSINESS UTIL.
STAFF ADVISORS
DIRECTOR OF PUBLIC AFFAIRS
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ASSOCIATE ADMINISTRATOR FOR MANAGEMENT OPERATIONS
ASSOCIATE ADMINISTRATOR EXTERNAL RELATIONS
ASSOCIATE FOR AERONAUTICS AND SPACE TECHNOLOGY
ASSOCIATE FOR SPACE SCIENCE
ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS
ASSOCIATE ADMINISTRATOR SPACE TRANSPORTATION SYSTEMS
ASSOCIATE ADMINISTRATOR SPACE TRACKING & DATA SYSTEMS
AMES RESEARCH CENTER
DRYDEN FLIGHT RESEARCH CENTER
GODDARD SPACE FLIGHT CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
JET PROPULSION LABORATORY
JOHN F. KENNEDY SPACE CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
LYNDON B. JOHNSON SPACE CENTER
WALLOPS FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES

RESEARCH
AND DEVELOPMENT

SUMMARY
INFORMATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 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 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 while minimizing their environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE TRANSPORTATION SYSTEMS: A program to provide all 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 transportation system to provide a wide variety of users with round trip access to space during the 1980's and beyond.

SPACE SCIENCE: A program utilizing space systems, supported by 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, using space, aircraft, and ground-based systems, to identify and demonstrate 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. 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 United States leadership in aeronautics and space. The program also provides for identification and evaluation of elements of NASA's aeronautics and space technology which can benefit National energy programs.

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

SPACE TRANSPORTATION SYSTEMS

Space Transportation Systems activities provide all the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the development and testing of the Space Shuttle--the first reusable space vehicle and the key element of a versatile, economical Space Transportation System to provide domestic and international users with round trip access to space for the 1980's and beyond.

The Space Shuttle is the most important element of the Space Transportation System. Its versatility and reusability will open up a new era in expanding the uses of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to Earth orbit of payloads and propulsive stages for higher 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 will enhance both the flexibility and the' productivity of space missions compared to existing expendable launch vehicles.

The Shuttle development program is in the final stages of ground certification testing of flight configured elements. The design certification review of the overall configuration was completed in April 1979 validating the basic technical soundness of the Shuttle system design. The major emphasis in FY 1980 will be on preparations for First Manned Orbital Flight. The checkout of the Columbia at Kennedy Space Center is progressing, although the scope and complexity of the initial launch processing flow are greater than originally planned and have caused delays in orbiter flight readiness. Technical problems have also affected progress in the main propulsion system development, and manpower and hardware have been added to the program in an effort to avoid further delays in achieving engine maturity at the rated power level and provide increased confidence in achieving performance at full power level. Other elements of the program are progressing well. The engines and external tank and solid rocket boosters required for the initial flight are in the initial stages of processing at the launch site, and all facilities at KSC are complete and in place for first flight and software validation is in progress. The production of follow-on orbiters is underway with the objective of providing operational orbiters to meet performance requirements for critical Department of Defense and civil missions.

Although the Shuttle development is demonstrating good overall progress, the delays encountered in processing the Columbia for launch and the impact of engine test problems have resulted in adjustments to program schedules requiring additional resources in all elements of the Shuttle system and supporting activities. This situation

has led to the requirement for the recommended supplemental appropriation in FY 1980 and to FY 1981 funding requirements above those previously planned. The FY 1981 Design, Development, Test and Evaluation activities will focus on orbital flight testing of the entire system and main engine testing to achieve full power level of performance. The budget request provides for completion of external tank and solid rocket booster deliveries to support the orbital flight tests, continued launch preparations, checkout and accomplishment of the orbital flight tests, and for continued engine testing. In Shuttle production, fabrication efforts on the second orbiter will be nearly completed and fabrication efforts on the third and fourth orbiter vehicles will be increased for delivery in support of Department of Defense missions at Vandenberg Air Force Base. Engine fabrication for the production vehicles will continue and flight spares for the orbiters' main engine, and ground support equipment will be procured. Additional launch processing equipment for the second line at Kennedy Space Center will be in the manufacturing stage during this time period.

In summary, progress at this critical phase of the Shuttle development effort has been substantial, but technical problems and increased requirements in contractor and subcontractor activities have made it necessary to adjust the program schedules and to request the supplemental appropriation for FY 1980. The FY 1981 budget request, which assumes enactment of the supplemental appropriation in FY 1980, provides for continuation of development, flight testing and orbiter production on a schedule to meet National requirements.

'Progress on the Space Shuttle will be matched in other activities vital to the establishment of the Space Transportation System operational capability and to preparations for early operational missions. The Spacelab, which will be a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built by the European Space Agency, with ten European nations participating in this development. The Inertial Upper Stage (IUS), which is being developed by the Department of Defense, will be used to deploy Shuttle-launched payloads to high energy and escape orbits. The spinning solid upper stage is being developed commercially and will be used for payloads that do not require the IUS capability. Other development and acquisition activities related to the Space Transportation System include ground support and control equipment, multiuse mission support equipment, and training equipment.

Hardware procurement and other activities in preparation for early Space Transportation System operational missions are in progress. FY 1981 funding will provide for continued procurement, assembly and checkout of the solid rocket booster, external tank, upper stages, and for flight plans, avionics software, flight control systems and crew procedures required for these missions.

Space Transportation Systems activities during FY 1981 will also provide expendable launch vehicles and services, as well as engineering support, required during the transition to the Space Transportation System.

SPACE SCIENCE

The Space Science program utilizes space systems, supported by airborne and ground-based observations, to conduct scientific investigations of the Earth and its space environment, the Sun, the planets, and 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, and 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 have been conducted to study solar phenomena. The discoveries from these missions and from the experiments flown during the Skylab Program provide the foundation for the Solar Maximum Mission to be launched in 1980. The Solar Maximum Mission spacecraft, together with data from Explorer spacecraft and Spacelab missions, will provide scientists with an opportunity to study the Sun, including solar flares and other solar phenomena, during the period of peak solar activity. The International Solar Polar Mission, a joint NASA and European Space Agency mission, will be launched in 1983 to study the polar regions of the Sun--regions which cannot be observed from the Earth or from current spacecraft. To achieve the trajectories required to study these polar regions, two spacecraft will be launched by the Shuttle-IUS combination, will swing past Jupiter, and use the gravity of that giant planet to send one spacecraft over the north pole of the Sun, and the other spacecraft over the south pole. The measurements to be made are expected to yield previously unknown information about the Sun and its dynamics and to advance our understanding of the link between solar activity and weather and climate trends on Earth.

Development of the Space Telescope will continue. This multiple purpose telescope will be launched by the Shuttle in 1983, 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 are yielding important scientific information. These missions are designed to explore the high energy phenomena observable with X-ray, gamma ray, and cosmic ray instruments. Work is also underway on Explorer spacecraft to study ultraviolet and infrared astronomy and the Sun-Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab.

The recommended FY 1981 program also provides for initiation of the Gamma Ray Observatory, a logical next step in high energy astrophysics. 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 occurring 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 orbiter continues to provide basic information about the massive cloud covered atmosphere of Venus. The Voyager missions, after providing a wealth of new information about Jupiter and its four largest moons, are on the way to Saturn. 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 1981 will be continued development effort on the Galileo mission which will carry a probe to make detailed measurements of the atmosphere of Jupiter and an orbiter to conduct extensive observations of the planet and its satellites. Because of launch capability considerations, it has become necessary to delay this mission from the previously planned launch during the January 1982 opportunity until the 1984 opportunity and to conduct separate launches of two spacecraft; one carrying the orbiter and the other the probe.

A concentrated scientific effort is underway to analyze and bring to bear on our understanding of the solar system the wealth of data acquired from all relevant sources, including the planetary flight missions, the Helios solar missions, the lunar flight programs, ground-based observations, laboratory investigations, and lunar sample studies.

The Life Sciences research and development program supports NASA's overall goals and objectives in the exploration and utilization of space by conducting studies in the areas of space biology and medicine and by expanding scientific knowledge in the area of the origin and evolution of life. The plan to achieve realization of these goals encompasses a program of research involving a composite of disciplines in ground-based research, in space flight experiments and in post-flight laboratory work building on the results of the flight experiments.

SPACE AND TERRESTRIAL, APPLICATIONS

The objective of the Space Applications program is to develop, demonstrate and transfer space technology, systems and related capabilities which can be applied for practical benefits here on Earth. Space Applications research and development covers the areas of Resource 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.

In Resource Observations, identification and monitoring by means of remote sensing from space have demonstrated new capabilities to provide data useful in such areas as agricultural assessments, water resources management, coastal zone monitoring, improvement of maps, land use and surface mine monitoring, forestry and range resources inventory, and mineral and petroleum exploration. Landsat 3, launched in 1978, is providing a wide variety of data applicable in these areas. Landsat-D, which will have a second generation, high resolution remote sensing instrument--the thematic mapper--and the flight-proven multispectral scanner,

will continue in development leading to launch in late 1981. The Magnetic Field Satellite and the Heat Capacity Mapping Mission continue to provide valuable information for geophysical and geologic studies. Experiments designed to test the applicability of active microwave measurements, and of high resolution imagery for mapping investigations, are planned for flight on early Shuttle missions. Joint activities with the users continue to demonstrate specific applications of the remote sensing data in a wide variety of areas.

The joint effort in agricultural research with the Department of Agriculture, the Department of Commerce, the Department of the Interior, and the Agency for International Development will continue. This effort emphasizes the use of remote sensing data, together with other data sources, to improve our knowledge with emphasis on improved agricultural early warning and crop commodity forecasting.

Space capabilities are also used in the development of precise measurements of the movements of the Earth's crust and other dynamic characteristics of the Earth to support research in earthquake mechanisms. A joint effort with the United States Geological Survey, National Science Foundation, National Geodetic Survey, the Department of Defense, and with other countries, will begin to monitor the motion and internal stability of several major tectonic plates and to determine the crustal deformation in seismically active areas.

In the area of Environmental Observations, NASA is involved with the National Oceanic and Atmospheric Administration and others in improving the understanding of atmosphere and ocean processes, providing space observations of parameters involved in these processes and extending the capabilities to predict environmental phenomena and their interaction with human activities. Areas of research and development include upper atmospheric research; global weather prediction; severe storm research; climate research; environmental quality monitoring; and, oceanic processes research. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography. The program focuses on the special contributions space-derived data can make in these fields.

NASA, in cooperation with other Federal agencies, is participating in a national program of climate research. Development will continue on the Earth Radiation Budget Experiment. This satellite system is designed to measure variations in the energy exchange between the Earth's atmosphere and space and other atmospheric factors important to climate research.

A National Oceanic Satellite System (NOSS) project will be initiated, in cooperation with the National Oceanic and Atmospheric Administration and the Department of Defense, to demonstrate an operational capability for application of remote sensing from space to the oceanographic program. The NOSS will be configured as a two satellite system, launched and capable of retrieval by the Shuttle, integrated with a single preprocessing and data distribution center on the ground.

Research and development will also be pursued in environmental quality monitoring and in oceanographic areas related to the remote sensing capabilities of spaceborne systems. Work will be in progress in FY 1981 on atmospheric experiments to be conducted on Spacelab missions.

Materials Processing researchand development activities are designed to exploit the unique characteristics of the space environment to achieve results which are not possible or practical on Earth. Experiments are being conducted in laboratories and with sounding rockets to build on the results of tests conducted on previous space flights and to prepare for experiments to be conducted on future Spacelab missions. The FY 1981 program provides for continued development of equipment and related activities for experiments to be conducted on early Spacelab missions and for enhancement of research activities.

Communications research and development efforts concentrate on advanced technology for communications satellite systems with significantly improved capabilities and on providing technical support and consultation to other Government agencies. Development is proceeding on the search and rescue satellite system, a co-operative venture with other US agencies, Canada, and France, to demonstrate improved capabilities €or detecting and locating distress signals from aircraft and marine vessels. The FY 1981 program alsu includes continuation of advanced communications research activities, and definition studies and advanced technology development on an experimental wideband communications satellite to operate in the newly allocated 30/20 GHz spectrum bands.

Technology utilization activities are designed to accelerate the transfer to the nonaerospace industry, as well as State and local governments, of new knowledge and innovative technology generated by NASA and NASA contractors. During FY 1981, NASA will continue its efforts to assure effective and widespread dissemination of new technology through a variety of established mechanisms including publications, industrial applications centers, a computer software management and information center, State technology applications centers, special application teams, and applications engineering projects.

AERONAUTICS AND SPACE TECHNOLOGY

The objective of the Aeronautics program is the advancement of aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs. This technology is necessary to help maintain the competitive position of the United States in the international aviation marketplace and to aid the military in maintaining the superiority of the Nation's military aircraft.

Research and technology base activities concentrate on the disciplinary areas of materials, structures, propulsion, avionics, aerodynamics and human-vehicle interactions to provide advanced technology essential to meeting the future needs of civil aviation. A strong generic research and technology base is critical to continued growth and improvement in United States aeronautical capabilities. Emphasis will continue to be placed on developing the technology to improve performance, reduce energy requirements, enhance operating efficiency, reduce undesirable environmental effects, improve safety and reliability, and improve terminal area operations for a variety of aircraft types. These efforts are integrated with additional focused tech-nology efforts to develop advanced long haul and short haul air transportation system concepts.

In the area of conventional take-off and landing aircraft, progress will continue on aircraft energy efficiency technology to provide, by the mid-1980's, the basis for a major reduction in fuel requirements for transport aircraft. In addition to efforts currently in progress, the recommended FY 1981 program includes a next step in advanced turboprop system technology to develop and verify propeller structural and aerodynamic scaling methodology for propellers for advanced turboprop propulsion systems.

In the area of rotorcraft, focused systems technology efforts initiated in FY 1980 will be continued. The near term objective is to develop verified design methods and design criteria for future quiet, efficient and all weather rotorcraft and to investigate configuration and component technology for advanced high speed and heavy lift/transport rotorcraft configurations.

Propulsion systems technology activities will include continuation of the variable flow propulsion system technology to develop and demonstrate the critical lower speed and lower temperature technologies unique to variable cycle propulsion systems for possible advanced supersonic cruise aircraft, and development of analytical models and predictive tasks required for designing turbine engine hot section components for increased durability and turbine life.

General aviation activities will focus on the reduction of noise emissions, crash worthiness and advanced low cost avionics systems. Work on vertical take-off and landing technology for potential future military and civil aircraft applications will be continued. Supersonic cruise research will focus on technology in the areas of propulsion, aerodynamics, structures, and controls. Research and technology efforts in the area of high performance aircraft will be conducted primarily in support of current and future military requirements ▪

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 program provides a sound foundation of research and technology in the areas of materials, structures, sensing and detection, guidance and control, data reduction and distribution, chemical and electric propulsion, space energy systems and aerothermodynamics.

Systems technology efforts include studies to focus the technology activities in directions which provide maximum benefits to future space programs. Other systems technology efforts are directed at developing the technology for advanced space communications systems and for conducting selected experiments in space. During FY 1981, experiments will continue to be integrated with the Long Duration Exposure Facility which will be maintained ready for integration with the Shuttle. The development and integration of experiments to be conducted on early Shuttle, Spacelab, and free-flying missions will be continued.

In the standards and practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and improvement of program practices, concentrating on such areas as specifications, testing, and flight project analysis. An independent assessment of Space Shuttle certification activities is being conducted.

Energy Technology efforts in NASA are primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on Earth. NASA provides technical support to the programs undertaken by other agencies to develop specific applications such as solar cells, solar heating and cooling, and electric power generation by wind power. NASA also makes its capabilities and facilities available to the Department of Energy and other agencies to accomplish energy technology activities on a reimbursable basis.

TRACKING AND DATA ACQUISITION

This program provides for continuation of tracking and data acquisition support for earth orbital spacecraft, planetary missions, sounding rockets, and research aircraft. This support is provided by a worldwide network of NASA ground stations, interconnected by a highly reliable communications system which provides the capability for instantaneous transmission of data and critical commands between spacecraft and the flight control centers. Facilities are also provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

The FY 1981 workload will remain high, with the Spacecraft Tracking and Data Network supporting an average of approximately 40 earth orbital scientific and applications spacecraft and the Deep Space Network supporting a full complement of planetary missions. Missions supported by the Spaceflight Tracking and Data Network include the High Energy Astronomical Observatories, the Heat Capacity Mapping Mission, Landsat-3, Magnetic Field Satellite, Nimbus-5, International Sun-Earth Explorers, International Ultraviolet Explorer, as well as international missions and missions of other U.S. Agencies. The Spaceflight Tracking and Data Network will also be supporting the Shuttle orbital flight tests. The support workload of the Deep Space Network will continue to include the Pioneer 6-11 missions, Helios 1 and 2 and Voyager 1 and 2 as well as Pioneer Venus.

A major aspect of the Tracking and Data Acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA will acquire this capability through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in 1981.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Federal Funds

General and special funds:

RESEARCH AND DEVELOPMENT.

'*See* Part III for additional information.

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; tracking and data relay satellite services as authorized by law; and purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration[; and including not to exceed $116,100,000 for Project **Galileo** and not to **exceed** $18,300,000 for space transportation system upper **stages,** without the approval of **the** Committees on Appropriations, $3,807,500,000] *$4,569,500,000*, to remain available until September **30,** [1981] 1982. ***(42 U.S.C.2/51, et seq.; Department of Housing and Urban Development—Zndependent Agencies Appropriation Act, 1980; additional authorizing legislation to be proposed.)***

Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1979 actual	1980 est	1981 est	1979 actual	1980 est	1981 est
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Space shuttle	1,638,300	1,586,000	1,873,000	1,588,332	1,601,000	1,897,000
(b) Space flight operations	299,700	446,600	809,500	307,039	412,100	688,000
(c) Expendable launch vehicle development	38,700	36,100	50,400	68,797	41,490	65,700
2. Scientific investigations in space:						
(a) Physics and astronomy	296,400	339,200	438,700	266,450	337,400	387,400
(b) Planetary exploration	183,400	219,900	179,600	189,501	209,300	204,800
(c) Life sciences	40,100	43,800	49,700	29,959	46,500	38,500
3. Space and terrestrial applications:						
(a) Space applications	295,200	364,300	387,000	277,342	362,110	366,100
(b) Technology utilization	9,100	12,100	13,100	7,571	9,800	9,800
4. Space research and technology	107.300	115.800	115.200	94.922	117,100	114.300
5. Aeronautical research and technology	264,100	308,300	290,300	244,275	279,700	302,800
6. Energy technology	5,000	3,000	4,000	6,887	3,700	4,100
7. Supporting activity:						
(a) Tracking and data acquisition	299,900	332,400	359,000	292,653	323,200	355,900
Total direct program	3,477,200	3,807,500	4,569,500	3,373,728	3,743,400	4,434,400
Reimbursable program:						
1. Space transportation systems:						
(a) Space shuttle	46,673	22,820	16,120	29,299	25,990	17,990
(b) Space flight operations	72,762	91,660	157,590	62,579	84,940	144.350
2. Scientific investigations in space:						
(a) Physics and astronomy	1,234	610	510	1,617	790	540
(b) Planetary exploration	10			6	4	
(c) Life sciences	297	233	180	255	230	198
3. Space and terrestrial applications:						
(a) Space applications	137,567	162,330	93,440	114,074	168,340	111,480
(b) Technology utilization	16,132	13,460	13,220	12,235	17,800	13,490
4. Space research and technology	1.055	−20	2	1.460	719	2
5. Aeronautical research and technology	19,763	12,240	9,870	19,998	15,750	10,600
6. Energy technology	196,311	224,430	275,400	134,489	213.370	267,670
7. Supporting activii:						
(a) Tracking and data acquisition	4,300	4,410	4,668	4,354	4,240	4,680
Total reimbursable program	496,104	532,173	571,000	380,366	532,173	571,000
Total program costs, funded	3,973,304	4,339,673	5,140,500	3,754,094	4,275,573	5,005,400
Change in selected resources (undelivered orders and stores)				115,133	488.991	135,100
10.00 Total	3,973,304	4,339,673	5,140,500	3,869,227	4,764,564	5,140,500

General and special funds—Continued

RESEARCH AND DEVELOPMENT—Continued

Program and Financing (in thousands of dollars)—Continued

Identification code 80-0108-0-1-999	Budget plan (amounts in research and development actions programed)			Costs and obligations		
	1979 actual	1980 est	1981 est	1979 actual	1980 est	1981 est
Financing:						
Offsetting collections from:						
11.00 Federal funds	-380,871	-412,130	-478.563	-380,871	-412,130	-478,563
14.00 Non-Federal sources	-115,233	-120,043	-92,437	-115,233	-120,043	-92,437
Reallocation of prior year unobligated reimbursable orders to current year:						
11.00 Federal funds				25,552		
14.00 Non-Federal sources				10,021		
21.40 Unobligated balance available, start of year: For completion of prior year budget plans:						
Direct				-240,403	-239,006	
Reimbursable				-116,945	-185,885	
23.40 Unobligated balance transferred to other accounts				680		
24.40 Unobligated balance available, end of year: For completion of prior year budget plans:						
Direct				239,006		
Reimbursable				185,885		
25.00 Unobligated balance lapsing				282		
40.00 **Budget authority (appropriation)**	3,477,200	3,807,500	4,569,500	3,477,200	3,807,500	4,569,500
Relation of obligations to outlays:						
71.00 Obligations incurred. net				3,408,696	4,232,391	4,569,500
72.40 Obligated balance, start of year				515,865	785,812	1,364,303
74.40 Obligated balance, end of year				-785,812	-1,364,303	-1,789,603
90.00 Outlays				3.138.749	3.653.900	4.144.200

Note —Reconciliation of budget plan to obligations

	1979 actual	*1980 estimate*	*1981 estimate*
Total budget plan	3 973.304	4,339,613	5,137,400
Deduct portion of budget plan to be obligated in subsequent years	348 368		
Add obligations of prior year M g e t plans	244 292	424 891	
Total obligations	3 869 227	4 764 564	5 137 400

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET PLAN SUMMARY

Code		FY 1979	FY 1980	FY 1981
		(Thousands of Dollars)		
	SPACE TRANSPORTATION SYSTEMS	2,011,600	2,403,300*	2,738,200
253	Space Shuttle	1,638,300	1,886,000*	1,873,000
253	Space flight operations	299,700	446,600	809,500
253	Expendable launch vehicles	73,600	70,700	55,700
	SPACE SCIENCE	505,400	600,800	668,000
254	Physics and astronomy	282,900	337,100	438,700
254	Planetary exploration	182,400	219,900	179,600
254	Life sciences	40,100	43,800	49,700
	SPACE AND TERRESTRIAL APPLICATIONS	283,900	343,900	394,800
254	Space applications	274,800	331,800	381,700
254	Technology utilization	9,100	12,100	13,100
	AERONAUTICS AND SPACE TECHNOLOGY	376,400	427,100	409,500
402	Aeronautical research and technology	264,100	308,300	290,300
254	Space research and technology	107,300	115,800	115,200
254	Energy technology	5,000	3,000	4,000
255	TRACKING AND DATA ACQUISITION	299,900	332,400	359,000
	Total	3,477,200	4,107,500*	4,569,500

*Includes proposed supplemental appropriation of $300,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFLJNCTION

Code		FY 1979	FY 1980	FY 1981
			(Thousands of Dollars)	
253	Space Flight	2,011,600	2,403,300"	2,738,200
254	Space Science, Applications and Technology	901,600	1,063,500	1,182,000
255	Supporting Space Activities	299,900	332,400	359,000
(250)	Subtotal, General Science, Space and Technology	3,213,100	3,799,200*	4,279,200
402	Air Transportation	264,100	308,300	290,300
	Total	3,477,200	4,107,500*	4,569,500

*Includes proposed supplemental of $300,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE AMINISTRATION

FISCAL YEAR 1981 ESTIMATES

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

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarter
OFFICE OF SPACE TRANSPORTATION SYSTEMS, TOTAL	1979	2,011,600	1,095,527	232,354	584,148	12,250	46,052	---	---	10	824	10,633	12,200	17,602
	1980	2,403,300	1,239,450	296,271	660,150	13,100	50,765	200	---	---	1,400	5,264	16,892	119,808
	1981	2,738,200	1,314,900	338.200	845.000	10.700	50,600	200	---	---	700	2.300	4,300	171,300
Space Shuttle	1979	1,638,300	949,775	156,600	511,594	6,350	---	---	---	10	824	93	200	12,854
	1980	*1,886,000	1,098,600	204,800	462,800	7.600	---	---	---	---	1,400	100	---	110,700
	1981	1,873,000	1,104,200	196,900	408,300	5,500	---	---	---	---	700	---	---	157,400
Space flight operations	1919	299,700	145,752	66,154	72,554	5,900	5,556	---	---	---	---	---	---	3,784
	1980	446,600	140,850	87,800	197,350	5,500	7.800	200	---	---	---	100	---	7,000
	1981	809,500	210,70(	138,500	436.700	5.200	7,100	ZOO	---	---	--	100	---	11,000
Expendable launch vehicles	1979	73,600	---	9,600	---	---	40.496	---	---	---	---	10,540	12,000	964
	1980	70,700	---	3,671	---	---	42,965	---	---	---	---	5,064	16.892	2,108
	1981	55.700	---	2.800	---	---	43,500	---	---	---	---	2.200	4.300	2.900
OFFICE OF SPACE SCIENCE, TOTAL	1979	505,400	24.177	560	125,099	---	87,048	128,983	7,028	74,323	185	1,052	185	56,760
	1980	600,800	27.148	2,536	155.271	---	83,665	195.694	5,678	58,036	164	106	---	72,502
	1981	668.000	34.381	3.487	177.658	---	121.608	184.600	6,874	53.078	288	77	---	85,949
Physics and astronomy	1979	282,900	346	335	124,275	---	83.299	19,314	7,028	20,401	---	1,052	185	26.665
	1980	337,100	1,713	1,813	155,226	---	79,908	53,950	5,678	12,817	---	59	---	25,936
	1981	438,700	6.181	2,358	177,583	---	117,828	80.977	6,874	8,901	---	37	---	37,961
Planetary exploration	1979	182,400	4,115	---	824	---	3,749	107.899	---	40,841	---	---	---	24.972
	1980	219,900	6,012	---	45	---	3,757	140,067	---	30,953	---	7	---	39.059
	1981	179,600	5,990	---	75	---	3,780	101,877	---	28,340	---	---	---	39,538
Life sciences	1979	40,100	19,716	225	---	---	---	1,770	---	13,081	185	---	---	5.123
	1980	43,800	19,423	723	---	---	---	1,677	---	14,266	164	40	---	7,507
	1981	49.700	22.210	1.129	---	---	---	1.746	---	15,837	288	40	---	8,450
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS. TOTAL	1979	283,900	24,291	620	26,974	3,199	159,941	23,520	3,118	8,716	54	10.499	5,709	17,259
	1980	343,900	25,430	1,528	29,255	3.040	183,120	20,163	4,215	16,930	37	15,348	11,168	33,666
	1981	394.800	42,140	345	24.490	3.795	199,650	23.560	4,765	19.545	50	13.695	17.750	45.015
Space applications	1979	274,800	24,146	520	26,412	3,199	159,076	22.951	3,114	7,983	---	9.789	5,294	12,316
	1980	331,800	25,330	1,428	28,705	2,940	182,320	18,463	3.915	16,010	---	14,548	10,368	27,773
	1981	381,700	41,990	195	23,950	3,720	198.770	21,570	4,390	18,295	---	12,805	17,000	39,015
Technology utilization	1979	9,100	145	100	562	---	865	569	4	733	54	710	415	4,943
	1980	12,100	100	100	550	100	800	1,700	300	920	37	800	800	5.893
	1981	13.100	150	150	540	75	880	1.990	375	1.250	50	890	750	6,000
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY. TOTAL	1979	376,400	7,179	---	11,597	---	9.656	23.567	614	58.468	8,903	116,643	131,091	8,682
	1980	427,100	10.540	---	8,367	---	8,848	24.503	600	64.681	13.300	143,682	142,122	10,457
	1981	4W.500	8.550	---	9,200	---	9.400	23.350	500	63.200	13.200	139.900	134.700	7.500
Aeronautical research and technology	1979	264.100	1.245	---	1,113	---	---	1,489	614	48,564	8,903	92.171	106,960	3,041
	1980	308,300	495	---	725	---	---	830	600	54,800	13,300	115,800	117.450	4,300
	1981	290,300	200	---	800	---	---	800	500	53,400	13.200	109.900	108,100	3,400
Space research and technology	1979	107,300	5,284	---	9,279	---	9.656	20,918	---	9,904	---	24,472	22,866	4,921
	1980	115,800	10,045	---	6,642	---	8,848	22,673	---	9.881	---	27.882	23,694	6,135
	1981	115,200	8,200	---	7,150	---	9,400	20,800	---	9,800	---	30,000	25,900	3,950
Energy technology	1979	5,000	650	---	1,205	---	---	1.160	---	---	---	---	1,265	720
	1980	3,000	---	---	1,000	---	---	1,000	---	---	---	---	978	22
	1981	4.000	150	---	1,250	---	---	1.750	---	---	---	---	700	150
OFFICE OF SPACE TRACKING AND DATA SYSTEMS	1979	299,900	---	---	---	---	216,557	59,021	5,800	---	3,150	---	---	15.372
	1980	332,400	---	---	---	---	234,000	69,800	6,500	---	3,300	---	---	18,800
	1981	359,000	---	---	---	---	249.700	74.400	9,800	---	3.600	---	---	21,500
TOTAL BUDGET PLAN	1979	3,477,200	1,151,174	233.534	747,818	15,449	519,254	235,091	16,560	141,517	13,116	138,827	149,185	115.675
	1980	4,107,500	1,302,568	300,335	853,043	16.140	560,398	310,360	16,993	139,647	18,201	164,400	170,182	255.233
	1981	4,569,500	1,399,971	342,032	1,056,348	14,495	630.958	306,110	21,939	135,823	17,838	155,972	156,750	331,264

*Includes supplemental request of $300 million.

SPACE
TRANSPORTATION
SYSTEMS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE TRANSPORTATION SYSTEMS

Programs	Budget Plan			
		1980		1981
	1979 Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)			
Space Shuttle	1,638,300	1,366,000	1,886,000*	1,873,000
Space flight operations	299,700	467,300	446,600	809,500
Expendable launch vehicles	73,600	70,700	70,700	55,700
Total	2,011,600	1,904,000	2,403,300*	2,738,200

*Includes proposed supplemental request of $300,000,000

SPACE
SHUTTLE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Design, Development, Test and Evaluation	1,270,300	830,500	1,030,500	683,000	
Orbiter	727,800	420,800	560,900	320,900	RD 1-7
Main engine	172,700	140,600	140,600	145,700	RD 1-11
External tank	104,800	68,403	79,400	48,000	RD 1-13
Solid rocket booster	115,400	57,500	61,200	14,000	RD 1-15
Launch and landing	149,600	143,200	188,400	154,400	RD 1-17
Changes/System Upgrading	---	---	100,000	150,000	RD 1-20
Production	368,000	755,500	755,500	1,040,000	
Orbiter	264,500	570,600	572,600	768,200	RD 1-22
Main engine	75,500	109,900	123,600	121,500	RD 1-23
Launch and landing	7,000	20,000	16,400	40,400	RD 1-23
Spares and equipment	21,000	55,000	42,900	109,900	RD 1-23
Total	1,638,300	1,586,000	1,886,000*	1,873,000	

*Includes Supplemental request of $300,000,000.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation:				
Johnson Space Center	949,775	973,500	1,098,600	1,104,200
Kennedy Space Center	156,600	164,200	204,800	196,900
Marshall Space Flight Center	511,594	427,500	462,800	408,300
National Space Technology Laboratories	6,350	4,000	7,600	5,500
Ames Research Center	10	---	---	---
Dryden Flight Research Center	824	1,500	1,400	700
Langley Research Center	93	100	100	---
Lewis Research Center	200	---	---	---
Headquarters	12,854	15,200	110,700	157,400
Total	1,638,300	1,586,000	1,886,000	1,873,000

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 will be the first reusable space vehicle, and will be configured to carry many different types of payloads to and from low earth orbit. Its development will provide multipurpose, economical space operations for earth applications, scientific, defense, and technological payloads. The 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 equipment to orbit; and to perform rescue missions. These capabilities will greatly enhance flexibility 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 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 can also provide a habitable environment for the crew, which will include scientists and engineers.

MISSION PROFILE:

The Space Shuttle will be launched into space by the thrust of its three liquid oxygen/liquid hydrogen main engines, burning in parallel with the twin solid rocket bnosters. Two minutes into the flight, at an altitude of about 45 kilometers (km) (24 nautical miles), the solid rocket boosters will burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) downrange. They will then be recovered for refurbishment and reuse. The orbiter will continue on into space, powered by its three main engines, for another six and one-half minutes. Just before orbital insertion, the engines

will be shut down and the external tank will be jettisoned. Following a ballistic trajectory, the empty tank will reenter, tumble, and break up over a remote ocean area about 18,500 km (10,000 nautical miles) downrange. The orbiter, aided by its orbital maneuvering engines, will enter Earth orbit to perform its mission. After completing the mission, the orbiter will again fire its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will have a 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 no greater than three times that of gravity (3-g forces) during launch and landing, and will be able to perform their work in a shirt-sleeve environment.

STATUS:

The Space Shuttle Program is in the final period of development toward the first orbital flight (STS-1), expected in the last half of 1980. All Space Shuttle system flight elements have been delivered to the Kennedy Space Center (KSC) for STS-1, other elements are proceeding in test and manufacture, and major ground test programs are being conducted. The Mated Vertical Ground Vibration Test (MVGVT), conducted at the Marshall Space Flight Center (MSFC), was completed early in 1979 using Orbiter 101 (Enterprise), an ET and SRBs, and the data has been used to update dynamic math models of the Space Shuttle system. These mathematical models are being used to predict the vehicle response under vibration during the launch and ascent phases of flight. The test elements used in the MVGVT were delivered to KSC for launch facility verification tests, which were successfully completed. Orbiter 101 was then returned to Palmdale, CA, where it will be used for future tests, removal of critical flightworthy parts, and possible use as part of a facility verification vehicle for the Vandenberg Air Force Base (VAFB). The Main Propulsion Test (MPT) series, which started in 1978 at the National Space Technology Laboratories (NSTL), continued through 1979. This test involves three main engines mounted on an orbiter aft fuselage and coupled to an ET to test the entire propulsion system. MPT progress has been slowed due to failures in testing and necessary engine modifications, but the test activity is now beginning to increase again. A highly successful full-duration MPT static firing test of 550 seconds was conducted on December 17, 1979, which represents accomplishment of a significant milestone. This was the first full duration test of the total propulsion system and it included engine throttling and gimballing. Hardware certification testing is continuing across all elements.

FY 1980 activities support preparations for the first orbital flight. Orbiter 102 (Columbia), which will be used for the Orbital Flight Test (OFT) Program, is in final assembly and checkout at the Orbiter Processing Facility (OPF) at KSC. Thermal protection system (TPS) installation problems have been a major cause for delay in this orbiter final assembly. In 1980, this orbiter will be delivered to the vehicle assembly building (VAB) for assembly with the ET and SRB's to prepare for launch. The orbiter structural

test article (STA) testing was completed by Lockheed at Palmdale, CA, in 1979. The STA was then transferred back to Rockwell International (RI) where it is being modified to become the second flight orbiter (Orbiter 099 - Challenger).

A number of technical problems (i.e., main fuel valve, turbine seal, steerhorn, and incorrect grade of welding wire) have occurred in 1979 during various phases of the main engine test program. A nozzle steerhorn failed as a direct result of using an incorrect grade of welding wire that was too soft and was mixed in with the correct strength welding wire, which resulted in a severely weakened weld joint. However, we have now achieved over 60,000 seconds of test time, and are on our way to the 80,000 seconds, which we expect to reach prior to STS-1. The first phase of the Preliminary Flight Certification (PFC) has been completed with over 5,000 seconds accumulated on one engine, and a second series of PFC testing on a second engine has started. The three engines which will be used for the first orbital flight all completed acceptance test firings, are installed and are undergoing checkout in Columbia at KSC. Modifications will be made to these flight engines early in 1980 to correct recent problems detected during engine testing at NSTL -- steerhorn improvements and a new turbopump.

The first flight ET has been delivered to KSC for use in STS-1, and three other tanks are in various stages of manufacture at the Michoud Assembly Facility (MAF). The fourth solid rocket motor (SRM) development firing and two qualification motor firings were accomplished during 1979. The third and final qualification firing is planned for early 1980. In addition, the SRB components for the first orbital flight were delivered to KSC in 1979.

The flight hardware elements for STS-1 are all at KSC and are progressing well through element processing toward stacking and mating into the overall assembled vehicle. The SRB's are stacked on the mobile launcher awaiting the ET. The ET checkout will be completed and it will be mated with the SRB's during the first quarter of 1980. Columbia, which has been undergoing manufacturing, modifications, and testing throughout FY 1979, is being prepared for mating. Integrated vehicle processing is planned to continue through a flight readiness firing prior to the planned STS-1 launch.

The central computerized Launch Processing System (LPS) and ground support equipment (GSE) in the forward stations of the first line of facilities at KSC are operational and processing the flight elements for the first Space Shuttle orbital mission. Only the launch pad and the SRB retrieval and disassembly stations are still in the activation phase. They will be operational by mid-1980. The primary orbital flight test landing station at Dryden Flight Research Center (DFRC) in California is operational and an alternate landing strip is being prepared at the White Sands Missile Range in New Mexico. The KSC processing test and checkout procedures and software for each station or sequence are being developed and verified.

To establish a national fleet of operational orbiters, Space Shuttle production includes fabrication of two additional orbiters, refurbishment of Orbiter 102 (Columbia), after its use in the orbital flight tests

and early operations, and conversion of the orbiter STA to an operational orbiter (Orbiter 099-Challenger). Also included are the second series of launch and GSE at KSC for the simultaneous launch processing of two orbiters, and initial operational spares and equipment. Activities planned in FY 1980 include: orbiter subsystem hardware fabrication for converting the STA to orbital flight capability, structures fabrication for Orbiter 103 (Atlantis), and main engine hardware fabrication. Procurement of GSE required for the "second line" launch capability at KSC and initial operational spares and crew equipment has been initiated and will continue.

During 1979, a number of important reviews of Space Shuttle Program management were held. Findings included the following: original cost constraints were too severe and reserves were inadequate, schedules demanded more performance than could be delivered, and long-range planning was inadequate. Corrective actions have been implemented throughout the Space Shuttle Program, including management improvements at NASA Headquarters, NASA Centers, prime contractors, and at the major subcontractors.

CHANGES FROM FY 1980 ESTIMATE:

NASA is requesting a supplemental appropriation of $300 million for FY 1980 to meet additional Space Shuttle development requirements and to provide for the potential impact of necessary changes and systems modifications required to increase reliability and safety and to lower operating costs of the space transportation system. The additional development requirements result primarily from increased efforts to complete systems installation and test, particularly the orbiter thermal protection system and prelaunch processing of the first orbital vehicle; systems qualification and certification problems across all elements of the program; and the delay of the first orbital flight test until the last half of 1980. The FY 1981 budget request assumes approval and timely availability of the proposed FY 1980 Supplemental Appropriation.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1981:

- Continue main propulsion testing to achieve 109% of rated power performance requirements
- Complete the second set of main flight engines
- Complete delivery of the third and fourth flight sets of solid rocket booster hardware to complete the OFT Program
- Complete delivery of three external tanks for the OFT program
- Complete analysis of the first manned orbital flight (STS-1) for application to the subsequent OFT flights
- Process development hardware at KSC, for the launch of orbital flights 2, 3, and 4
- Continue follow-on orbiter fabrication and assembly leading to a national fleet of operational orbiters
- Reconfigure Columbia for the first operational flight

DESIGN, DEVELOPMENT, TEST, AND EVALUATION

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of dollars)		
Orbiter	727,800	420,800	560,900	320,900

OBJECTIVES AND STATUS:

The Space Shuttle orbiter is a reusable launch vehicle which serves as the orbiting spacecraft to deploy and retrieve payloads in low earth orbit and to provide quarters for the personnel. It reenters the atmosphere and lands as an unpowered aircraft, returning crew and payloads. A payload of 29,500 kilograms (65,000 pounds) can be placed in low earth orbit at an altitude of 185 km (100 nautical miles). The physical dimensions of the payload may be as large as 4.6 meters (15 feet) in diameter and 18.3 meters (60 feet) in length.

The Orbiter Columbia was assembled in Palmdale, CA, checked out, and delivered to the Orbiter Processing Facility (OPF) at KSC in March 1979. Considerable open work was transferred with the vehicle. The majority of open work and manufacturing has been completed with the exception of the installation and testing of TPS tiles. Orbiter integrated tests will be completed early in 1980, and the vehicle will be prepared for stacking and prelaunch checkout in mid-1980. The testing required to certify Columbia for the first flight test is scheduled to be completed in mid-1980.

Although the TPS presented the major orbiter problem during 1979, other difficulties were encountered in the auxiliary power units, avionics software, the landing wheels and tires, and structural modifications required by the latest derived loads data. Redesigns, improvements, and corrective actions ark proceeding successfully in all these areas.

Tests of the STA, which has a flight type airframe, have been completed by Lockheed at Palmdale, CA. The vehicle has been returned to Rockwell at Palmdale, CA, and is undergoing demating for modifications and updating to the Challenger flight vehicle configuration. Orbiter 101 (Enterprise) completed full-scale ground vibration tests at MSFC, and was used at KSC for facility interface verification. The Enterprise has been shipped to Palmdale, CA, where hardware components will be used as test articles or for flight spares. The vehicle will be configured for facility verification at VAFB.

The overall avionics verification testing is underway at the Space Shuttle Avionics Integration Laboratory (SAIL) at JSC for ascent and at the Flight Systems Laboratory (FSL) at Rockwell in Downey, CA, for entry. Verification tests of various acceptable but off-nominal environment Space Shuttle vehicle equipment conditions, as well as equipment failure conditions, are underway. Initial testing is being conducted with the latest available flight software for the primary and backup flight control systems, and when the final configuration inspected flight software is received, the avionics flight verification testing will be completed. Engineering real-time simulations are being conducted to investigate flight control problem areas derived from structural and wind tunnel testing. Software modifications will be required to implement the changes resulting from the engineering simulations.

Preparations are underway to conduct SAIL testing with the Electrical Systems Test Laboratory (ESTL) at JSC. The ESTL provides real-time data representing both the ground and tracking and data relay satellite systems and communications links to verify that the tracking and communications flight systems in the SAIL function properly with the rest of the avionics system. Combined systems testing is planned at FSL to demonstrate the flight control actuation systems for the aerosurfaces and the main engine thrust vector controls with the Space Shuttle hydraulic system using the FSL--Hardware Evaluator and Flight Control Hydraulics Laboratories. Remote Manipulator System (RMS) verification testing on the guidance and control test stations at SAIL is also scheduled for 1980. Overall avionics verification testing will be conducted at SAIL to demonstrate the suitability of flight crew procedures and mission techniques using qualified flight crew members manning the crew station during verification tests. Final flight software initial conditions for the specific launch day data and vehicle configuration will be demonstrated prior to the STS-1 flight, and landing simulations on the Ames Research Center new moving base simulation facility are planned to provide further verification of the STS-1 landing capabilities and techniques.

RMS activities managed by JSC in FY 1980 will focus upon preparations to define and support RMS flight tests during the OFT. The generation of flight tests documentation will be based upon data analysis of the simulation operations performed during FY 1979, for payload handling, manipulator control, and operator training. The Canadian funded efforts are centered upon the manufacture and hardware acceptance tests (ground) for delivering the RMS in the second quarter of CY 1980, and support to JSC on development of flight test documentation and engineering support to integrate the RMS with

the orbiter at KSC. The change in delivery date of the design, development, test and evaluation (DDT&E) RMS from November 1979 to the second quarter of CY 1980 is due to additional testing and hardware redesign requirements.

Support activities managed by JSC will continue, including: software modifications in the Mission Control Center (MCC), use of crew training simulators, development of government furnished equipment such as space-suits, and the performance of tests to support the orbiter project. The emphasis for FY 1980 is on preparation for the OFT's.

We have accelerated the development of the Manned Maneuvering Unit (MMU) in order to have on-orbit inspection and repair capability for the TPS. A qualification unit and two flight articles will be produced, and crew training will begin on the contractor's simulator (Martin Marietta Corporation, Denver, CO). The MMU and associated equipment will be required in January 1981. It is not required for the first flight since the flight is designed for a benign environment and each tile will have been verified to safety factors of at least 1.4 times the full operational requirement.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 orbiter estimate has increased by $140.1 million. This increase resulted from the additional engineering and subcontractor activity due to problems encountered in the qualification and certification programs and the additional effort required to complete the application and testing of thermal protection tiles, and other subsystem installations at KSC. There have been a number of major changes such as on-orbit TPS repair and a heads-up display, as well as numerous changes required to make the system operate properly as determined by the comprehensive test programs. In addition, there have been a number of subcontractor cost increases due to development and producibility problems. Examples include: TPS tiles, auxiliary power unit, orbiter maneuvering system pod, the KU-band rendezvous radar, S-band communications subsystems, and extravehicular suit development. Other funding increases have been experienced in support areas caused by schedule delays, and in systems areas due to additional vehicle system testing planned for FY 1980.

BASIS OF FY 1981 ESTIMATE:

The OFT Program, using Columbia, is planned for initiation in the last half of 1980 with the first manned orbital flight (STS-1). Post flight analysis of this first flight will be conducted, and engineering will be provided to support follow-on development flights. Orbital flights are planned on an average of every three to four months. The OFTs are expected to continue throughout FY 1981.

During STS-1 final countdown and flight, the SAIL and FSL will be configured to provide real time support to the mission. In addition, these facilities will be used to analyze flight data, prepare analysis for post-flight reports and to investigate flight anomalies. Specific avionics verification programs will be conducted for each OFT to confirm the avionics operation with primary and backup flight software in the new configurations. These include operations of the RMS, KU-band radar, the Tracking and Data Relay Satellite (TDRS), and payloads' operations. Specific testing to verify the operation of the Space Shuttle avionics system with the Inertial Upper Stage (IUS) and its payloads will also be conducted. Flight support and post-flight analysis will be conducted for each subsequent orbital test flight. Testing and analysis of some specific mission operations involving vehicle maneuvering, extravehicular activity and payload operations will be conducted at SAIL and FSL to verify the avionics system support of the missions plans. A number of avionics equipment and flight software improvements have been identified to be incorporated during the OFT Program and early operational flights. The software deliveries are phased to be commensurate with avionics improvements and mission requirements. Each of these improvements will also be verified on SAIL and FSL.

The support activities necessary for each orbital flight will continue in FY 1981. The MCC will support integrated simulations with the Space Shuttle Mission Simulator to train the flight crews and flight controllers for these orbital flights.

Each development flight is a test to progressively support the verification of the Space Shuttle for operational use. Design certification and flight readiness reviews will be conducted before each flight to assure that there are no constraints to the specified flight mission assignment. The orbital tests are necessary to verify hardware and software operation, ground and flight procedures, system characteristics over a range of conditions, primary and backup operational modes, and overall performance. Flight test data on the systems performance will be reviewed after each flight and corrective action taken, where necessary, to meet operational requirements. Throughout the development flight test program, engineering will be provided to perform this analysis, resolve problems, and verify systems operations. These FY 1981 efforts will lead to the certification of the Space Shuttle's readiness to enter the operational phase in FY 1982.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1981:

- Complete orbiter analysis of the first OFT (STS-1)
- Support OFT flights 2-4 in preparation, data analysis, engineering, and incorporation of necessary changes
- Complete certification of Orbiter 102 flight readiness for follow-on OFTs
- Deliver Mission/MOD kits for specific orbital flights
- Continue life demonstration tests on critical orbiter subsystems
- Develop improved TPS for follow-on operational vehicles

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Main Engine.....	172,700	140,600	140,600	145,700

OBJECTIVES AND STATUS:

The Space Shuttle orbiter will use three high pressure liquid hydrogen/oxygen engines, each with a 2,100,000 newton (470,000-pound) vaccum thrust level. The Space Shuttle Main Engine (SSME) represents a major advance in propulsion technology, and incorporates maximum utilization of existing technologies. In addition, it has the advantage of a long operating life. It is the first large liquid fuel rocket engine designed to be reusable, and will require minimum maintenance between flights. An engine-mounted controller is used to ensure operation within the limits of the high temperatures and pressures in the combustion cycle. Performance has been increased by using a two stage combustion process with a high expansion ratio nozzle, which results in more efficient engine operations.

During FY 1979, problems with several main engine components continued to delay the test program causing the main engine project to accumulate fewer test seconds than planned. Engine development testing was proceeding at a good pace until a nozzle steerhorn failure (May 14, 1979) destroyed most of the internal parts of Engine 0201. A main fuel valve failure on a Main Propulsion Test Article (MPTA) Engine 2002 (July 2, 1979) caused further temporary suspension of testing. During main propulsion testing (November 4, 1979), an early shutdown was initiated when a high pressure oxygen turbopump (HPOTP) turbine seal failed on Engine 0006. During the shutdown, another nozzle steerhorn failed destroying most of the internal parts of Engine 2002. An investigation determined that the second steerhorn failure was the result of a "soft" weld caused by use of the incorrect grade of welding wire mixed in with the correct strength welding wire. Failure modes and causes of these failures (main fuel valve, nozzle steerhorn, HPOTP turbine seal) have been identified, modifications incorporated, and testing resumed. Another engine has been assigned to the MPT Program. The successful full duration MPT test lasting 550 seconds (December 17, 1979), represented a significant milestone in the main propulsion development program. As a result of the problems during 1979, completion of the MPT Program in support of STS-1 has slipped to mid-1980.

In spite of these problems, progress this year has been significant. The first certification cycle of the Preliminary Flight Certification (PFC) program was completed. Sixteen tests were conducted for a total of 5,245 seconds on Engine 2004. This included four flight mission profile tests of 520 seconds, one flight mission profile over-stress test (102% rated power level (RPL), and two abort mission simulations of 665 and 823 seconds. A repeat of the PFC program is now in progress on the same engine (2004).

Seven of the thirteen objectives have been accomplished with a total of 3,000 seconds accumulated to date. A total of four PFC cycles will be conducted on two or more engines with at least two certifications on one engine. To date, a total of approximately 530 tests have been conducted accumulating over 60,000 seconds of operation with about 175 tests and over 28,000 seconds at RPL. This past year, we conducted about 130 tests and accumulated over 22,000 seconds of operation with about 100 tests and over 17,000 seconds at the RPL. Thus, over 77% of the test seconds-accumulated this past year has been at RPL or higher. Much of the time not at RPL is start transient time and throttling time to various power levels to determine engine performance at the lower power levels.

Testing will continue on flight configured engines during 1980 leading to the main engine flight certification for STS-1. It is planned to accumulate approximately 80,000 seconds of test time prior to flight including: single engine, main propulsion testing, and PFC testing. The MPTA, consisting of a cluster of three engines, a flight-weight external tank, and the aft fuselage of the orbiter, is maintained in the STS-1 configuration and will continue in testing during the fiscal year. Data from main propulsion testing will constitute a part of engine verification. PFC testing will be completed accumulating approximately 20,000 seconds on two or more engines. Single engine testing will also be intensive to prove the durability of each component of the system. Full power level (FPL-109% of RPL) testing will start late in FY 1980. By mid-1980, all engine modifications will have been incorporated in the flight engines installed in Orbiter 102 to support the flight readiness firing and the first orbital flight.

In addition to the development and test work by Rocketdyne and the subcontractors, the main engine activities provide the necessary project support efforts. These efforts include the procurement of propellants for test firing the engine and its components, the maintenance of the engine systems hardware simulation laboratory, logistic support, and the evaluation of materials and processes.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, continuing support will be provided for the OFT. This effort will include a full complement of component and full engine test capability and analytical support for the flight conditions. Single engine testing will continue in order to accomplish PFC of the engine at FPL. During the certification program, the engine must demonstrate reliability and performance at 109% of rated power. The last two MPTA tests are scheduled for FY 1981 to demonstrate this 109% power level operation of three engines in a cluster. FY 1981 main engine funding will also support the engine system simulation laboratory, engine software integration, and procurement of propellants for the test programs at Santa Susana and at NSTL.

MAJOR PRGJECT ACTIVITIES PLANNED IN FY 1981:

- o Continue engine testing to achieve final flight certification at FPL
- o Complete fabrication and delivery of the second set of flight engines
- o Provide laboraboty, test, and analytical support for the OFT Program

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
External Tank (ET).....	104,800	68,400	79,400	48,000

OBJECTIVES AND STATUS:

The ET will contain 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 liftoff to main engine cutoff, which occurs just before orbital insertion. Following the main engine cutoff, the ET will separate from the orbiter and tumble 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 will contain 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).

During 1979, structural testing of the liquid hydrogen tank was successfully accomplished at MSFC. The ground vibration test tank was shipped to KSC where it was mated to a set of inert SRB's and the Orbiter Enterprise for a thorough checkout of the launch facilities, GSE, and supporting interface equipment. The tank was then shipped to MAF for storage and eventual reuse as a flight tank after modifications are accomplished.

During the summer, a design change was implemented to prevent the formation of ice on the tank protuberances which if dislodged during ascent could damage the orbiter tiles. This will be accomplished by a newly designed KSC ground purge system and the addition of spray-on foam insulation (SOFI) and electrical heaters around the potential ice forming areas. The determination of aerodynamic crossflows from the SRB's, and newly defined air loads which could exceed the cable trays' structural strength, will be resolved by the addition of large SOFI ramps. The first flight tank, delivered to KSC in mid-1979, is in the process of having these changes incorporated, including the ice/debris and air load SOFI ramps. It is expected that all modifications will be completed in early 1980.

The second flight tank is in the process of having its TPS applied. Delivery to KSC of this tank is planned for the third quarter of 1980. The third and fourth flight tanks will be structurally assembled, the TPS applied, and readied for shipment to KSC during the year. Deliveries of these two tanks will take place in FY 1981.

During FY 1980, a major engineering effort will be expended on the lightweight tank (LWT) design. The goal of reducing the weight of the tank by 6,000 pounds will be achieved by optimizing the thickness of the basic skin, ribs, and chords of the intertank, liquid oxygen, and liquid hydrogen tanks. Early in FY 1980, 20% of the LWT design had been released for raw material ordering and vendor fabrication of components. A preliminary design review was held during this quarter, and a critical design review is planned for May 1980 which will support the delivery of the first LWT before the end of 1981.

In FY 1980 efforts are being undertaken to improve the producibility of the ET. The basic objective is to develop new techniques and processes to build the ET more efficiently, and more economically. Areas of activity include improved welding techniques and an automated inspection system; an alternate foam material for the liquid hydrogen tank aft dome; and improvements in tank priming, cleaning and protection. In the thermal protection area, SOFI, and ablator improvements are being developed, and improvements in the forming and chemical milling processes have started.

At the beginning of FY 1980, the liquid boost module was selected as the thrust augmentation baseline concept to achieve increased ascent performance capability for the Space Shuttle. This concept employs Titan hardware (engines and modified propellent tankage) mounted under the ET. Since this liquid propulsion module impacts the ET structure of the liquid hydrogen tank, design studies were initiated in FY 1980 which will continue into 1981.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The ET estimate for FY 1980 has increased by $11.0 million. This increase was principally caused by changes, particularly to protect against protuberance icing and to accommodate additional air loads data. The ET project cost also grew because of increased estimates to perform weight reduction and the additional ET producibility efforts.

BASIS OF FY 1981 ESTIMATE

The third and fourth development tanks will be in the final phases of assembly and checkout at MAF with deliveries planned for the first half of 1981. Design modification efforts of the LWT will peak during the year. This work will result in optimizing to reduce the amount of material in the major structural elements of the ET while still keeping manufacturing costs low. Producibility improvements

in assembly and manufacturing techniques will be a major engineering effort during the year in order to reduce operational costs. ET design studies for thrust augmentation to accommodate the liquid boost modules will also be in progress in FY 1981.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1981:

- Deliver last two development ET's (ET-3 and -4)
- Complete final ET installation at KSC for STS-2, 3 and 4
- Evaluate flight data performance (STS-2 and -3 flights)
- Continue designs for:
  - Lightweight tank
  - Producibility improvement
  - ET thrust augmentation

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Solid Rocket Booster (SRB).....	115,400	57,500	61,200	14,000

OBJECTIVES AND STATUS:

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

The main element in the SRB system is the Solid Rocket Motor (SRM), which is being developed by Thiokol, Wasatch Division, Utah. Other booster system elements such as the recovery system, Thrust Vector Control (TVC), attach structures, forward and aft skirt, and separation motors are being procured separately. MSFC is performing designated systems integration tasks, and has the responsibility for total systems integration of the SRB effort.

In 1979, the booster separation motor qualification test firings were successfully completed, and the flight motors for the first two OFTs were delivered to KSC. The structural test program, to verify the major structural elements for flight loads, were completed during 1979, and water impact loads testing started. These tests are scheduled for completion early in 1980. Fabrication of the flight structural components is progressing very well. Delivery of the major structural components to KSC required for the four OFTs has been completed. Fabrication of the parachutes for the orbital flights is continuing with the flight sets for the first two flight missions delivered to KSC. The TVC systems testing was completed at MSFC to verify the overall performance characteristics, and successful TVC system operation was completed during the SRM test firings at Thiokol. The TVC systems for STS-1 have successfully completed hot firing and are installed on the flight aft skirts. The booster assembly contractor has been actively involved with the assembly and checkout of the boosters for STS-1, and they have delivered the hardware to the VAB high bay area for stacking.

The component qualification test program for all the SRB major systems has progressed satisfactorily with approximately a 75% completion of the qualification testing required for the first flight. The total test program is scheduled for completion in early 1980. During 1979, the fourth and final development motor was loaded and test fired. Two of the three SRM qualification tests of the flight configuration have been successfully fired, and the third will be tested in early 1980. All SRM segments for STS-1 have been delivered and stacked at KSC.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The SRB estimate for FY 1980 has increased by $3.7 million. This change was caused by cost increases in the SRB subsystems, qualification test problems, and technical changes; as well as DDT&E flight hardware delivery delays to support the slipped development flight schedule.

BASIS OF FY 1981 ESTIMATE

Manufacture and assembly of flight hardware for the DDT&E flights will continue through 1980. The booster assembly contractor will assemble and checkout the SRB's for all the flight missions, and will be involved with the refurbishment and checkout of recovered hardware for use in all orbital development flights continuing into 1981. During FY 1981, the major activities will consist of the assembly and checkout of the boosters for the orbital development flights, and the refurbishment and checkout of recoverable hardware. The capability to verify the acceptability of refurbished hardware for reuse will be completed. An OFT flight utilizing refurbished hardware will also be accomplished during 1981.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1981:

- o Complete delivery of all OFT hardware
- o Complete assembly and checkout of flight SRB's at KSC for OFT Program
- o Refurbish and launch first reusable hardware flight set
- o Continue production efficiency and cost improvements plan

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
			(Thousands of Dollars)	
Launch and Landing.....	149,600	143,200	188,400	154,400

OBJECTIVES AND STATUS

The Space Shuttle launch and landing project includes the preparation of a series of Space Shuttle landing, ground processing, and launch station sets at KSC and the DFRC and their operation through the OFT phases. These station sets include: handling, testing, and servicing systems; and GSE. The Launch Control Center (LCC) at KSC contains the heart of the computerized automated Launch Processing System (LPS), which connects to many of the station sets for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing. In addition to the landing facilities at KSC and DFRC, landing support facilities are planned for construction at the White Sands Missile Range, New Mexico, to provide a backup lake bed landing site for early OFTs.

Activation of the various launch and landing station sets has been paced to match the flight hardware development, certification, and readiness for flight. However, the launch support team has been fully implemented, and all personnel are on board and engaged in prelaunch checkout. The Space Shuttle landing stations at DFRC and KSC, and the OPF and LPS at KSC were activated in FY 1979, and were operational at the beginning of FY 1980. The mobile launcher, parachute packing, propulsive element checkout (SRB, ET, SSME), and vehicle assembly stations in the VAB were activated in the first quarter of FY 1980. The launch pad and SRB retrieval and disassembly station are progressing on schedule toward activation and operational status in the third quarter of FY 1980. A second firing room and LPS control set will also be activated in FY 1980 to allow the development and checkout of ground test software in parallel with vehicle testing. During FY 1980 construction of facilities at White Sands is being accomplished to handle the orbiter processing in event of landings at that site.

Delivery and installation of most of the required KSC GSE was completed during FY 1979 and early FY 1980. About 98% of the required KSC provided GSE (approximately 290 models) and 90% of the contractor provided GSE (approximately 680 models) have been delivered and installed in the processing stations. Both GSE and flight systems replacement spares are being laid in, processing fluids are being supplied to support checkout and testing, and propellants are being accumulated for the first launch.

The processing station activation remaining for FY 1980 includes the completion of activation of the launch pad and SRB retrieval and disassembly stations. The fuel cell and hypergolic propellant loading systems are still in the test certification phase, an ice protection and purge swing arm is being installed at the launch pad, and the remaining GSE is being implemented on schedule.

The major portion of launch and landing work now is the operation of the station sets and the processing and launch of the flight hardware. Processing includes test and checkout of the individual flight elements, stacking and mating of the elements to assemble the overall space vehicle, and testing, servicing, and launching the vehicle. The development contractors which provide on-site launch support include Rockwell International, Martin Marietta, United Space Boosters, Inc. and Thiokol.

The Orbiter Columbia has been in processing in the OPF since its delivery to KSC in March 1979. It was delivered without some flight systems and TPS tiles installed, and has since been undergoing manufacturing completion in parallel with systems testing. Most systems have now been tested. Some qualification and certification tests have been performed, and some performance and integration tests remain to be completed. The first flight ET was delivered in July 1979, and it is now being processed in the VAB. The first set of flight SRB's, which were delivered in November and December 1979, have undergone subassembly of skirts and nose frustrums to motor segments and stacking on the mobile launcher in the vehicle assembly station in the VAB.

The vehicle processing still to be accomplished in FY 1980 includes: completion of fabrication and testing of the Orbiter Columbia, mating the ET, orbiter, and SRBs; and processing the mated vehicle through vehicle interface test, flight readiness firing, countdown, and launch. After launch, the SRB's will be retrieved and disassembled for refurbishment and reprocessing. The orbiter will land at DFRC after the STS-1 mission, be deserviced, then mated with the carrier aircraft and ferried back to KSC; where it will be inspected, repaired, and reprocessed including the replacement of a number of TPS tiles. Other flight elements will be processed for STS-2 during FY 1980, and work on the turnaround of Columbia will be initiated immediately after STS-1.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The primary reason for the $45.2 million increase in the budget for the launch and landing project is the additional time and effort required to prepare for the launch of STS-1. This additional effort has impacted the funding requirements because Orbiter 102 has been in processing in the OPF longer than planned, while the test and checkout phase of launch preparation is being completed. In addition, the test and checkout phase is proving to be more complicated and require more manpower than had originally been estimated. The capacity of the LPS computers required expansion, and many changes necessary to make the ground system operate properly continued to be required to prepare GSE for operational use.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, the principal activities in the launch and landing project will focus on processing flight elements and vehicles for STS-2 through STS-4. The fiscal year effort should start with the assembled space vehicle for STS-2 in the VAB, proceed with interface testing there, and then the full processing procedure at the pad. This FY 1981 processing activity is supported with the LPS, logistics, transportation, propellants, and spares provisioning. There are also provisions for facility and equipment modifications and required changes throughout this development period.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1981:

- Complete space vehicle processing and launch for STS-2
- Perform element and space vehicle processing and launch for subsequent OFT missions
- Retrieve reusable flight hardware from OFTs

CHANGES AND SYSTEMS UPGRADING

	FY 1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Changes and Systems Upgrading	-	-	100,000	150,000

OBJECTIVES AND STATUS:

Recent management and cost reviews at various levels throughout the Space Shuttle Program at NASA and with major contractors **have emphasized the need for an adequate allowance for likely changes and** potential systems modification to achieve improved performance. Such funds are necessary, particularily at this time, to provide for the modificatons which are most likely to result from the orbital flight tests, necessary changes to increase reliability and safety, and to lower operating costs of the space transportation system.

Space Shuttle system areas in which these changes and upgrading efforts are likely to be required include the elevon actuators, the radiator door configuration, the launch processing system, plus changes in the fuel cells, inertial measurement unit, and the auxiliary power unit. As these requirements develop and are approved they will impact the funding estimates for either development or production and the funding will be applied accordingly.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

This provision for changes and systems upgrading is a newly identified requirement consistent with the recommendations of the program management reviews and constitutes a part of the **proposed** FY 1980 **supplemental appropriation for the Space Shuttle Program.**

BASIS OF FY 1981 ESTIMATE:

In FY 1981, the orbital flight test program will be in progress with flights scheduled on a three to four month intervals. It is anticipated that changes and systems modifications will be identified from our flight test experience. To provide an adequate allowance against the expectation of these unknown requirements materializing due to the flight activity, the FY 1981 estimate has been increased over that planned in FY 1980.

PRODUCTION

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Orbiter	264,500	570,600	572,600	768,200	RD 1-22
Main Engine	75,500	109,900	123,600	121,500	RD 1-23
Launch and Landing	7,000	20,000	16,400	40,400	RD 1-23
Spares and Equipment	21,000	55,000	42,900	109,900	RD 1-23
TOTAL PRODUCTION	368,000	755,500	755,500	1,040,000	

OBJECTIVES AND STATUS:

Space Shuttle production provides for modification of the orbiter STA to orbital flight configuration (Orbiter 099), refurbishment of Orbiter 102 after the OFT program and early operations period, and the fabrication and assembly of two additional orbiters to establish a national fleet of operational orbiters. Production activities also include fabrication of main engines, preparation of the second series ("second line") of Space Shuttle ground processing and launch support equipment at KSC to permit simultaneous processing of two Spact Shuttle vehicles, and the necessary Space Shuttle spares and equipment required to establish the initial inventory to support the operational flight rate capability of the Space Shuttle.

The structural test program performed at Palmdale, CA, utilizing the orbiter STA airframe, was completed in 1979. The test data is being used to certify the structural capability of the orbiter. After completion of the planned structural testing, the STA was returned to the Rockwell plant at Palmdale to be converted to an orbital configuration (Orbiter 099 -- Challenger) for delivery in mid-1982. The modifications which have been started consist of the removal of specific elements and instrumentation required during testing; installation of a flight-type crew module; addition of functional subsystems such as the orbital maneuvering system, the reaction control system, the atmospheric revitalization system, and the flight control and communications systems; and the application of the TPS.

Fabrication and assembly of the major subsystems of Orbiter 103--Atlantis, which is scheduled for delivery late in 1983, has begun at Rockwell International and at the major structural subcontractors. The crew module and the forward and aft-fuselage elements are in assembly at Rockwell; and the wings, vertical stabilizer, and mid-fuselage are in assembly at Rockwell's subcontractors. Some long lead ordering of critical parts was also accomplished for Orbiter 104 (Discovery) during FY 1979. Orbiter 104 is scheduled for delivery at the end of 1984. During 1979, NASA defined a weight reduction program for imnlementation on Orbiters 099, 103, and 104. A definitized contract, replacing the letter contract placed in effect in FY 1979, is to be negotiated and signed in FY 1980 for the manufacture of the RMS for the production orbiters. Funds appropriated for FY 1979 to maintain the option for possible fabrication of a fifth orbiter were used to begin procurement of critical long lead time items. NASA only ordered items which were common to a four or five orbiter program and not specifically for a fifth orbiter.

FY 1980 funding provides for continuation of long lead time material and component procurements for those additional flight engines required for the operational orbiter fleet. Engine component procurements include hot gas manifold and preburner body forgings, turbopump castings, main combustion chamber parts, and selected raw materials and plate stock for engine component fabrication. In addition, fabrication of liquid hydrogen and liquid oxygen high and low pressure turbopump components has been initiated, and assembly of the first set of production engines will begin during FY 1980.

In order to provide the "second-line" capability required at KSC during the operational years, the procurement of necessary additional ground and launch support equipment was initiated during FY 1979. This equipment will be installed in the OPF and the LCC at KSC. NASA has also initiated the procurement of flight crew equipment for the extravehicular mobility unit (spacesuit), communications equipment, and the portable oxygen system. In addition, procurements for ET and SRB rate tooling will be initiated in FY 1980.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The current FY 1980 estimates are the same in total as projected in the FY 1980 budget. There has been a rebalancing to reflect the revised orbiter delivery schedules and the acceleration of engines to provide backup hardware to support the development program.

BASIS OF FY 1981 ESTIMATE:

Orbiter

Modification of Orbiter 099 to orbital flight configuration will continue during FY 1981 for delivery to KSC in mid-1982. Fabrication of a new crew module and other major subsystems, such as the orbital maneuvering system and the reaction control system, will be continued for assembly into Orbiter 099.

Fabrication of the major structural elements for Orbiter 103 will continue in FY 1981 for delivery in late 1983. These activities will include the aft fuselage, crew module, wings, and TPS tiles. In addition, manufacturing activities will be initiated on subsystems such as the orbital maneuvering system, reaction control system, flight control and communciations systems, and environmental control systems.

In FY 1981, fabrication will begin on the fourth flight vehicle, Orbiter 104, which is planned for delivery at the end of 1984. The efforts will consist of continuing the procurement of long-lead items such as basic materials and forgings by the major structural subsystem contractors. Selected subassembly vendors with a long lead time fabrication cycle will also continue manufacturing hardware for Orbiter 104. The weight saving activities initiated in FY 1979 will continue during FY 1981 to support Orbiter 099, 103 and 104 deliveries.

In FY 1981, Remote Manipulator System (RMS) production will also continue in order to provide the arms, spares, and GSE €or follow-on operational use.

Main Engine

Production engine materials and component procurement will continue during FY 1981. Component deliveries such as forgings, turbopumps, main combustion chamber parts, and other engine parts will be phased to support the fabrication and assembly operations. Fabrication and assembly of engines for installation into Orbiter 099, will be completed and the engines will be delivered to KSC during FY 1981. Fabrication and assembly of engines for installation into Orbiter 103 will be underway by the end of FY 1981. Early delivery of production engines will provide additional hardware in the event it is needed for development testing. All engines will also undergo acceptance testing at NSTL before delivery to KSC.

Launch and Landing

The capability at KSC to support simultaneous launch processing and checkout of two orbiter vehicles requires the procurement of additional ground and launch support equipment. In FY 1981, the procurement of this "second-line" capability will be continued. The FY 1981 efforts will increase for GSE purchases, installation in the OPF Bay No. 2 and the two remaining high bays of the VAB, modifications to the second mobile launch platform, and installation of launch processing system equipment in the Launch Central Center's (LCC's) second firing room.

Spares and Equipment

Space Shuttle spares and equipment include: orbiter flight and GSE spares, main engine spares, KSC launch site GSE spares, and crew equipment. SRB and ET rate tooling required to increase the rate of production during the operational years is also provided. During FY 1981, NASA will initiate procurement of flight spares for the required orbiter subsystems and main engine component spares, and will continue purchasing tooling for the increased SRB and ET production rate required for future operations.

SPACE FLIGHT
OPERATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Space transportation systems operations capability development	64,500	69,800	54,100	89,000	RD 2-3
Development, test and mission support	177,200	172,600	172,600	183,500	RD 2-13
Advanced programs	7,000	13,000	13,000	10,800	RD 2-19
Spacelab	26,700	58,800	58,800	151,700	RD 2-21
Space transportation system operation	24,300	153,100	148,100	374,500	RD 2-23
Total	299,700	467,300	446,600	809,500	
Distribution of Program Amount by Installation:					
Johnson Space Center	145,752	170,800	140,850	210,700	
Kennedy Space Center	66,154	71,700	87,800	138,500	
Marshall Space Flight Center	72,554	208,450	197,350	436,700	
National Space Technology Laboratories	5,900	5,500	5,500	5,200	
Goddard Space Flight Center	5,556	6,700	7,800	7,100	
Jet Propulsion Laboratory	---	---	200	200	
Ames Research Center	---	---	---	---	
Langley Research Center	---	---	100	100	
Lewis Research Center	---	---	---	---	
Headquarters	3,784	4,150	7,000	11,000	
Total	299,700	467,300	446,600	809,500	

OFFICE OF SPACE TRANSPORTATION SYSTEMS SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

Space Transportation Systems (STS) Operations Capability Development provides for space transportation system development activities other than the Space Shuttle. These development and support activities are necessary to the orderly transition to STS operations. Principal areas of activity include the STS Upper Stages, Multi-mission and Payload Support Equipment, Mission Control Center Upgrading (Level II), Payload and Operations Support and Thrust Augmentation.

Development, Test and Mission Support 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 Laboratories for space transportation systems research and development activities.

The Advanced Programs 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 European 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 and which will lead 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, the Upper Stages into a versatile and economical system; accomplish mission planning; provide the operational recurring hardware and consumables; and support all launch, flight, recovery, crew and related activities.

Space Transportation System (STS) Operations Capability Development

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Space transportation system upper stages	19,300	18,300	18,300	39,000	RD 2-5
Multimission and payload support equipment	10,400	9,600	9,600	13,000	RD 2-7
Mission control center (MCC) upgrading (Level II)	10,300	16,000	12,900	15,800	RD 2-8
Payload and operations support	10,000	10,900	10,900	11,200	RD 2-9
Thrust augmentation	4,000	15,000	2,400	10,000	RD 2-11
Teleoperator retrieval system	10,500	---	---	---	---
Total	64,500	69,800	54,100	89,000	

OBJECTIVES AND STATUS:

The Space Transportation Systems Operations Capability Development activity includes five major areas of effort: Space Transportation System Upper Stages; Multimission and Payload Support Equipment; the Mission Control Center (MCC) Upgrading (Level II); Payload and Operations Support and Thrust Augmentation. The STS Upper Stages, which consist of the Inertial Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS), are an integral part of the Space Transportation System. 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. The IUS, being developed by the Department of Defense, is a multi-stage, solid propellant expendable vehicle which will become operational in 1981. The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy planetary missions. The Spinning Solid Upper Stages (SSUS), being developed by the McDonnell Douglas Corporation as a commercial venture are spin-stabilized solid propellant expendable upper stages sized to be used for Delta and for Atlas-Centaur class payloads to be launched into geosynchronous orbit.

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 for 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 two simultaneous orbiter missions, the ground simulation network, and an MCC-launch site interface.

The Payload and Operations Support activity consists of three major efforts: Operations Management Support, Orbital Flight Test (OFT) Payload Integration, and the Payload Operations Control Center (POCC). The Operations Management Support efforts are focused on determining the most efficient method of operating the Space Transportation System. The Orbital Flight Test Payload Integration provides for integrating payloads on the OFT flights during the 1980-1981 period. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads.

Thrust Augmentation is the definition of requirements and specifications to provide the additional thrust necessary to insure full Space Shuttle system payload deployment capability of orbiter missions launched from the Vandenberg Air Force Base. Of the possible Thrust Augmentation options studied, the selected approach is the addition of a liquid boost module, using Titan hardware mounted under the External Tank.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The STS Operations Capability Development estimate changes are explained within each project.

BASIS OF FY 1981 ESTIMATES:

STS Upper Stages funds are required in FY 1981 to continue to support the development of the NASA-Unique IUS configuration, hardware, software, IUS mission planning, and implementation.

FY 1981 funding for the Multimission and Payload Support Equipment (MMPSE) is required to complete development, initial testing and orbiter installation of MMPSE mission kits and the payload specialist station (PSS); complete testing of the trace gas analyzer and the first set of cargo integration and test equipment (CITE); continued design of mixed cargo hardware and CITE dual capability.

FY 1981 funding is required to continue support in upgrading the Mission Control Center (Level 11) at the Johnson Space Center, including completion of the design specifications for multi-vehicle command and control software and related systems and the initiation of systems integration and testing.

In addition, FY 1981 funds are required to complete checkout and testing of the Payload Operations Control Center in support of operational flight schedule requirements and support of orbital flight test mission payloads. Operations Management Support will continue to focus on efficient modes of operating the Space Transportation System (STS).

Thrust Augmentation effort must continue in FY 1981 on Phase B design studies to conclude definition of design specifications and to study the impact of the Thrust Augmentation concept with respect to thermal and loads impact on the total Shuttle system and facilities.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Space Transportation System (STS) Upper Stages.....	19,300	18,300	18,300	39,000

OBJECTIVES AND STATUS:

The Space Transportation System (STS) Upper Stages are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These Upper Stages are the Inertial Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS) required for delivery of payloads to geosynchronous orbits and for high energy missions, such as planetary exploration missions.

The Inertial Upper Stage is being developed by the Department of Defense (DOD). It is a multi-stage, solid propellant expendable vehicle and will be operational in 1981. NASA is coordinating the incorporation of NASA-unique and other non-DOD requirements during the design, development, test, and evaluation phase to insure IUS operations compatibility with the space transportation system. The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy planetary missions.

The Inerial Upper Stage (IUS) payload capability exceeds the capability needed by many geosynchronous payloads using today's expendable launch vehicles. The Spinning Solid Upper Stage is being developed commercially for these smaller payloads in two weight classes. The Delta class (SSUS-D) will be capable of injecting up to 2750-pound payloads into geosynchronous transfer orbit, while 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 cost economies to the user community. These relatively low cost upper stages have simple physical and functional interfaces €or 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. As a result, the launch costs to the user can be significantly reduced. The SSUS emphasis is on servicing the commercial spacecraft user and his requirements.

The DOD two-stage IUS configuration and the NASA unique twin and twin spinner vehicle developments are proceeding on schedule to meet scheduled launches beginning in late 1981.

The critical design review has been successfully completed and vehicle and airborne support equipment component qualification is underway and scheduled for completion early in 1980. Six motor case burst tests, three motor skirt tests, and two full-scale motor firings were satisfactorily conducted this year. Also in FY 1980, systems qualification of the two-stage vehicle and its airborne support equipment will be completed. The two-stage IUS will support the first launch of TDRSS in late 1981.

The systems level preliminary design review has been held for the NASA unique twin and twin spinner IUS with a delta design review scheduled for early 1980. Vehicle and airborne support equipment designs have been modified to allow incorporation of changes (primarily structural) that were selected to provide performance improvements necessary to meet design reference mission requirements. The NASA unique development program is in the process of being rephased to a schedule which will support an International Solar Polar Mission first launch in early 1983. As a result, the critical design review will be rescheduled for late 1980. The development of ground and flight operations capability and IUS/Orbiter integration analyses and testing is continuing.

The commercial development of the SSUS-A and SSUS-D by McDonnell Douglas Corporation is proceeding on schedule to meet anticipated launch requirements. The design has been completed and critical design reviews accomplished. Materials and components have been procured and most elements are manufactured and ready for assembly. SSUS-D motor development has been completed and qualification is beginning; two development motors were successfully tested at simulated altitude in May and September of 1979, and the first qualification motor was tested in November. Testing to determine the spacecraft vibration environment induced by SSUS-A motor burn was completed in December. The SSUS qualification program is now starting and will be the principal development activity during 1980. During FY 1980, planning and analyses to integrate the SSUS with the Shuttle will be continued.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

Although no change from the FY 1980 budget is shown at this time, present estimates indicate that it will be necessary to provide some additional funding to continue upper stage development on a schedule consistent with flight missions requirements. Appropriate notification will be provided to Congressional committees as the extent of this additional requirement is more clearly defined.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 STS Upper Stages funding is required to continue to support the development of the NASA-unique IUS configuration. This effort includes completion of the critical design review of the NASA unique developments and initiation of component and software qualification. In addition, the funding will support continuation of the development of NASA IUS launch site ground operations capability; IUS/Orbiter integration analyses and testing; and the development of IUS mission planning and flight operations capability.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Multimission and Payload Support Equipment	10,400	9,600	9,600	13,000

OBJECTIVES AND STATUS:

Multimission and Payload Support Equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between the payloads and elements of the Space Transportation System (STS). These requirements can be satisfied more economically from a standardized 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 integrated 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 Test Range.

(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 space transportation system 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 Shuttle attached payloads while they are active.

(4) Flexible Multiplexer/Demultiplexer - The flexible multiplexer will combine the orbiter data stream and up to five separate payload telemetry or command data streams into a single output signal. The function

of the flexible demultiplexer is to separate the combined data signal, either telemetry or command, back into the appropriate orbiter or payload data streams.

(5) Cargo Integration and Test Equipment (CITE) - This equipment is required 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.

(6) Trace Gas Analyzer - The trace gas analyzer system will perform in-flight monitoring of the aggregate "offgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of each of the atmospheric constituents.

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

In Fy 1980, manufacture of multimission and payload support equipment such as the intersite transportation equipment and the trace gas analyzer will be completed. Other activities include activation of the first set of cargo integration and test equipment (CITE); initial design and development of the dual CITE capabilities; continued design of the mixed cargo hardware, mission kit equipment and the self-contained payload containers; and continued development of the payload specialist station.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds are required €or development, initial testing and orbiter installation of multimission and payload support equipment such as the self-contained payload containers, mission kits and payload specialist station. Testing of the trace gas analyzer and the first set of Cargo Integration and Test Equipment (CITE) will be completed. FY 1981 funds will also provide for the continued design of the mixed cargo hardware and CITE dual capability.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Mission control center (MCC) upgrading (Level 11)	10,300	16,000	12,900	15,800

OBJECTIVES AND STATUS:

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. MCC Level I, funded under the Shuttle development program, provides hardware and software to configure the MCC to support Shuttle development flights. The MCC during the operational era will require additional flight control rooms, support rooms, hardware and software to accommodate two simultaneous orbiter missions, a ground simulation network, dual launch site interfaces, and Spacelab and IUS systems monitoring.

Upgrading the Mission Control Center (Level 11) at the Johnson Space Center will continue in FY 1980 with the completion of design specifications for dual vehicle command and control software and initiation of detailed systems design, development and implementation. Development completion and initial testing of the Flight Planning System II, consisting of flight design and crew activity planning elements, will be achieved, in support of early flight rate requirements.

CHANGES FROM FY 1980 BUDGET ESTIMATES:

The Mission Control Center (MCC) Level II budget in FY 1980 has been reduced by $3.1 million by rephasing the development of MCC capabilities in conjunction with opexational payload requirements consistent with the Shuttle schedule adjustment. Of this reduction, $2.4 million has been reallocated to Thrust Augmentation definition studies. The remaining $.7 million reduction is a portion of the general appropriation reduction in Research and Development.

BASIS FOR FY 1981 ESTIMATE:

Upgrading the Mission Control Center (Level 11) will continue during FY 1981. Funds will be required for procurement of communication interface equipment and the reconfiguration software development, as well as design, checkout, and testing of the trajectory, telemetry and command software systems.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Payload and operations support	10,000	10,900	10,900	11,200

OBJECTIVES AND STATUS:

The Payload and Operations Support activity consists of three major areas of effort: Payload Operations Control Center (POCC); Operations Management Support; and Orbital Flight Test (OFT) Payload Integration.

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

In FY 1980, development of hardware and software systems for the Payload Operations Control Center at the Johnson Space Center will continue to allow payload command and control and some real time data review and analysis; and analytical integration activities will be completed for the Orbital Flight Test Payloads.

Operations Management Support will focus on defining the most efficient mode of operating the Space Transportation System (STS). FY 1980 studies will continue the examination of options in STS management during the operational era, the analysis of elements of STS cost per flight, the retrieval of payload data from nonstandard STS orbits, and range safety requirements. Some of the tasks for FY 1980 include a review of analytical techniques for plume impingement and contamination, computerized safety assessments and toxic material control and disposal techniques.

The Orbital Flight Test (OFT) Payload Integration provides for the integration of payloads on the OFT flights. The activities include management integration such as planning, scheduling, and coordinating all elements; interface definition in environmental, structural and thermal areas; safety analysis; hardware integration; flight support; and development of the interface control document. The FY 1980 funds will continue to support conceptual flight planning, launch site planning, and thermal and loads analysis for payloads to be flown on the Shuttle orbital flight test missions.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds will be used to complete checkout and testing of the Payload Operations Control Center in support of the operational flight schedule requirements and for operation of those parts of the POCC which will support the orbital flight test mission payloads. Funding for Operations Management Support will be used to continue the focus on efficient modes of operating the Space Transportation System (STS).

Orbital Flight Test Payload Integration funding in FY 1981 is required for the integration and handling of payloads for the OFT missions in the late 1980 through the 1981 time period.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Thrust Augmentation	4,000	15,000	2,400	10,000

OBJECTIVE AND STATUS:

As the Space Shuttle development has progressed, it has become clear that the required payload capability will not be sufficient for certain important missions, primarily out of the Vandenberg Air Force Base. This deficiency results primarily from increases in Orbiter weight as a result of design/equipment changes. Approved payload programs scheduled for early STS operational flights from Vandenberg Air Force Base can be accommodated by the Space Shuttle orbiter with currently projected performance capability by limiting certain single payloads to that capability, by restricting the total cargo weight for multiple payload missions, and by limiting the experiment weights and/or durations of Spacelab missions. However, these limitations reduce cost effectiveness and prevent full utilization of the Space Shuttle Orbiter's design potential and its new and unique capabilities. Additional thrust is necessary to ensure that the full Space Shuttle system payload deployment capability of 32,000 pounds and 25,000 pounds retrieval capability can be achieved for the 98° inclination, 150 NM circular Shuttle mission launched from Vandenberg Air Force Base. The current projected capability is not sufficient to perform this mission. The thrust augmented STS meets all design and performance reference mission requirements and offers the potential to accommodate payload growth, new payloads, and concepts. Consequently, it is important to the future national space capability that thrust augmentation be developed and made available to support payload requirements which exploit the full capability of the STS.

NASA performed preliminary evaluations of alternative performance augmentation concepts of which the most promising, from both the performance and cost aspects, were solid rocket motor strap-ons to the SRB and/or the ET, and a liquid rocket engine package placed under the external tank (ET). The liquid rocket engine, the liquid boost module concept for Space Shuttle Thrust Augmentation was adopted as the baseline concept. This concept employs existing Titan engines and tankage, modified as required, to be mounted under the External Tank. Thrust Augmentation will increase Space Shuttle performance from Vandenberg Air Force Base by 12,000 pounds to 36,000 pounds. Total development and integration costs were assessed by NASA as being comparable for the liquid and solid concepts; however, the liquid rocket engine package offers a greater increase in capability for the baseline case.

FY 1980 work includes systems engineering tests and wind tunnel and model tests, structural and aerodynamic loads analyses, and Phase B studies to identify the design specifications and performance requirements for the liquid boost module. The FY 1980 effort will also consist of systems engineering activities to understand the

aerothermal, structural, dynamic, and vibroacoustic impact of the liquid boost module on the external tank and solid rocket boosters. Facility requirements will also be studied.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The NASA budget request of $15 million for FY 1980 was authorized. However, no funds were included in the NASA appropriation for thrust augmentation activities. During the discussion in both the House and Senate upon the presentation and adoption of the appropriations conference report, it was agreed that NASA could use other funds for continuation of design work for thrust augmentation. Consistent with this stipulation and the currently projected operational. need date at Vandenberg Air Force Base, funds in the amount of $2.4 million have been reallocated from within the Space Flight Operations line item to continue ongoing studies of the baselined liquid boost module thrust augmentation concept.

BASIS OF FY 1981 ESTIMATE:

In order to achieve the necessary operational capability in calendar year 1985, effort must continue in FY 1981 primarily to conclude the definition of the liquid boost module design specification and to study the impact of thrust augmentation on each element (orbiter, external tank, and solid rocket booster), as well as the impact on the overall system and launch facility.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

DEVELOPMENT, TEST AND MISSION SUPPORT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Research and test support	42,016	41,900	31,100	32,400	RD 2-14
Data systems and flight support	55,617	47,000	35,900	40,200	RD 2-15
Operations support	34,476	39,500	43,600	45,900	RD 2-16
Launch systems support	45,091	44,200	62,000	65,000	RD 2-17
Total	177,200	172,600	172,600	183,500	

OBJECTIVES AND STATUS:

Development, Test, and Mission Support (DTMS) provides the common engineering, scientific and technical support required to conduct ongoing and proposed space transportation systems (STS) research and development at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL). DTMS functions include research and test support, data systems and flight support, operations support, and launch systems support. These common efforts are necessary to support early project definition; to provide engineering support for indepth technical examination of development efforts of prime and major subcontractors on space transportation systems projects; to provide common support equipment and supplies; and to perform backup design, testing and analysis in high technology areas of design and development.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The total funding for DTMS has not been changed in FY 1980. However, there has been a reallocation within the total to reflect current requirements in support of the revised Space Shuttle schedules. Operations Support and Launch Systems Support requirements have increased. In addition, certain Research and Test Support and Data Systems and Flight Support activities have been integrated into the direct program budget because of the intensified requirements for Shuttle development and test.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding provides for the common engineering, scientific and technical support required for activities performed in the Space Shuttle program, the STS Operations Capability Development (OCD), and Advanced Programs.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Research and Test Support.	42,016	41,900	31,100	32,400

OBJECTIVES AND STATUS:

Research and test support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. These activities complement the work of the major development contractors located across the country in contractor plants and U. S. Government facilities. Examples of FY 1980 activities include: (1) support of the Space Shuttle Main Engine (SSME) static test firing activities and integrated component testing as well as the qualification of the main propulsion system; (2) support of refurbishment efforts for the solid rocket booster (SRB); (3) engineering support for the Space Shuttle Orbital Flight Test (OFT) activity; and (4) flight evaluation of the external tank (ET), SRB, SSME and related systems.

CHANGES FROM THE FY 1980 BUDGET ESTIMATE:

The current estimate for FY 1980 is $10.8 million less than the budget estimate reflecting the reallocation of resources within DTMS and provision for intensified Space Shuttle Avionics Integration Laboratory (SAIL) activities supporting testing and integration of the Space Shuttle avionics system within the Space Shuttle Program estimates.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, research and test support efforts will be focused primarily on critical Space Shuttle activities, including the Space Shuttle OFT activity. Also supported will be design and development activities and research and development efforts in STS OCD, and Advanced Programs. Engineering and test support is provided to assure achievement of technical goals as they relate to each program.

Examples of FY 1981 Space Shuttle support activities include: (1) support of laboratories to do certification and verification testing of flight hardware; (2) continuing support of the communications and tracking systems space to ground compatibility and performance testing; and (3) analysis and certification of government furnished equipment, environmental control life support systems, structural and propulsion subsystems, and crew station training through utilization of mockups, neutral buoyancy crew station trainers, and the remote manipulator facility. FY 1981 research and test support funds are also required to support Space Shuttle certification inspections, test, configuration control panels, and integration efforts.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Data Systems and Flight Support.....	55,617	47,000	35,900	40,200

OBJECTIVES AND STATUS:

Data systems and flight support efforts are associated with the ground-based flight data systems, flight simulation systems, special purpose and general purpose data systems, and flight support.

The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the JSC's MCC, including the real-time computer complex in support of the Space Shuttle OFTs, as well as operation and maintenance of those facilities in preparation for operational mission support. Also included is the operation of the JSC central data computation facility and special purpose data system required to support center-wide activities in mission analysis, systems engineering development, and test functions for the Space Shuttle Program.

Flight support provides for development of Space Shuttle flight control and recovery plans and procedures, flight plans, flight data compilation, crew procedures and training, and other elements of the data base required for crew activities, operation and maintenance of the T-38 training aircraft, flight data management, and support of Space Shuttle payload accommodation and integration.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The current estimate for FY 1980 is $11.1 million less than the budget estimate reflecting provision for flight simulation support activities required for the orbital test flight missions within the estimates for Space Shuttle Design, Development, Test and Evaluation. The flight simulation support activities include operation and maintenance of the mission and part-task simulators used for flight crew training and flight procedures development and validation.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding of ground-based flight data systems supports the upgrading of the MCC, the central computing facility, flight support and flight data management functions for the OFT effort.

Aircraft operations' activities which will be supported in FY 1981 include partial maintenance, modification, and engineering support services relating to the T-38 training aircraft. FY 1981 funding requirements also provide for the flight control, crew training, and engineering support of flight operations planning control for the OFT missions.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1381 Budget Estimate
		(Thousands of Dollars)		
Operations Support.....	34,476	39,500	43,600	45,900

OBJECTIVES AND STATUS:

Operations support provides for contractor effort and related supplies and equipment to operate and maintain on-site activities at JSC, MSFC, KSC, and at NSTL, and also for off-site operations at the White Sands Test Facility.

CHANGES FROM FY 1980 ESTIMATE:

Operations support funding estimates for FY 1980 have increased by $4.1 million to provide for additional flight documentation requirements and operations support in preparation for the first manned orbital flight (STS-1).

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in FY 1981 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal furbishing, anodizing, plating stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation, and maintenace of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photo-

graphic 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 1981 funds will provide the basic level of support to the NSTL for the static test firing and integrated component testing of the SSME and the qualification of the main propulsion system.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Launch Systems Support.....	45,091	44,200	62,000	65,000

OBJECTIVES AND STATUS:

Launch systems support provides for the development and test of the checkout and launch facilities and associated GSE, as well as the technical services required to support the test, checkout and launch of the Space Shuttle and payloads for the development test flights.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

N 1980 launch systems support funding was increased by $17.8 million to meet additional manpower and overtime requirements for KSC facility operations support in preparation for the Space Shuttle orbital flight testing.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 launch systems support requirements at KSC are for the continuing preparation of the launch facilities to accommodate the Space Shuttle OFT missions. FY 1981 activities will support the integration and checkout of the space vehicle, its payloads, and ground support systems to accommodate the Space Shuttle flight hardware and payload systems.

Funding in FY 1981 will provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Space Shuttle; support for development testing of KSC designed Space

Shuttle equipment in the launch equipment test facility; maintenance and operation of the KSC electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

FY 1981 funding will also support the electrical/electronic and launch instrumentation systems, such as automated checkout equipment, operational voice and TV communications, measurements, and telemetry. These activities include operations and maintenance support of communication, computational and instrumentation systems for the Space Shuttle, and instrumentation and measurement support for development testing of the KSC designed Space Shuttle equipment in the launch equipment test facility.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

ADVANCED PROGRAMS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Advanced Programs.....	7,000	13,000	13,000	10,800

OBJECTIVES AND STATUS:

The Advanced Programs objective is to provide technical as well as programmatic data for the definition and evaluation of potential future space programs and systems. The definition includes identifying future systems requirements, costs, and capabilities in order 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 Space Shuttle. In support of these activities, subsystem studies and supporting 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 technology.

In FY 1980, activities will be concentrated on definition of future orbital power systems and space platforms for use in both low earth orbit and geosynchronous orbit; advanced orbital capabilities including definition of concepts and experiments to fabricate and erect structures in space; the provision of satellite services (i.e., placement, retrieval, and on-orbit maintenance and repair); the definition of advanced transportation systems concepts such as manned orbital transfer vehicles including crew and propulsion modules for geosynchronous operations; the concepts definition and analysis of satellite placement and retrieval systems remote from the orbiter; and the definition of the Solar Electric Propulsion System (SEPS).

BASIS OF FY 1981 ESTIMATE:

In FY 1981 major emphasis will be placed on continuing studies, engineering investigations, and definition of near-term mission options that are possible because of the operational capability and flexibility of the space transportation system. In the future power systems and platform area, the emphasis will include definition of low earth orbit platforms for operations with a power system, design studies of geosynchronous platforms, and life and crew support engineering activities required for extended duration orbital missions. The 25 KW power system design definition and key subsystems studies to support the design definition of this system will be completed. In the advanced orbital capabilities area, investigations of potential tools and equipment used in extravehicular activity and teleoperator operations will be carried out.

The definition of space structures experiments will be continued, and the deployable antenna flight experiment definition study will be completed. In addition, structures engineering activities including testing of beam builders and preparation of simulations will be continued. Studies of extravehicular activity operations essential for satellite and platform maintenance as well as studies of assembly and repair of future structures in space will be continued. Concept and engineering development efforts on teleoperator systems to permit remote satellite servicing and studies on extravehicular activity support equipment as well as automated rendezvous and proximity operations techniques will be continued. Other planned activities for FY 1981 include continuation of studies of future upper stages to enhance the space transportation system capabilities and permit improved geosynchronous operations.

Appropriate subsystems studies and supporting development will be undertaken in support of the above activities in order to provide technical depth to the varied definition activities.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SPACELAB

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacelab.....	26,700	58,800	58,800	151,700

OBJECTIVES AND STATUS:

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

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

In FY 1980, fabrication of the crew transfer tunnel will be continued. This tunnel will link the Spacelab module to the Shuttle Orbiter cabin. Manufacture, test and validation of verification flight instrumentation equipment which 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, will also be continued.

Development of United States ground support equipment will continue in 1980. Integration of the Spacelab simulator with the Shuttle mission simulator used for crew training will also be continued in FY 1980. The outfitting of ESA pallet structures with systems being developed for use during orbital flight tests will be completed in FY 1980. The Software Development Facility will also be completed and used to generate computer programs such as the experiment computer operating system.

In FY 1980, the Spacelab integration contractor will perform systems engineering, logistics planning, systems software preparation, and analytical experiment integration to prepare for the orbital flight tests in 1981 and the two Spacelab verification flights scheduled for 1982. The interface between the Shuttle orbiter and the Spacelab will continue to be defined and fabrication of hardware required for mating the orbiter with the Spacelab will proceed.

NASA plans to enter into a contract with the European Space Agency to start procurement of follow-on Spacelab hardware. The production of this hardware is scheduled to span six years.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding is required to continue incremental procurement of the Spacelab flight hardware from ESA. This procurement includes a second set of Spacelab flight elements and initial spares to support the early flights.

FY 1981 funding will also be applied to the manufacture and test of the crew transfer tunnel and the ground support equipment to be used for integration and checkout of the Spacelab engineering model and flight hardware at the Kennedy Space Center. Also, fabrication of the support equipment to be used for transporting flight hardware between the integration and launch sites will be continued. Other items of flight hardware procured by NASA such as a flight recorder and closed circuit television switching network will be delivered in FY 1981. Spare parts for hardware manufactured in the United States will also continue to be procured.

At the Johnson Space Center the Spacelab simulator and the less sophisticated single systems trainer will be placed into operation. The hardware to be used for mating the Spacelab with the Space Shuttle orbiter is planned to be delivered in FY 1981. The Software Development Facility, completed in FY 1980, at the Marshall Space Flight Center, will be used to checkout and integrate both ground and flight compter programs.

The McDonnell Douglas Technical Services Company, the Spacelab integration contractor, will continue to develop the procedures for integration, maintenance and on-ground repairs for the early Spacelab missions. These procedures will be tested with the Spacelab Engineering Model and flight unit which are scheduled to be delivered beginning in FY 1981.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SPACE TRANSPORTATION SYSTEM OPERATIONS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Shuttle operations	15,100	114,600	119,300	320,500
Spacelab operations	--	800	--	1,600
Upper Stages operations	2,900	22,300	18,700	32,900
Payload Support operations	6,300	15,400	10,100	19,500
TOTAL	24,300	153,100	148,100	374,500

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, while reducing the cost of space operations. 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 low earth orbit; and provide on-orbit servicing of satellites.

The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab and the upper stages into a versatile and economical space transportation system. Shuttle mission planning, procurement planning for recurring hardware and consumables, and support planning for operations involving launch, flight recovery crews and related activities are well underway. In addition, procurement of long lead items for major expendable hardware components has been initiated.

Spacelab Operations provide for development and implementation of Spacelab ground-turnaround and flight operations, including mission planning, Spacelab to Shuttle integration and ground support operations. 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 (IUS) for 5,000-pound class geosynchronous (IUS/two-stage) spacecraft

and planetary (IUS/twin spin) spacecraft, Spinning Solid Upper Stages (SSUS) for 4,400-pound Atlas Centaur class (SSUS-A) and up to 2,750-pound Delta class (SSUS-D) geosynchronous spacecraft.

Payload Support Operations provide for optional payload related hardware, services and launch site capability development required to meet a users transportation requirements outside the scope of currently defined standard Space Transportation System services.

CHANGES FROM 1980 BUDGET ESTIMATE:

FY 1980 funding reflects the unspecified $5.0 million Congressional reduction in Space Flight Operations. The schedule delay in the first operational flight and subsequent early flights provided the flexibility to rephase and defer Spacelab mission planning, upper stage hardware procurement, and payload support.

BASIS OF FY 1981 ESTIMATE:

Shuttle Operations - FY 1981 funding is required for Space Shuttle flight hardware components which include the external tank and solid rocket boosters. External tank components will be delivered to the Michoud Assembly Facility in Louisiana for fabrication and assembly of the liquid oxygen and liquid hydrogen propellant tanks. After final testing, the external tank will be shipped by barge to the Kennedy Space Center (KSC) in Florida. Segments for the solid rocket motors (SRM) will be prepared at the contractor's plant and shipped to KSC for SRM case assembly. Other solid rocket booster components such as electronic and instrumentation parts, thrust vector control components, recovery systems, attach structures, forward and aft skirts, and separation motors, will be shipped to the Kennedy Space Center where final assembly and checkout will be performed prior to flight. FY 1981 funding is required for pre-launch preparations at KSC and for the development of Shuttle flight plans using standardized avionics software, mission planning, trajectory analyses, and crew procedures.

Spacelab Operations - FY 1981 funding is required for mission operations and crew operations planning for the early operational missions. Mission operations efforts include computer software programming and engineering maintenance for the Mission Control Center and the Payload Operations Control Center. Crew operations include establishment of the flight data file, crew Procedures, and system handbook as well as training of the command controller personnel for the Payload Operations Control Center.

Upper Stage Operations - Funding in FY 1981 is required to support the procurement of major components and initial subsystem assembly of the first IUS twin/spin vehicle. Continued funding for production of IUS and SSUS upper stages is also needed in FY 1981 to support NASA missions including Tracking and Data Relay Satellites, International Solar Polar Mission, Galileo and Active Magnetospheric Particle Tracer Explorer.

Payload Support Operations - Funding in FY 1981 is required to support on-going payload integration analysis and implementation for currently scheduled launches. NASA payloads requiring significant support in 1981 include: International Solar Polar Mission, Long Duration Exposure Facility, Space Telescope, early Spacelab missions, and the Tracking and Data Relay Satellite System.

EXPENDABLE LAUNCH VEHICLES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Scout	10,600	7,300	5,100	2,200
Centaur	17,320	18,300	18,300	5,600
Delta	45,680	43,100	46,100	47,900
Atlas-F	---	2,000	1,200	---
Total	73,600	70,700	70,700	55,700
Distribution of Program Amount by Installation:				
Kennedy Space Center	9,600	3,800	3,700	2,800
Goddard Space Flight Center	40,496	40,400	43,000	43,500
Langley Research Center	10,540	7,200	5,000	2,200
Lewis Research Center	12,000	16,400	16,900	4,300
Headquarters	964	2,900	2,100	2,900
Total	73,600	70,700	70,700	55,700

OFFICE OF SPACE TRANSPORTATION SYSTEMS — EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

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

The expendable launch vehicles program includes funding for vehicle hardware, such as solid rocket motors, boosters, upper stages, shrouds, adapters, mission-unique hardware, and launch support including preparation of hardware for launch, guidance and control services, mission software, prelaunch and postlaunch engineering analysis, transportation, propellants, and range support. It also includes procurement of vehicle hardware to be used as backup support for early users transitioning to the Space Transportation System Operations. In addition, an uprating program to improve the performance of the Delta launch vehicle is being initiated to provide sufficient capability to launch NASA's Landsat mission and various reimbursable customers missions.

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

CHANGES FROM FY 1980 BUDGET ESTIMATE:

There has been no change in the total FY 1980 estimates, however, funding adjustments were made within the total to reflect current program requirements including extension of Delta backup capability in support of Space Transportation System users, resulting from delay in the Shuttle first manned orbital flight.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SCOUT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Scout	10,600	7,300	5,100	2,200

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 19 years, there have been 101 launches, and 87 of these launches have been successful.

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. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation, located in Dallas, Texas. Scout vehicles are launched from the Western Test Range, California; from Wallops Island, Virginia; and from the San Marco platform off the African coast near Kenya.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The estimate has been reduced by $2.2 million because of better definition of NASA requirements and a greater share of the costs being born by DOD users. The $2.2 million has been reallocated to the Delta project to be applied to STS transition backup requirements.

BASIS FOR FY 1981 ESTIMATE:

The funds required in FY 1981 will be used for engineering, technical support, vehicle testing and checkout, launch operations and maintenance of launch facilities and ground equipment. FY 1981 funds will provide for preparation and launch of two San Marco cooperative missions from the African San Marco launch platform. These launches will complete NASA's use of the Scout launch vehicle.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

CENTAUR

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Centaur.....	17,320	18,300	18,300	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, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

In addition, the Centaur has been previously used with the Titan booster to launch heavier spacecraft beyond the capability of the Atlas Centaur. In this configuration, the Titan Centaur has successfully launched two Helios missions, two Viking missions, and two Voyager missions. Since NASA has no future plans to use the Titan Centaur vehicle combination, it has been phased out.

BASIS OF FY 1981 ESTIMATE:

The last NASA mission requiring the Atlas Centaur launch vehicle was the HEAO-3 launched in September 1979. However, use of this vehicle is being continued by reimbursable customers under NASA management and control. The funding required in FY 1981 is for an orderly phaseout and closeout of the Atlas Centaur program. This closeout includes restoration of contractor-owned facilities which are being used to produce the Atlas Centaur launch vehicle and the vital components that are integral to this vehicle system. In addition, it includes the mothballing and teardown of facilities that will not be required for future requirements. Our current planning is based on a closeout of the program by the end of 1981.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

DELTA

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Delta...	45,680	43,100	46,100	47,900

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 150 launches and has experienced a success record of over 91 percent. It is presently operational with two and three stage configurations and a multiburn second stage capability. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 solid motor, which is spin stabilized. This vehicle, in its three-stage configuration, is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). It is capable of placing a 1,772 kilogram payload (3,900 pounds) into a 555 kilometer (300 nautical mile) orbit.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The *$3.0* million increase in the Delta project estimate is required to extend the Delta production and launch capability and initiate development of an uprated Delta vehicle. These requirements result from delays in the Shuttle first manned orbital flight. As a result of the Shuttle delays, backup capability must be extended and a vehicle capable of launching a heavier spacecraft must be developed. These funds will allow for a continued backup capability through September 1980. This increase is provided for by reallocation of funding from the Scout and Atlas-F projects.

BASIS OF FY 1981 BUDGET ESTIMATE:

The FY 1981 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support NASA spacecraft requirements and to sustain a minimum production capability to back up early users scheduled on the Space Transportation System. Funds are also required for technical and engineering support

to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment. In addition, a vehicle uprating is being initiated to increase the performance capability to 2,750 pounds to geosynchronous transfer orbit to support Landsat and reimbursable mission requirements. The Delta uprating will allow continued capability to retrieve the Landsat mission and allow NASA to offer the capability to launch heavier spacecraft to other users.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

ATLAS-F

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Atlas-F..	---	2,000	1,200	---

OBJECTIVES AND STATUS:

The Atlas-F is a one and one-half stage vehicle which uses liquid oxygen and kerosene as propellants. The vehicle is a refurbished surplus Intercontinental Ballistic Missile (ICBM) being managed by the USAF for space missions. NASA has used this vehicle to launch the TIROS-N and Seasat missions, both of which were successfully launched during 1978.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The $2.0 million requested in the FY 1980 budget provided €or modifying the Atlas vehicle, the fairing and for the vehicle integration of the Search and Rescue missions. The Search and Rescue missions will be launched as piggyback missions with National Oceanic and Atmospheric Administration satellites beginning in late 1982 or early 1983. The decrease of $800 thousand is a result of the requirements to modify these vehicles. These funds have been reallocated to the Delta project to cover Space Transportation System backup transition vehicle support for Shuttle users.

SPACE SCIENCE
PROGRAMS

NATIONAL, AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

Programs	Budget Plan			
		1980		1981
	1979 Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)			
Physics and astronomy	282,900	337,500	337,100	438,700
Planetary exploration	182,400	220,200	219,900	179,600
Life sciences	40,100	43,900	43,800	49,700
Total	505,400	601.600	600,800	668.000

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
High energy astronomy observatories (HEAO) development.	10,647	4,800	2,100	---	RD 4-8
Solar maximum mission (SMM) development.....	16,700	600	3,100	---	RD 4-9
Space telescope (ST) development.....	79,200	112,700	112,700	119,300	RD 4-10
International solar polar mission (ISPM) development..	12,500	50,000	47,900	82,600	RD 4-12
Gamma ray observatory (GRO) development.....	---	---	---	19,100	RD 4-14
Shuttle/Spacelab payload development and mission management.....	34,900	41,300	40,900	72,100	RD 4-16
Explorer development.....	31,288	30,400	32,300	33,000	RD 4-19
Mission operations and data analysis (MO&DA).....	25,453	36,500	37,100	38,900	RD 4-21
Research and analysis (R&A).....	44,005	34,300	34,100	42,800	RD 4-24
Suborbital program.....	28,207	26,900	26,900	30,900	RD 4-29
Total.....	282,900	337,500	337,100	438,700	
Distribution of Program Amount by Installation:					
Kennedy Space Center.....	335	---	1,813	2,358	
Johnson Space Center.....	346	206	1,713	6,181	
Marshall Space Flight Center.....	124,275	158,112	155,226	177,583	
Goddard Space Flight Center.....	83,299	76,963	79,908	117,828	
Jet Propulsion Laboratory.....	19,314	58,353	53,950	80,977	
Wallops Flight Center.....	7,028	5,219	5,678	6,874	
Ames Research Center.....	20,401	4,157	12,817	8,901	
Langley Research Center.....	1,052	855	59	37	
Lewis Research Center.....	185	---	---	---	
Headquarters.....	26,665	33,[illegible]	25,936	37,961	
Total.....	282,900	337,500	337,100	438,700	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Solar Maximum Mission	SMM	1980
International Solar Polar Mission	ISPM	1983
Space Telescope	ST	1983
Gamma Ray Observatory	GRO	1985
Space Shuttle Orbital Flight Test Payloads	OSS-1	1981
Spacelab	Spacelab-1	1982
	-2	1982

(Shuttle/Spacelab Payloads in support of Space Science objectives will build to a flight rate of approximately 2.5 equivalent Spacelab missions per year by 1984).

Explorers:

Dynamics Explorer	1981
San Marco-D/Low Orbit	1981
San Marco-D/Multistationary	1982
Solar Mesosphere Explorer	1981
Infrared Astronomical Satellite	1981
Cosmic Ray Isotope Experiment	1981

LAUNCH SCHEDULE (CONTINUED)

PROJECT	MISSION	CALENDAR YEAR
	Active Magnetospheric Particle Tracer Explorer	1983
	Cosmic Background Explorer	1985
	Extreme Ultraviolet Explorer	1985
Suborbital Programs:		
Sounding Rockets		About 60 launches per year
Balloon Flights		About 20 launches per year
Airborne		About 80 flights per year with C-141 Airborne Observatory

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

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the solar terrestrial space environment and 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 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, gamma ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, black holes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated in the Physics and Astronomy program 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 the Physics and Astronomy program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in the Physics and Astronomy program are made available to the scientific and technical communities for applications to and the advancement of scientific knowledge, education, and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful. The High Energy Astronomy Observatories (HEAO's), the most recent series of large observatory missions, are making major contributions to our understanding of the high energy processes and of the distribution and characteristics of X-ray emitting objects. Explorer satellites, a program involving a series of relatively low cost missions whose origin dates back to the beginning of our country's space program, continue to make major discoveries about celestial phenomena, as well as about the nature of the solar terrestrial interactions and their effect on the near-earth environment. For example, the International Ultraviolet Explorer has recently observed evidence of a halo of hot gas around our own galaxy and has provided evidence, in conjunction with HEAO-2 observations, which may imply the existence of massive black holes in some globular star clusters. The International Sun-Earth Explorers are now successfully investigating fundamental processes occurring as a result of the extremely

complex solar wind/magnetosphere/ionosphere interactions. The Explorer program also plays a key role in development of technology and serves as a further test opportunity for the technologies necessary for iater, more complex observatories.

Major accomplishments during FY 1979 included the launch of the second and third observatories of the HEAO series. The first HEAO mission has been successfully completed. The second of the HEAO series, HEAO-2, is currently conducting unique high resolution imaging X-ray observations. The third of the HEAO series, HEAO-3, is carrying out a preliminary survey of the sky for gamma ray lines and is measuring the composition of cosmic ray particles. Significant scientific results obtained from the HEAO missions to date include the discovery by HEAO-1 of more than 1,000 new X-ray sources, the demonstration by HMO-2 that a much wider variety of stars emit X-rays in greater quantities than previously predicted, and new information provided by HEAO-3 concerning the detailed composition of cosmic rays in the iron, nickel, cobalt groups of elements. Small-scale, high velocity structures in the Sun's upper atmosphere have been discovered through the use of instrumented sounding rocket flights. A new technique has been successfully tested for measuring the temperature and velocity of the solar wind as it orginates within the Sun's corona, and several sounding rocket payloads of specialized X-ray instruments have been prepared for correlative flights during the operation of the Solar Maximum Mission. Major progress was also made in the development of experiments and other flight equipment for future Physics and Astronomy flight missions. The Solar Maximum Mission, the Space Telescope, the International Solar Polar Mission, the Dynamics Explorer, the Infrared Astronomical Satellite, and the Solar Mesosphere Explorer are in various stages of flight development. The Solar Maximum Mission experiments and spacecraft have, in fact, been integrated and tested in preparation for launch in early 1980. All the experimenters are under contract for the International Solar Polar Mission and the prime contractor for the U. S. spacecraft has been selected. The instrument development for the initial Physics and Astronomy Shuttle payload, OSS-1, progressed in FY 1979. The experiments on OSS-1 will gather solar physics data, evaluate the ambient and induced Shuttle space environment, and provide data on payload thermal control technology. Significant progress has also been achieved in the preparation of the Spacelab 1 and 2 missions, which are operational demonstration flights of Spacelab hardware produced by the European Space Agency. During FY 1979, selection of the initial follow-on Shuttle/Spacelab Physics and Astronomy experiments was made, some of which will fly as early as 1983. Also selected for future development were three facility class instruments, the Solar Optical Telescope, the Chemical Release Module, and the Shuttle Infrared Telescope Facility.

During FY 1979, the Spacelab mission management responsibility for all NASA Spacelab missions was consolidated within the Physics and Astronomy program. Responsibility for the design and development of the actual experiments for other than the Physics and Astronomy program remains with the respective disciplines: Life Sciences, Space Applications, and Space Research and Technology.

FY 1980 funding will support the continued development and launch of major flight projects including launch operations and data analysis associated with the Solar Maximum Mission planned for an early 1980 launch. The Solar Maximum Mission investigations will involve some 200 scientists. The period of solar maximum activity is nearly twice as high as the average (as measured by sunspot count) and thus promises many flares and other energetic phenomena for study.

In FY 1980 development activities will continue on the Space Telescope leading to a Shuttle launch in 1983. The Space Telescope will allow research at the forefront of optical and ultraviolet astronomy for decades. Work will also continue on the International Solar Polar Mission which will be the first mission to explore the three-dimensional space around the Sun. The Dynamics Explorer, which will investigate the interaction of the Earth's magnetosphere and ionosphere, is in final development leading to launch in 1981. Preparations will continue for the launch of the Infrared Astronomical Satellite (IRAS), a cooperative mission with the Netherlands and the United Kingdom, in 1981. The IRAS will perform an infrared, all-sky survey and will study, in more detail, selected galactic and extragalactic sources. Development work on the San Marco-D missions, which are cooperative missions with Italy, will be continued, leading to launches in 1981 and 1982. Development will also be continued on the Cosmic Ray Isotope Experiment, which will be launched on a Department of Defense satellite in 1981. Finally, development efforts will be continued on the Solar Mesosphere Explorer, which will be launched in 1981. The Solar Mesosphere Explorer will determine solar ultraviolet flux, and study corresponding changes occurring in ozone and related chemistry as a result of the ultraviolet radiation.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 estimate for the Physics and Astronomy program has changed only slightly in total--a reduction of $400 thousand as a result of a general Congressional reduction in the NASA budget request. A number of adjustments have been made among the individual subprogram elements in order to respond to technical problems, and successes, and to other unforeseen circumstances. All of these adjustments have been accommodated within the total budget for the program, and in the context of balanced programmatic priorities.

Significant reductions in two projects have permitted the application of additional resources to problem areas: (1) the successful launch of the third and last mission in the High Energy Astronomy Observatories program, HMO-3, with fewer technical/schedule problems than anticipated, allowed a reduction of $2.7 million in the FY 1980 estimate; (2) in the International Solar Polar Mission development project, a revision in the phased funding of the effort, to match requirements under the recently-awarded spacecraft contract, has permitted a reduction in the FY 1980 estimate.

Resources made available by these reductions have been applied to those projects which have experienced technical/schedule problems and repricing adjustments, primarily the Solar Maximum Mission and Explorer Development. These funding adjustments are discussed in the narrative sections in each of the affected program areas.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, a new project will be initiated, the Gamma Ray Observatory, leading to a 1985 launch. The Gamma Ray Observatory is a comprehensive mission designed to study the full sky over the total range of the gamma ray energies. Gamma rays are the most energetic electromagnetic radiation known. It is believed that their study will reveal details of fundamental cosmic nuclear and high energy processes, especially those occurring in active galaxies and quasars as well as in supernovae.

FY 1981 funding will provide for the launch of the Space Science payload which will be flown on an orbital flight test mission; and development will continue on the Space Telescope. In FY 1981, an unusually high level of launch activity will take place, including the launch of the Dynamics Explorers, the Infrared Astronomical Satellite, the Solar Mesosphere Explorer, the first of the San Marco-D missions, and the Cosmic Ray Isotope Experiment. Development will start on the Active Magnetic Particle Tracer Explorer (AMPTE). Design and definition studies will also be carried out for several potential future explorer missions.

In FY 1981, work will continue on the mission management efforts for all NASA Spacelab payloads. The FY 1981 funds will also provide for the instrument development and mission management for Spacelab 1 and 2, and for instrument development and mission management activities for future Spacelab missions.

FY 1981 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 High Energy Astronomy Observatories, the International Ultraviolet Explorer, the International Sun-Earth Explorers, and an Atmosphere Explorer. Mission Operations and Data Analysis will also be underway for the Solar Maximum Mission and the Dynamics Explorers. FY 1981 funding will also support preparations for science operations for the Space Telescope.

For Suborbital programs, FY 1981 funds will provide for continuetion of sounding rocket activity, and continuing scientific investigation through balloon and aircraft flights.

FY 1981 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 our supporting research and technology program, tasks critical to maintaining a firm scientific base for physics and astronomy will continue. In the area of Spacelab Payload definition, efforts will continue on detailed studies of specific instruments. The data analysis activity will include operation of the National Space Science Data Center (NSSDC) and the general data analysis activities.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

HIGH ENERGY ASTRONOMY OBSERVATORIES (HEAO) DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
HEAO spacecraft	7,496	2,300	1,900	---
HEAO experiments	2,853	1,400	100	---
Ground operations	298	1,100	100	---
Total...	10,647	4,800	2,100	---
Basic mission operations and data analysis.	(5,439)	(5,351)	(6,336)	(128)
Extended mission operations and data analysis.	(3,714)	(8,549)	(8,548)	(10,606)
Atlas/Centaur (expendable launch vehicle program).	(4,905)	(---)	(1,515)	(---)

OBJECTIVES AND STATUS:

A major scientific objective of the HEAO program is to observe and investigate not only those X-ray sources that are already known, but also a much larger number, which either because of their distance or their low intensity, remained undetected before the advent of HEAO. A product of this work has been the detection of classes of intrinsically weak X-ray sources within our own galaxy, as well as the observation of the stronger sources outside our galaxy. Other equally important objectives include the observation of rare species of cosmic rays, which are crucial to our understanding of heavy element formation, and the search for nuclear gamma ray lines, which are important in understanding the origin of the elements. This program promises to advance our understanding of newly discovered processes that release extraordinary amounts of energy. It will also enhance our understanding of the creation of matter, and it will deepen our knowledge of observed phenomena such as quasars, plusars, novae and supernovae.

The HEAO Program consists of three missions utilizing Atlas-Centaur launch vehicles launched from the Eastern Test Range. HEAO-1, an X-ray survey mission, was launched in August 1977, and completed 19 months of highly successful operations prior to its reentry in March 1979. HEAO-1 results included the discovery of over 1,000 X-ray sources, as well as an isotropic plasma of many million degrees temperature. HFAO-2 was successfully launched in November 1978, and carries a grazing incidence X-ray telescope to make detailed studies of specific X-ray sources. The third mission (HEAO-3) was successfully launched in September 1979, and carries a combination of cosmic ray and gamma ray instruments. Results obtained to date from the HEAO missions are discussed under Mission Operations and Data Analysis.

CHANGES FROM FY 1980 ESTIMATE:

The FY 1980 estimate reflects a reduction in funding requirements for the HEAO-3 spacecraft associated with the on-time, successful launch; fewer technical and schedule problems were experienced than had been anticipated. These savings have been applied to increased baseline HEAO operations costs and to the Explorer program to resolve technical problems in ongoing development projects.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SOLAR MAXIMUM MISSION (SMM) DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	10,911	---	2,269	---
Experiments	4,139	---	689	---
Ground operations	1,650	600	142	---
Total	16,700	600	3,100	---
Basic mission operations and data analysis	(---)	(4,900)	(4,500)	(3,400)
Extended mission operations and data analysis	(---)	(---)	(---)	(1,600)

OBJECTIVES AND STATUS:

The major objective of the Solar Maximum Mission (SMM) is to conduct detailed studies of the solar flare processes and the associated solar active regions during the next period of peak solar activity, which will occur in 1979 through 1981. The investigations will be conducted over a broad spectral range with high spectral, spatial and time resolution, and with the objective of explaining the underlying physical mechanisms and complex energy transfer and high energy particle acceleration processes involved.

To achieve the scientific objective, SMM will be launched near the period of maximum solar activity in order to observe a sufficient number of large and small flare events. The study of flares is currently considered to be one of the most timely and important in the NASA solar physics programs, both by virtue of the significance of the phenomenon and by the state of readiness of the technology required to capitalize on the phenomenon. A great deal has already been learned about the flare process through instruments flown

on the Orbiting Solar Observatories and Skylab. The SMM instruments will be the first to make simultaneous observations over the necessary broad range of wavelengths.

In the area of solar terrestrial relationships, indications of a link between some form of solar activity (radiation, particles, and magnetic fields) and the Earth's weather and climate are increasing. With the basic capabilities of the flare payload, the inclusion of solar constant instrumentation, and the complementary International Sun-Earth Explorer research, the SMM will make a significant contribution to our understanding of the effects of solar phenomena.

The procurement, assembly, and test of the experiments and spacecraft subsystems for SMM were completed in FY 1978. During FY 1979, the experiments and the spacecraft were integrated. In FY 1980 the observatory system is being tested, calibrated, and will be launched. In addition, the mission operations teams have been trained, and the guest investigator teams formed.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $2.5 million in FY 1980 funding requirements is the result of a delay in the launch of the SMM from the fourth quarter of 1979 to the first quarter of 1980. Technical problems were encountered during final testing of the observatory which required rework and retest of the spacecraft system. Resources were made available from within the Physics and Astronomy program, as discussed in the FY 1980 CHANGES section of the introduction.

BASIS OF FY 1981 FUNDING REQUIREMENT:

SPACE TELESCOPE (ST) DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	52,900	82,500	76,900	95,100
Experiments	26,300	30,200	35,800	24,200
Total	79,200	112,700	112,700	119,300
Mission operations and data analysis	(---)	(1,800)	(1,800)	(6,700)
Space transportation system operations	(100)	(100)	(100)	(3,200)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the stars and galaxies, and 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 radiations in the visible and ultra-violet 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 observations of objects so remote that the light will have taken many billions of years to reach us. As a result, we will be able to look far into the distant past of our universe. It will also contribute significantly to the study of the early stages of stars and the formation of solar systems and 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. It will also be possible to study individual stars in nearby galaxies and perhaps determine if they have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit in 1983 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 will differ from existing automated satellites in that its design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment and reuse.

During FY 1979, continued progress was made in the design and development of the Space Telescope. The first primary mirror blank was fabricated and shipped to the Optical Telescope Assembly contractor for grinding and polishing. Polishing of the mirror, which will be performed by a new computer-controlled polishing machine, was demonstrated by polishing a 60-inch mirror to Space Telescope specifications. A backup to the flight primary mirror was fabricated and delivered in August 1979, for polishing, using traditional manually controlled polishing machines. The observatory contractors completed design activities leading to Preliminary Design Reviews in the last half of FY 1979. Detailed designs were initiated following these reviews. The Preliminary Design Reviews for the Science Instruments were conducted in early FY 1979, after which the payload selection was confirmed and detailed instrument designs initiated. In addition, a contract was awarded for the development of the control and data handling system for the scientific instruments, and for the preparation of the verification and acceptance activities associated with the instruments.

FY 1980 activities support detailed design and development of the Optical Telescope Assembly, the Support Systems Module, and the Scientific Instruments. Polishing of the flight primary mirror will begin in April 1980. The Crticial Design Reviews for the Optical Telescope Assembly and the Scientific Instruments are scheduled for completion by mid-1980. After these reviews, fabrication and assembly activities will begin. In late FY 1980, the fine guidance sensor engineering model and the star simulator are scheduled to be delivered to the support systems module contractor for Space Telescope Pointing Control Subsystem Development Tests. Preliminary coding of flight software for the Support Systems Module will also be completed in FY 1980.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The total FY 1980 funding requirement for the Space Telescope development is unchanged. However, there is a redistribution between spacecraft and experiments which is based on revised estimates prepared at the time of confirmation of the science payload. This adjustment is consistent with scheduling of the overall project mi1estones.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will support the fabrication and assembly activities of the Optical Telescope Assembly, the Scientific Instruments and the Support Systems Module. The fabrication and assembly of the Scientific Instruments is scheduled to be completed in mid-FY 1981, with verification testing to follow. The Primary Mirror of the Optical Telescope Assembly (OTA) is scheduled to be completed and assembly of the OTA subsystems is scheduled to begin in mid-FY 1981. The Critical Design Review for the Support Systems Module will be completed in FY 1981, after which fabrication and assembly activities will begin. Final coding of flight software will be completed and its validation begun in early FY 1981.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

INTERNATIONAL SOLAR POLAR MISSION (ISPM) DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	2,969	35,000	32,900	62,600
Experiments	9,252	14,000	14,000	14,500
Ground operations	279	1,000	1,000	5,500
Total	12,500	50,000	47,900	82,600

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Space transportation systems operations.....	(1,700)	(6,700)	(9,700)	(15,700)

OBJECTIVES AND STATUS:

The International Solar Polar Mission is a joint NASA and European Space Agency mission designed to obtain the first view of the solar system from a new perspective -- a view from far above and far below the plane in which the planets orbit the Sun's equator. The two spacecraft 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 may allow us to gain insight into the possible effects of solar activity on the Earth's weather and climate.

The objective of the International Solar Polar Mission is to conduct an exploration of those regions of the heliosphere above and below the equatorial plane of the Sun. Observations in the extreme, high latitude regions of the Sun have not been made before, and evidence indicates that this region of space is greatly different from the region in which the Earth is located. Based on the growing evidence of a link between solar activity and terrestrial weather and climate, the need to understand the processes that might result from such a link becomes more pressing. The characteristics of the solar wind vary with the solar cycle, and the variability is becoming progressively better known as a result of continuing space exploration. The high latitude features on the Sun are believed to affect the solar wind conditions at Earth. The Solar Maximum Mission and the International Sun-Earth Explorers will study the solar process from essentially the solar equatorial plane.

NASA and the European Space Agency (ESA) will each provide one spacecraft of approximately equal and complementary capabilities. Science experiments have been assigned to each of the two spacecraft by a joint selection committee. Launch, tracking and data acquisition, and mission operations will be carried out by NASA, with ESA participation.

Employing a concept that exploits the gravitational pull of Jupiter, the launch of the mission is planned for February 1983. Both the NASA and ESA spacecraft will be launched from a single Shuttle/Inertial Upper Stage vehicle on a trajectory to Jupiter. The gravitational force of Jupiter will be used to swing the two spacecraft on mirror image courses (north and south) back over the Sun, well above the solar equatorial plane. Both spacecraft will then pass over the north and south poles of the Sun.

During FY 1979, the experiments were confirmed, flight instrument design began, interface specifications were established, and the spacecraft system contractor was selected.

During FY 1980 the preliminary designs of the spacecraft, experiments, and ground operations will be developed. Long lead time components and subsystems will be procured.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The reduction of $2.1 million in the FY 1980 estimate reflects a rephasing of funding requirements to match the current schedule of development activities, and the associated contractual funding pattern, under the spacecraft contract awarded in late 1979.

The International Solar Polar Mission launch plan was examined during 1979 in connection with the general review of the projected early system capabilities of the Space Transportation System. While it was determined that the baseline plan (single launch in 1983 of NASA/ESA spacecraft) would be retained, it was deemed prudent to maintain the option of dual launches for these two spacecraft in 1983. The preliminary cost estimates for maintaining this option and for the impact on the Solar Polar Mission of the slip of the Galileo mission to 1984 (which now makes Solar Polar the first planetary-type mission to be launched by STS) are currently under detailed review by the Agency.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will provide for continued development of the spacecraft systems and experiments. Detailed designs, hardware procurement, and bread-board testing will be accomplished.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

GAMMA RAY OBSERVATORY (GRO) DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	---	---	---	2,830
Experiments	---	---	---	16,100
Ground operations	---	---	---	170
Total	---	---	---	19,100

OBJECTIVES AND STATUS:

The objective of the Gamma Ray Observatory (GRO) program is to measure gamma ray radiation from the universe and, thus, to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of GRO are thus to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occuring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; 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 astronomically intriguing 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 therefore consistently been given high priority by the science community.

The GRO will be launched by the Space Shuttle. The spacecraft is designed to accommodate five gamma ray instruments. It is planned that four of the instruments will have their principal axes pointing in the same direction. The spacecraft will point these instruments in a fixed direction in space for long periods of time (hours to weeks). The accessibility of different regions of space at any given time will only be limited by solar array pointing and seasonal constraints.

The current planning estimate for the GRO is $180–225 million. This includes development through launch plus thirty days in-flight checkout. The estimate for support during the two-year mission operations period and for analysis of the scientific data is *$30–45* million. The estimate for Space Transportation System support is approximately *$40* million.

BASIS FOR FY 1981 ESTIMATES:

The FY 1981 funding requirements will support the initiation of design and development for the Gamma Ray Observatory. A competitive procurement is planned during FY 1980 leading to the selection of two or more contracts to perform parallel, independent mission concept studies. Following these studies, a contractor will be selected from among the study participants to develop a spacecraft, to integrate the spacecraft and scientific instruments, and to support the mission operations. Scientific instruments for GRO have been selected for definition from responses by the scientific community to an Announcement of Opportunity.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB SCIENCE PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Science experiments	24,692	25,800	16,900	25,200
Mission management	10,208	15,500	24,000	46,900
Total	34,900	41,300	40,900	72,100
Space transportation systems operations	(2,600)	(20,100)	(13,200)	(32,100)

OBJECTIVES AND STATUS:

The objectives of the Shuttle/Spacelab science 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 science experiment funding provides for the development of Physics and Astronomy experiments and the analysis of the flight data. Mission management funding provides for system management and engineering of the payload hardware, flight hardware and software necessary to support the experiment complement, payload specialist support, physical integration of the payload with the Spacelab, flight operations, and data dissemination to the science investigators for all NASA Spacelab flights.

Shuttle Orbital Flight Test (OFT) and Spacelab-1 and -2 Payload Development

The experimental payload scheduled for launch in 1981 on a Shuttle orbital flight test will consist of six instruments that will gather solar physics data, evaluate the Shuttle environment, and provide data on thermal control technology. These instruments are mounted on a Spacelab pallet, and a Life Sciences experiment is located inside the orbiter cabin. In FY 1979, the instrument design and development activities were completed. The FY 1980 budget will support completion of instrument fabrication and assembly and test of the integrated payload. Flight operations planning has been in process since FY 1979 and will be completed this year. Launch and flight operations will occur in FY 1981.

Spacelab 1, which will consist of a pressurized module plus a pallet will carry a complement of 38 instruments from the U.S., Europe and Japan, and will be flown in 1982. The primary objective of the mission is to demonstrate the capabilities of the Spacelab system, and the secondary objective is to obtain multidiscipline scientific data with emphasis on atmospheric and space plasma physics. Spacelab 1 activities underway in FY 1980 include selection of the flight instrument complement, continuation of experiment development, completion of mission peculiar equipment final design, development of mission operations, and continuation of analytical integration and payload specialist training.

The Spacelab 2 development activities are on schedule for flight in 1982. Spacelab 2 will be the first flight of an all-pallet configuration of Spacelab. Although the primary objective of the mission is to verify the Spacelab system, the secondary objective is to obtain scientific data with emphasis on astrophysics and solar physics. The payload consists of eleven U.S., and two United Kingdom astrophysics and solar physics experiments. The instrument pointing system, developed by the European Space Agency, will be flown for the first time on this mission. Spacelab 2 activities in FY 1980 include final design and operation reviews on the integrated payload and mission peculiar equipment, continuation of experiment development, development of missions operations, and continuation of analytical integration and payload specialist training.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

Physics and Astronomy experiments to be flown on the Shuttle/Spacelab are divided in two classes: principal investigator instruments and multiuser instruments. Principal investigator instruments are those proposed 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 general, principal investigator and multiuser instruments will fly together, making scientifically coordinated payloads. In response to an Announcement of Opportunity, issued in 1978, soliciting proposals for investigations to be conducted on missions after Spacelab 3, forty-two principal investigator instruments were selected for definition studies. In the multiuser class, after extensive instrument feasibility and definition studies, NASA selected the Solar Optical Telescope, the Chemical Release Module and the Shuttle Infrared Telescope Facility for development. The Solar Optical Telescope will allow high resolution observations of the solar surface features using a number of focal plane instruments. The system will be designed for changes of focal plane instrumentation between successive flights. The Chemical Release Module will be used to trace the atmospheric motions of neutral constituents to map magnetic and electric fields, to display plasma instabilities, and to study, using test particles, particle behavior. The Shuttle Infrared Telescope Facility will conduct high resolution studies of selected celestial infrared objects and 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 itself.

During FY 1979, the mission management responsibility for all NASA Spacelab payloads was assigned to the Office of Space Science. Beginning in FY 1981, funding support for the NASA-wide Spacelab payload mission management will be budgeted in this program area.

The FY 1981 payload development effort will concentrate on missions which will be flown in 1983. These missions are predominately life science payloads and a mission drawing from the Physics and Astronomy science disciplines. Currently under development is the Annular Suspension Pointing System, an advanced, highly stable and accurate pointing system designed to satisfy instrument requirements for early Shuttle/ Spacelab missions.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The $400 thousand reduction in the total Shuttle/Spacelab science payload development and mission management project is the result of a general Congressional reduction to the NASA FY 1980 R&D appropriation. Within the project, there has also been a realignment between the science experiments and the mission management efforts. First, a subproject definition change is reflected in the FY 1980 Budget Estimate column: support equipment ($4.1 million) budgeted under the Science Experiments line last year is now carried under Mission Management. Secondly, the selection and contracting process for future Spacelab science experiments has required more time than planned. This factor, together with the adjusted Space Transportation System flight schedule, has permitted a reduction in the FY 1980 estimates for Science Experiments. On the other hand, further definition activity, along with experience gained in the planning for the early missions, has made evident the greater scope of work required in the mission management function. This fact, together with the plan to contract for certain mission planning work on Spacelabs 1 and 2 previously planned to be accomplished by civil service staff, is reflected in the increase in the FY 1980 estimate for mission management.

BASIS OF FY 1981 ESTIMATE:

OSS-1 and Spacelab 1 and 2

The FY 1981 budget request provides for the mission management and science experiment data analysis of the experiments which will be flown on a Shuttle orbital flight test in 1981. This level of funding will also provide for the completion of Spacelab 1 and 2 hardware, initiation of integration of the Spacelab 1 and 2 hardware with the Spacelab system, and final preparation of launch and operations plans.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

FY 1981 funding provides for the development of Physics and Astronomy principal investigator instruments now selected and under definition. The Solar Optical Telescope, Chemical Release Module, and Shuttle Infrared Telescope Facility will be under development in FY 1981.

The FY 1981 mission management funds will support the ongoing mission integration activities for NASA missions. Missions involved in this program in FY 1981 will include Space Applications, Space Research and Technology, Life Sciences, and Physics and Astronomy areas. FY 1981 funds will also be utilized to support the engineering and analysis for interface definition and mission definition of Shuttle/Spacelab instruments during development phases.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

EXPLORER DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Dynamics explorer	11,022	11,100	11,900	12,600
Solar mesosphere explorer (SME)	2,413	6,900	7,460	4,078
Infrared astronomical satellite (IRAS)	15,840	5,700	10,213	5,066
Active magnetospheric particle tracer explorer (AMPTE)	---	---	---	6,600
Other explorers	2,013	6,700	2,727	4,656
	31,288	30,400	32,300	33,000
Mission operations and data analysis (MO&DA)	(12,350)	(13,000)	(13,707)	(14,783)
Scout and Delta (expendable launch vehicles program)	(8,600)	(---)	(800)	(---)
Space transportation system operations	(---)	(3,700)	(1,900)	(4,200)

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 U.S. Government 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. The Solar Terrestrial program is in a transition from the early discovery and mapping phase conducted over the past decade to a phase in which specific problems will be investigated in more depth, frequently using simultaneous multipoint measurements. Efforts underway include development activity for the Solar Mesosphere Explorer (SME), the Dynamics Explorer (DE) and the San Marco-D missions. The SME is designed to investigate the stability of the Earth's ozone layer with emphasis on determining the response of ozone to changes in the solar ultraviolet flux. DE will provide data on the strong interactive processes coupling the hot convecting plasmas of the magnetosphere and the cooler plasmas and gases of the Earth's ionosphere and upper atmosphere. The San Marco-D, cooperative missions with Italy, will conduct a group of experiments to study the relationship between solar activity and Earth meteorological phenomena. Definition studies for several missions are underway, including the Active Magnetospheric Particle Tracer Explorer (AMPTE), a cooperative program with the Federal Republic of Germany, with development activity planned in FY 1981.

Astrophysics Explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, X-ray, ultraviolet, and infrared and low frequency radio regions of the electromagnetic spectrum. Major efforts underway include continuation of hardware and subsystems procurement and experiment fabrication for the Infrared Astronomical Satellite (IRAS); continuation of development work for the Cosmic Ray Isotope Experiment (CRIE), a cooperative program with DOD in which NASA will provide a scientific instrument for flight on an Air Force spacecraft; and future mission definition studies including the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EWE), and the X-ray Timing Explorer (XTE).

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase in FY 1980 funding requirements is the result of technical problems encountered in the development of spacecraft and instruments in ongoing projects. In particular, the Infrared Astronomical Satellite has experienced a number of technical difficulties which have resulted in increased costs, including cryogenic system fabrication, mirror polishing, and focal plane detector systems development.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will provide for completion of development activity, launch, and initial orbital operations for the IRAS, SME, DE, and San Marco-D/L missions; completion of development work on CRIE for launch on an Air Force spacecraft; initial development activity for the AMPTE mission; and design and definition studies for future Explorers including the COBE, EWE, XTE, and Solar Corona Explorer (SCE) missions.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
High energy astronomy observatory (HEAO) basic mission.....	5,439	5,351	6,336	128
HEAO extended mission.....	3,714	8,549	8,548	10,606
Solar maximum mission (SMM) basic mission.....	---	4,900	4,500	3,400
SMM extended mission	---	---	---	1,600
Space telescope (ST).....	---	1,800	1,800	6,700
Explorers.....	12,350	13,000	13,707	14,783
Orbiting astronomical observatory.....	2,450	2,900	2,209	1,683
Orbiting solar observatory (OSO).....	1,500	---	---	---
Total.....	25,453	36,500	37.100	38,900

OBJECTIVES AND STATUS:

The purpose of the effort is to conduct operations and to analyze data from the Physics and Astronomy satellites after launch. This program also supports the continued operations 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 first two High Energy Observatories (HEAO-1 and -2) have provided new and complementary data on a wide variety of cosmic X-ray sources. HEAO-1 completed a highly successful mission of mapping the entire X-ray sky with unprecedented sensitivity and reentered the atmosphere in March 1979. Among the primary results were the discovery of more than one thousand new sources; the determination of precise locations of many sources allowing optical identifications; the establishment of whole new classes of X-ray emitting objects; the detection of line emission from hot, highly ionized iron in neutron star binaries, supernova remnants, active galaxies, and clusters of galaxies; the discovery of the ubiquity of X-ray emission by normal stars; and the measurement of the spectrum of the diffuse X-ray sky background which is suggestive of an origin in a hot, tenuous gas at a temperature of 400 million degrees Kelvin.

HEAO-2 completed its first year of operation in November 1979, and has yielded a series of impressive results. For example, HEAO-2 has confirmed the stellar X-ray emission detected by HEAO-1 and demonstrated

that a much wider variety of stars emit X-rays in greater quantities than previously predicted. Similarly HEAO-2 observations of supernova remnants have had a profound impact on theories of the supernova explosion and the neutron star formation process. Beyond our own galaxy, HEAO-2 has mapped both the Milky Way's nearest neighbor galaxies, as well as the most distant quasars observed with optical telescopes. During its first year of operation, nearly *400* proposals have been submitted to use the HEAO-2 in a guest observer mode. These proposals have come from over 80 research groups around the world.

HEAO-3 was launched in September 1979. All instruments are returning excellent scientific data. The galactic plane has been extensively scanned with the gamma ray spectrometer, and preliminary analysis of the data shows the detection of line features from several known sources. The cosmic ray instruments have provided new information of the detailed composition of cosmic rays in the iron, nickel, and cobalt group.

The Solar Maximum Mission (SMM) is planned for launch in the first quarter of 1980. The SMM spacecraft will make detailed observations of the solar flare processes during the coming period of maximum solar activity, which is currently predicted to be 20 to 30% above the 130-year average cycle throughout 1980 and 1981. The SMM will carry instruments to permit detailed coherent investigations of flare-accelerated electrons and nucleons, of flare plasmas over a wide range of temperatures, and of coronal disturbances resulting from flares. In addition, coordinated observations by the SMM and the currently operational International Sun-Earth Explorers (ISEE) will permit studies of the source of specific solar wind disturbances and their effect on the Earth's magnetosphere.

In addition to the normal support required for mission operations, the Space Telescope program presents 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 at the focal plane. During the operational period, it will be used primarily by general observers scheduled 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 responsibiltiies for the observatory, the Institute will implement NASA policies in the areas of planning, management, and scheduling of the scientific operations of the telescope.

Several Explorer spacecraft remain operational and are providing valuable data. The International Ultraviolet Explorer (IUE) and International Sun-Earth Explorers (ISEE) continue to perform their missions well, with very productive guest investigator programs. The last Atmospheric Explorer (AE-E), launched in 1975, is still functioning well, and is providing insight into thermospheric and atmospheric variations not otherwise obtainable. For example, AE is providing interesting new data which seems to show solar ultraviolet input correlating in a different way with sunspot activity than it did during the last solar cycle. The

Interplanetary Monitoring Platforms continue to provide data on solar wind, cosmic rays, and on the Earth's geomagnetic tail from locations needed to correlate with spacecraft in other locations.

The Orbiting Astronomical Observatory (OAO-3), Copernicus, which was launched in 1972, continues to provide a three-axis stabilized automated facility for observing celestial objects and interstellar material in the X-ray and ultraviolet spectral ranges. OAO-3 is the only currently operating satellite capable of making spectroscopic observations in the important 900-1,150 angstrom wavelength region. During the past seven years, new techniques have been developed which have enhanced the usefulness of OAO-3 by allowing the observation of objects six times fainter than could be observed when the satellite was first launched. As a result, many new classes of objects have been studied by this observatory. FY 1980 funds support the operation of OAO-3 and the analysis of data obtained. The program has involved over 160 investigators and 170 different scientific projects. During the past year, however, the far ultraviolet detectors aboard OAO-3 have suffered a rapid degradation due to increased levels of solar activity. This degradation limits the science that OAO-3 can perform and it has been decided to terminate the mission in the fall of 1980. This will allow sufficient time for an orderly completion of the highest priority science.

CHANGES FROM F 1980 BUDGE ES IMAT

The FY 1980 changes reflect (1) an increase in the mission operations and data analysis phase of the HEAO program in order to cover increased cost for baseline operations; (2) a decrease in SMM operations costs due to a delay in the launch date; (3) a decrease in the guest investigator program for OAO-3 based on the decision to terminate operations in November 1980; and (4) an increase in the mission operations phase of the Explorer program in order to provide additional support for guest investigations on the IUE mission.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds will provide support for the continued operations of the HEAO-2 and HEAO-3 missions and related data analysis activity; the operations and data analysis activity for the Dynamics Explorers-A and -B missions scheduled for launch in 1981; data analysis activity for CRIE scheduled for launch on an Air Force spacecraft in 1981; extension of operations and data analysis activity for IUE, ISEE-A, -B, and -C, and AE-E; and support for continued analysis of the extensive archive of data obtained by OAO-3 and the Small Astronomy Satellite (SAS) C mission. FY 1981 funding will also support the operations and data analysis activities of the Solar Maximum Mission (SMM) as well as the continuation of preparations of science operations for the Space Telescope, including the initiation of a Space Telescope Science Institute.

BASIS OF FY *1981* FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Supporting research and technology (SR&T)	19,776	21,500	21,500	24,900	RD 4-27
Spacelab science payload definition	2,968	3,200	3,000	6,100	RD 4-28
Advanced technological development	200	2,500	2,500	2,700	RD 4-28
Data analysis	8,624	7,100	7,100	9,100	RD 4-29
Upper atmospheric research	12,437	---	---	---	
Total	44.005	34,300	34.100	42,800	

OBJECTIVES AND STATUS:

This program provides for the research and technological base necessary to 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 Technological Development (ATD). Activities included are Supporting Research and Technology (SR&T), Spacelab Science Payload Definition, ATD, and Data Analysis. Beginning in FY *1980,* the Upper Atmospheric Research program and direct supporting activities were included in the Space Applications program.

Supporting Research and Technology (SR&T)

The objectives of Supporting Research and Technology are: (1) to enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; *(2)* to develop theories to explain observed phenomena and predict new ones; *(3)* to optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; and *(4)* to strengthen the technological base for sensor and instrumentation development and to conduct basic research necessary to support our understanding of Astrophysics and Solar Terrestrial relationships.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's environment and comparative studies of other

planetary environments, including the study of Sun-Earth environmental factors. The work in solar physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary and planetary environments. Research supported in 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.

A major activity in SR&T is the Solar Terrestrial Theory program which is designed to provide for theoretical investigations of the predominately plasma physical 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 investigations of solar system plasmas and for this to play a vital role in the planning of future space missions and research efforts.

The SR&T program funds tasks at universities, nonprofit and industrial research institutions, NASA Centers, and other government agencies. Current emphasis is being placed on studies for advanced instrumentation which will increase both the sensitivity and resolution of detectors. Feasibility and scientific definition studies are being conducted on several potential candidate future missions, including the Gravity Probe-B which will 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's orbit. Scientific definition will also be started for the Cosmic Ray Observatory (CRO), a mission which will carry large cosmic ray instruments to measure particles of very high energy and low flux.

Spacelab Science Payload Definition

Spacelab Science Payload studies have provided the data necessary to establish a sound foundation for the Physics and Astronomy experiments to be conducted on Shuttle/Spacelab missions. The initial studies concentrated on establishing the feasibility of performing discipline-dedicated missions and multidisciplinary missions employing both facility-class and principal investigator-class instrumentation. The studies have identified the benefits which can be realized by reflying instruments and facilities. Instruments selected for study were those identified as having both complementary and evolutionary scientific uses. By planning to reuse and evolve instrument capabilities and to use instruments together as ensembles when they become available, a forceful and efficient research strategy for Spacelab use has evolved.

Multiuser Class Instruments (MUI's) now being defined include: the Shuttle Infrared Telescope Facility (SIRTF), a cryogenically cooled telescope which will carry out high sensitivity infrared observations, the Solar Soft X-Ray Telescope, the Tethered Satellite System, and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class UV/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 1980, further payload definition involving detailed description of instruments, payload configurations and operational missions will continue.

Advanced Technological Development

The Advanced Technological Development (ATD) activities support detailed planning and definition of new Physics and Astronomy 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 available. Funding is applied to the definition and preliminary design of subsystems and elements critical to eventual mission development in order that technical readiness and resources may be betrer known before the missions are proposed €or implemeptation.

Candidate missions for the 1980's that require ATD activities include the Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astrophysics Facility (AXAF), the Solar Probe, 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 1.2 meter class imaging X-ray telescope is planned to have a sensitivity approximately20 times that of HEAO-2. The Solar Probe Mission will perform detailed scientific observations of the Sun from a high elliptical orbit whose aphelion takes it to within four solar radii of the Sun's surface. The Solar Internal Dynamics Mission (SIDM) will investigate the oscillations visible on the Sun and use the data obtained to study the dynamic state of the Sun's interior. During FY 1980, major emphasis is being given to definition of the GRO mission in preparation for FY 1981 development activity and to preliminary feasibility studies on the OPEN mission.

Data Analysis

The acquisition, analysis and evaluation of data represents the primary purpose of our 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. More specifically, it is the time when the data may be correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (solar cycle) effects can be studied using complementary sets of data, and when many new ideas can be tested that originate from the results of the initial analysis.

For example, long-term observations of the X-ray source Vela X-1 provided important constraints on the internal structure of neutron stars. Thus, additional data is processed and analyzed, multi-instrument studies are made, and various proposed models or theories are critically tested by use of the data.

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 (GSFC), was established to serve as a central repository 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 concentrated at times when several spacecraft are especially favorably situated for correlative geophysical studies.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The reduction of $200 thousand in the FY 1980 estimate results from a slight adjustment in activity associated with payload planning under the revised Shuttle flight schedule.

BASIS OF FY 1981 ESTIMATE:

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology	19,776	21,500	21,500	24,900

During FY 1981, 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 and advanced X-ray detectors and instrumentation. Feasibility and scientific definition studies will be conducted on several potential candidate missions for future years, including 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 through both ground-based observations and theoretical studies of high energy phenomena. New thrusts will be initiated concerning the development of advanced generation instruments, especially for the extreme ultraviolet and X-ray wavelengths, and for analyzing the internal structure and dynamics of the solar interior. New thrusts will also be

established in the area of Atmospheric Electrodynamics. In the area of Theoretical Studies, investigations will be carried out by concentrated 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.

BASIS OF FY 1981 ESTIMATE:

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Spacelab science payload definition	2,968	3,200	3,000	6,100

In FY 1981, further definition of new concepts, as well as those presently under study, will be performed. The studies will provide descriptions of instruments and facilities, payload configurations and operational mission profiles. In addition, concepts and methods of extending time in orbit beyond the present Spacelab capability are being studied and evaluated. The detailed scientific definition of those facility instruments that are strong candidates for hardware development in the early 1980's will also be carried out in FY 1981. In the area of Spacelab Mission Integration, activities will be undertaken to identify user requirements and define interfaces for investigations which have yet to be assigned to a specific mission. New ways to reduce Spacelab mission integration costs as well as to permit Spacelab missions to be responsive to user demands will be pursued. Definition studies on the requirements and uses of the Space Platform concept will continue.

BASIS OF FY 1981 ESTIMATE:

Advanced Technological Development (ATD)	200	2,500	2,500	2,700

FY 1981 funding will provide for continuation of studies and definition of future missions planned for the 1980's. The FY 1981 funding will allow for further system definition studies, and instrument definition for investigations selected in FY 1980 for the OPEN mission. In addition, funding will support studies on the Advanced X-Ray Astrophysics Facility *(AXAF')*, the Solar Probe, and the Solar Internal Dynamics Mission (SIDM). Within the FY 1981 funding, contractor definition studies will be accomplished to assure the technological and scientific readiness of the candidate future missions.

BASIS OF FY 1981 ESTIMATE:

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Data Analysis	8,624	7,100	7,100	9,100

Emphasis in the Data Analysis project, 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). Several workshops will be held during FY 1981 devoted to specific physical problems (e.g., preflare storage of energy). FY 1981 funds will also support the operations of the National Space Science Data Center.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS					Page No.
Sounding rockets	21,307	21,700	21,700	25,000	RD 4-29
Airborne research	4,600	4,000	4,000	4,500	RD 4-31
Balloon program	2,300	1,200	1,200	1,400	RD 4-32
Total	28,207	26,900	26,900	30,900	
Sounding rockets	21,307	21,700	21,700	25,000	

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. The current level of activity is about 60 rocket flights per year.

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

1. 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:

a. The nature, characteristics, and composition of the magnetosphere and near space.

b. 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.

c. The nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

2. To support the basic objectives of the Physics and Astronomy program by providing the means for flight testing instruments and experiments being developed for later flight on satellites, Shuttle/Spacelab and space probes; and for calibrating or obtaining vertical profiles in concert with current orbiting spacecraft.

In 1979, 56 rockets were launched from eight 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 the February 1979 solar eclipse over the northwestern United States and western Canada, seven launches were made from western Ontario, Canada, in support of Plasma Physics and Upper Atmospheric studies. A similar expedition is planned to support Plasma Physics and Solar Physics studies during the solar eclipse over East Africa in February 1980. Also, in support of Solar Terrestrial studies in FY 1980, chemical release experiments will continue to be launched on sounding rockets to measure winds, wind shears, temperatures, plasma motions, and electric fields.

In the astronomy and high energy astrophysics disciplines, continuing emphasis is being placed on development of instruments for studies of stars and extended sources in the ultraviolet (W) and X-ray spectral regions. Of special interest during 1979 were several flights of an ultraviolet imaging telescope. The instrument obtained high quality photographs of nearby galaxies in both the far and mid-ultraviolet. These data help delineate hot young objects in these galaxies and will provide important new targets for the Space Telescope. During FY 1980, the first flight of an extreme ultraviolet spectrograph is planned.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds will provide for continuation of most of the efforts described above. Emphasis will be given to initiation of a concept called Experiments of Opportunity Payloads (EOP) which would make the capabilities of the Shuttle available to sounding rocket experimenters and potentially increase scientific

data acquisition periods from the present five minutes per flight up to 24 hours. The EOP concept calls for sounding rocket payloads, technology, and hardware to be launched by the Shuttle into a closeby orbit, operate in a free-flyer mode for up to 24 hours and then be retrieved and returned by the Shuttle. Payloads will be flown on a space available basis and have minimum interface with the Shuttle. An EOP development test flight is planned in the 1981-1982 time frame to provide a basis for evaluating the feasibility of the concept. Other efforts planned in FY 1981 include: (1) the first flight of an extremely high resolution, far ultraviolet spectrograph, which will provide a test of microchannel plates as space detectors and (2) the first test of new low cost technique using coated aluminum sheets for focusing X-rays.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Airborne [redacted]	4,600	4,000	4,000	4,500

OBJECTIVES AND STATUS:

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

The Airborne Research program has utilized two aircraft, the C-141 instrumented with the 91-cm infrared (IR) telescope and the 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-cm 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).

During the past year, support was provided for the February 1979 Solar Eclipse over the northwestern United States and Canada, and for an expedition to lower latitudes to observe the Galactic Center. In addition, a scheduled airframe inspection was accomplished on the C-141A. During FY 1980, support will

be provided for four airborne expeditions to areas in the Pacific to identify infrared sources not readily observable from the continental United States. Of special interest is the support planned for simulated Shuttle re-entry using an SR-71 aircraft (Project IRIS, Infrared Imagery Simulation). The main thrust of the FY 1980 program will be continued exploration of star forming regions as well as the development of more sensitive instrumentation for both photometry and spectroscopy.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, airborne research funds will be used to continue operations of the Airborne Observatory and the Lear Jet, to provide support for astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

	1979 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Balloon program	2,300	1,200	1,200	1,400

OBJECTIVES AND STATUS:

For the development of scientific experiments for space flight and for independent scientific missions, it is necessary 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 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 1979, 21 balloons were flown from five global sites to support the research activities of approximately 19 organizations. Of special interest was the successful resolution of problems affecting heavy-lift balloons, and a resumption of flights in the spring of 1979. One of these flights, carrying a 5,000-pound package of ultrasensitive instruments, has detected a stream of antimatter from interstellar space--the first such matter ever found outside a terrestrial laboratory. In the Infrared Astronomy area, about 40 percent of the galactic plane was surveyed resulting in the discovery of many new infrared sources.

FY 1980 funding provides support for about 20 flights including an expedition to Hawaii for carrying out scientific research in High Energy Astrophysics. In Infrared Astronomy, the survey of the galactic plane will be continued, which will provide additional information on the rate of star formation in our Milky Way system.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding provides for continuation of the Balloon program with approximately the same number of flights as in N 1980. New techniques for understanding high energy nuclear interactions using cosmic rays will be tested in FY 1981 prior to being incorporated into Spacelab. In Infrared Astronomy, emphasis will be on continuing the survey of the galactic plane and using new techniques to better understand how stars are formed prior to designing instruments for Spacelab.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1981 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Galileo Development	78,700	116,100	116,100	63,100	RD 5-5
Mission Operations and Data Analysis	59,300	59,000	58,800	64,800	RD 5-8
Research and Analysis	44,400	45,100	45,000	51,700	RD 5-10
TOTAL	182.400	220.200	219.900	179.600	
DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION:					
Johnson Space Center	4,115	6,380	6,012	5,990	
Marshall Space Flight Center	824	10	45	75	
Goddard Space Flight Center	3,749	3,830	3,757	3,780	
Jet Propulsion Laboratory	107,899	136,330	140,067	101,877	
Ames Research Center	40,841	44,520	30,953	28,340	
Langley Research Center	---	---	7	---	
Headauarters	24,972	29,130	39,059	39,538	
TOTAL	182.400	220.200	219.900	179.600	

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1981 ESTIMATES

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Galileo:	Galileo:	
- Probe	- Probe	1984
- Orbiter	- Orbiter	1984

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Planetary Program includes the scientific exploration of the planets, their satellites, the 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 have been highly successful. The strategy that has been adopted calls for equal 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. Mars has provided a program focus because of its potential as a site of biological activity and the Viking landings in 1976 carried the exploration of this planet forward to a new, high level of scientific and technological achievement, 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 taking 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 fundamental data about the formation of the planet. However, because of the opacity of the atmosphere, information about the Venus surface character remains sparse so that one of the more pressing goals of the Planetary Program is to fill this data gap.

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 have returned excellent pathfinding data, contributing significantly to the success of the history-making flybys of two Voyager spacecraft through the Jovian system in the spring and summer of 1979. The Voyager data relating to Jupiter and its four largest moons constitutes a small analogue of the Sun and planets. The Voyager spacecraft are now enroute to Saturn where encounters will take place in November 1980 and August 1981. The first close-up examination of that planet occurred in September 1979 when Pioneer 11 reached Saturn after receiving a gravity-assist at Jupiter five years earlier. Numerous discoveries were made as a result of this encounter and it was demonstrated

that a safe, close passage by Saturn's rings could be made. Voyager 2 must take a similar path if it is to proceed to Uranus for a 1986 flyby. Pioneer 10 has already crossed the orbit of Uranus on its way out of the solar system and is providing new information about a previously uncharted region of interplanetary space.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany. This mission, which will be launched by the Space Shuttle/IUS, has been rescheduled to early 1984 after it became clear that the Shuttle/IUS could not launch Galileo in 1982. A wide range of science experiments, chosen to make maximum progress beyond the Voyager findings has been selected. The Galileo development effort is proceeding on a schedule which will permit early 1984 launches of the Orbiter and Probe. FY 1981 funds will be used to continue this development effort.

The pre-eminence of the U.S. 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 ongoing missions, and that the necessary research is performed to maximize the return from ongoing and future missions. Included in the research and analysis programs 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 are also highly interdisciplinary with attention paid to establishing coordination among various research groups. The results of the research are widely and swiftly disseminated. The lunar sample analysis effort is mission-oriented and is coordinated with research efforts in this area supported 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.

One important class of solar system objects, comets and asteroids, has as yet not been subjected to investigation by spacecraft missions. Comet rendezvous and flyby missions are being defined as technology advances bring exploration of these small bodies within our grasp. Study of these primitive objects holds the promise of a breakthrough in our understanding of the nature of the early solar system.

BASIS OF N 1981 FUNDING REQUIREMENTS:

GALILEO DEVELOPMENT

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	54,083	83,260	90,875	42,184
Experiments	18,714	24,266	17,200	11,900
Ground operations	5,903	8,574	8,025	9,016
TOTAL	78,700	116.100	116.100	63.100
Space Transportations Systems Operations	(2,400)	(16,900)	(5,500)	(10,400)

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 our program of exploration of the solar system.

The objectives of this program are to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites, utilizing a new deep space spacecraft concept which combines both remote sensing and direct measurements on an orbiter spacecraft with separate atmospheric probe.

The Galileo mission was originally scheduled to be launched as a single spacecraft in January 1982, The baseline 1982 mission plan called for the Galileo orbiter to carry the probe to Jupiter and relay its data back to Earth before starting a twenty-month orbital tour. During the twenty-month tour, the orbiter would have eleven encounters with the highly interesting Galilean satellites. The project was planned to be completed in July of 1987. However, when it became clear that the Space Shuttle/IUS could not provide the performance required for the launch of Galileo in 1982, several alternate plans for the mission were reviewed. The most economical and efficient alternative for the Galileo mission is to utilize separate Space Shuttle launches for the Galileo orbiter and probe, and to shift the launches to the earliest subseouent opportunity to utilize a Mars assist on the voyage of the orbiter to Jupiter in February and March 1984. Galileo is the only planetary program still under development and the 1984 mission will preserve the science content of the original mission as recommended by the National Academy of Sciences (Space Science Board) with the lowest increase in total cost.

The restructured mission makes maximum use of the development effort expended to date. The 1984 mission will result in a delay in science return of only one year although the launch is delayed by two years. This is a result of the shorter trip time available in the 1984 opportunity.

Although 1984 is not as favorable a Jupiter launch opportunity as 1982, the Mars powered swingby makes it an excellent opportunity. This trajectory, which will be employed by the Galileo 1984 orbiter mission, will reduce the performance required from the Shuttle and IUS. In order to accomplish the powered maneuver at Mars, the amount of fuel on board the orbiter must be doubled and there must be some redesign of the propulsion system. In the 1984 configuration, over 60% of the weight of the orbiter is in the propulsion system; therefore, the supporting structure must be strengthened. Those electronic subsystems and structural elements of the orbiter which were intended solely to support the probe will be deleted. Otherwise, the orbiter need not be changed. All of the design and development effort on science instruments and electrical subsystems is still valid. The current contracts for development of orbiter subsystems will remain in force. Delivery schedules will be slipped to avoid the use of overtime but will remain tight to minimize costs. Because of the increase in the spacecraft mass caused by the additional fuel, mass margins are still tight, but considered adequate.

The probe need not be modified. All science instruments can be retained. The delivery schedule on present contracts will be adjusted to achieve the most efficient application of funds.

The launch of the probe separately from the orbiter requires the development of a probe carrier spacecraft. For a planetary spacecraft, the probe carrier can be of a relatively light and simple design. The demands on electronic subsystems are not severe. It will simply fly past Jupiter and leave the solar system after delivering the probe. Therefore, no large propulsion system is required. Because the spacecraft is light we can use a direct trajectory to Jupiter. It may be possible to use, on the probe carrier, some of the electronic subsystems designed to support the probe which have been deleted from the orbiter. It is planned to procure the probe carrier through competitive proposals from industry. The cost of this spacecraft should be relatively low for a 1984 launch since there are existing spacecraft designs on which a carrier can be based. The development schedule appears to be reasonable.

The probe spacecraft trajectory will be designed so that the probe will enter the atmosphere of Jupiter when the orbiter is in a proper position to provide remote sensing of the probe entry site. Without this information, it will be significantly more difficult to understand the data from the probe. Likewise, without the simultaneous orbiter and probe measurements, the orbital data on the atmospheric dynamics of Jupiter will be less understood.

The Federal Republic of Germany has made a commitment to develop the retropropulsion element for the mission, and has agreed to sustain this endeavor for the 1984 mission. Design and development of the spacecraft and

probe elements as well as the science instruments are underway. This momentum can be efficiently redirected toward the 1984 launch opportunity.

In FY 1980, the design, development and fabrication activities will continue. Requirements imposed by the revised launch date are being translated into final designs for the major elements of Galileo--the probe and orbiter spacecraft, the mission operations, the spacecraft propulsion module, the on-board power systems, and the Space Transportation System interface. Competitive procurement of the probe carrier spacecraft will be initiated.

CHANGE FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 Galileo estimate remains unchanged in total; however, adjustments have been made within the project elements to accommodate the 1984 launch dates. The 1984 launches require a modification of the spacecraft propulsion system to allow a powered Mars flyby and the orbiter structure will be modified as necessary. Orbiter hardware required solely to support delivery of the probe to Jupiter will be deleted. The probe will remain unchanged. A probe carrier spacecraft, which will deliver the probe to Jupiter and relay the probe data back to Earth, must be developed. Replanning of schedules is also required.

BASIS OF IN 1981 ESTIMATE:

FY 1981 funding requirements will provide for continued fabrication and test of the Galileo science instruments, the probe and the orbiter spacecraft. The award of a probe carrier contract in FY 1981 is planned, and will be followed by the orbiter critical design review.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Voyager basic mission	16,742	19,000	19,000	25,600
Voyager extended mission	---	---	---	3,000
Pioneer Venus basic and extended mission	9,000	9,800	9,400	7,700
Pioneer 6-11 extended mission	3,125	4,000	2,800	2,500
Helios extended mission	200	---	100	100
Viking extended mission	5,000	---	1,000	---
Planetary flight support	25,233	26,200	26,500	25,900
Total	59,300	59,000	58,800	64,800

OBJECTIVES AND STATUS:

The Mission Operations and Data Analysis Program funds the operations phase of planetary missions after development, launch, and initial in-flight checkout are complete. It also provides for multimission flight support. Currently, active planetary missions being supported within mission operations and data analysis are Voyager, Pioneer Venus, Pioneer 6-11, Helios and Viking.

The objective of the Voyager mission to the outer planets is to conduct scientific studies of the Jupiter and Saturn planetary systems, including their numerous satellites and the rings of Saturn. If conditions are favorable, Voyager 2 may also go on to Uranus to investigate that exciting planet. While the two spacecraft are cruising to the outer planets, they are also performing continuing investigations of the interplanetary medium. Since their launches in 1977, the two Voyager spacecraft have encountered Jupiter and investigated this system. Both spacecraft are in good condition and on cruise trajectories toward Saturn. The primary radio receiver of Voyager 2 has failed; however, the spacecraft is being operated successfully by using its backup receiver, even though that equipment is somewhat impaired by a component failure. Encounter operations for Voyager 1 will begin in mid-August 1980 and the closest approach to Saturn will occur in November 1980. Similar operations for Voyager 2 will occur in 1981 with closest approach at Saturn in August 1981. A wealth of new planetary data is expected from the investigations provided by the Voyager spacecraft as they traverse the Saturnian system. Subsequent to the Saturn encounters, the

spacecraft will continue to provide data on the interplanetary medium. Voyager 1 will investigate the outer limits of our solar system.

The objectives for Pioneer Venus are 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 is carried out by 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 was put into a highly elliptic orbit that approaches within 150 kilometers of the surface. On December 9, 1978, the four probes and multiprobe bus entered the atmosphere. The probes made measurements as they descended to the surface at widely separated points, and the bus also collected data. The mission has been, and continues to be, an outstanding success.

The objective of Pioneers 6-9 is to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 AU. (The Earth's distance from the Sun is 1 AU, an astronomical unit). The objectives of Pioneer 10 and 11 are to explore space beyond 1 AU, the Asteroid Belt, and the environment of Jupiter. Pioneers 6-9, with launches starting back in 1965, are still operational, but now generally 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 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 spacecraft have returned excellent data and continue successful operation.

During FY 1980, three Viking spacecraft are continuing to collect data at reduced levels. The two landers are in an automatic mission mode, in which they collect and store data for transmission to Earth upon interrogation. Orbiter-1 is expected to become depleted of attitude control gas by mid-1980. When this orbiter is shut down, the ability to obtain relays from Lander-2 will be ended, and Lander-2 will also be shut down. Lander-1, capable of transmitting directly to Earth on command, will continue to collect data.

Planetary Flight Support provides for mission control and other activities which support the tracking telemetry and command functions for all planetary spacecraft. The activities include general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL), and the selected project functions such as computer analysis and preparation of data records. These functions are performed at the Mission Control and Computing Center at JPL.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The $200,000 decrease in the mission operations and data analysis budget is a result of a Congressional general reduction in the FY 1980 NASA Research and Development appropriation request. Minor adjustments were also made in several of the program elements. Viking operations were continued into FY 1980, as reflected by the increase of $1.0 million, to take advantage of the excellent data still being received.

BASIS OF FY 1981 ESTIMATE:

The successful encounters at Jupiter by the Voyager spacecraft have resulted in numerous discoveries, high demand for the image products, and a large data base for intense analysis by the scientific community. The Voyager FY 1981 funding will provide for mission operations during the Voyager 2 cruise period between the Jupiter and Saturn encounters, two Saturn encounters, and the start of the Voyager 2 cruise to Uranus. The project scientists will be engaged in analyzing and publishing the results from the two Jupiter encounters in 1979, and from the encounters with Saturn. The flight team will also be developing the sequences and software for the Voyager 2 Saturn encounter, which will occur in August 1981. Voyager 1's encounter period at Saturn will start with concentrated observations of the ringed planet and its many satellites in 1980. The FY 1981 funds will provide for processing and analysis of the data obtained during the first two years of the Pioneer Venus extended orbital operations. FY 1981 funds will also provide for Pioneer 6-11 mission operation and data analysis with emphasis on data from the Saturn encounter of Pioneer 11.

FY 1981 planetary flight support funds will provide mission control and computing support for all active deep space missions.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Supporting research and technology	29,500	33,300	33,600	37,500	RD 5-12
Advanced programs	5,400	5,800	5,400	7,800	RD 5-13
Mars data analysis	4,500	6,000	6,000	6,400	RD 5-13
Solar electric propulsion/comet studies	5,000	---	---	---	
Total	44,400	45.100	45.000	51,700	

OBJECTIVES AND STATUS:

The Research and Analysis program contains three supporting elements required to assure that data and samples returned from flight missions are fully exploited, to undertake complementary laboratory and theoretical efforts, and to define the science rationale and develop required technology to undertake

future planetary missions. The three elements are: (1) Supporting Research and Technology; (2) Advanced Programs; and (3) Mars Data Analysis.

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.

In the Spring of 1979, the new Infrared Telescope Facility in Hawaii commenced planetary observations, and in October 1979 became fully operational. In addition to planetary observations, the Facility has provided support to the Voyager 2 encounter of Jupiter.

The Planetary Atmospheres activity includes data analysis and laboratory and theory 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, will lay the basic groundwork for major advances in knowledge in 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 Galilean satellites of Jupiter 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, both from spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The Planetary Materials activity supports 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 similar analysis. These studies continue to yield new and otherwise unobtainable information about the solar

system, particularly about its early history. NASA maintains a balanced program of work on extraterrestrial materials consistent with its mission. 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 state-of-the-art scientific instrumentation. Most of the effort is currently directed toward the definition of instrumentation for an eventual mission to a comet.

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 assessed 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.

Current studies and supporting activities cover such possible future missions as the Venus Orbiting Imaging Radar (VOIR), a comet mission, a Saturn orbiter mission with Saturn and Titan probes, and an asteroid multiple rendezvous mission.

Mars Data Analysis -- The Mars Data Analysis activity continues to assure that wc fully capitalize on the wealth of data provided by Viking. The activity covers the broad scope of the returned data--biology, chemistry, geology, and meteorology.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $300 thousand from the budget estimate for the Supporting Research and Technology Program is a result of the transfer of instrument definition activities from the Advanced Programs area to the Supporting Research and Technology Program. The current estimate for Advanced Programs also reflects a reduction of $100 thousand as a result of a Congressional general reduction in the appropriation request.

BASIS OF FY 1981 ESTIMATE:

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Supporting Research and Technology.....	29,500	33,300	33,600	37,500

During FY 1981, research efforts will continue in the areas of Planetary Astronomy, Planetary Atmospheres, Planetary Geochemistry and Geophysics, Planetary Geology, Planetary Materials, and Instrument Definition. Infrared telescopic observations of Saturn will be undertaken in support of the Voyager missions, and radar telescopes will be used to continue the investigation of Venus and other solar system bodies. Other significant observations will be conducted both to increase our knowledge of the outer planets and the small bodies of the solar system, and to advance our readiness for future missions. 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 made to better understand the present state and 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 1981.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Advanced Programs	5,400	5,800	5,400	7,800

In FY 1981, the major effort in Advanced Program will be devoted to continued prepartions for the Venus Orbiting Imaging Radar Mission, including more detailed mission definition studies and advanced technology development. Work will also proceed on advanced mission definition, and on instrument definition and development, in support of future cometary and other planetary science mission opportunities.

Mars Data Analysis	4,500	6,000	6,000	6,400

The Mars Data Analysis activity which began in FY 1979 has provided support for over 80 research efforts in a wide range of discipline areas such as biology, chemistry, geology, and meteorology. The FY 1981 funds will provide for the continuation and/or completion of these efforts and the initiation of new analyses.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Life sciences flight experiments	15,700	12,900	16,600	19,200	RD 6-3
Vestibular function research	---	3,700	---	---	---
Research and analysis	24,400	27,300	27,200	30,500	RD 6-5
Total	40,100	43.900	43.800	49.700	

Distribution of Program Amount by Installation:

Johnson Space Center	19,716	16,650	19,423	22,210
Kennedy Space Center	225	650	723	1,129
Jet Propulsion Laboratory	1,770	2,050	1,677	1,746
Ames Research Center	13,081	18,480	14,266	15,837
Dryden Flight Research Center	185	200	164	288
Langley Research Center	---	---	40	40
Headquarters	5,123	5,870	7,507	8,450
Total	40,100	43.900	43.800	49,700

OFFICE OF SPACE SCIENCE LIFE SCIENCES PROGRAM

PROGRAM OBJECTI AND JUSTIFICATION

The objective of the Life Sciences program is to support NASA's overall goals and objectives in the exploration and utilization of space by conducting studies in the areas of space biology and medicine and by expanding scientific knowledge in the area of the origin and evolution of life. The realization of this objectiye, which is intimately linked to our understanding of the basic mechanisms of biological and medical processes, is achieved through a program of research conducted both on Earth and in space. The near-term activities will help us to discover and investigate the effects of the space environment on humans to facilitate their safe, useful participation in space activities. A continuum flows from the ground-based research activities to the flight experiments, and then from flight findings to laboratory work on the Earth. Thus, the Life Sciences program utilizes a composite of disciplines addressing all space-related problems in biology and medicine.

The Life Sciences program is composed of three major program thrusts. The first is a program consisting of flight and ground-based experiments, whereby the physiological effects of the space environment on humans are explored. The unique properties of space (e.g., micro-gravity, radiation, etc.) provide, for the first time in our history, an opportunity to explore significant problems in biology under a controlled set of conditions that cannot be adequately duplicated in laboratories on Earth. The second is the continous in-flight observation of crews venturing in space and the testing and refining of countermeasures and establishing requirements in space exploration. The third thrust is the studies in exobiology, with special emphasis on a problem of profound philosophical and scientific significance: the origins and the distribution of life in the universe.

The first major thrust is conducted through ground-based research, and through flight opportunities on the Shuttle as well as through the US/USSR Biological Satellite program. In preparation for the early Spacelab flights, and subsequent selection of Shuttle passengers, ground-based research is being conducted on the limits of physiological tolerance to space flight stresses. Seven life science experiments are being developed by NASA for the Spacelab-l mission. These experiments emphasize the study of the effects of space flight on humans, such as changes in vestibular function and hematological indices and the impact of space radiation and the effect of gravity on plant growth and biological rhythms.

The first Spacelab flight, dedicated to Life Sciences experiments, is planned for 1983. Over 360 proposals in response to our first Announcement of Opportunity were received in 1978 and since then 82 of the most promising experiments were selected for a "definition phase". Final selections for the first dedicated flight will be made in 1981. Development of general purpose equipment for use on life science missions is in progress.

NASA continues its ongoing participation in the joint US/USSR Biological Satellite program, the latest of which was (Cosmos 1129) launched and successfully recovered in October 1979. Thirteen US experiments were flown on this flight; these experiments explored relevant medical and biological problems. In addition, experiments are being developed for US participation in a 1981 USSR biological satellite mission. In conjunction with the outlined flight program, complementary integrated ground-based research continues to enrich the Life Sciences data base and develops rationale for future flight experiments.

The second major thrust is in the area of operational medicine. The goals of this program are to assure astronaut and payload specialist health and ability to function effectively in the space environment, which in turn, will provide sound foundations for a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is placed on the early detection and prevention of debilitating diseases, and on the testing of countermeasures designed to prevent untoward physiological responses associated with exposure to the space environment. It is essential that continuous long-term monitoring of Shuttle crew and complements is performed in a standard and organized fashion in order to establish the long-term clinical significance and development of risk factors which might be associated with repeated exposure to the space environment.

Exobiology is the third major program thrust. The goal is to understand the origins and distribution of life throughout the universe. Particular emphasis is placed on developing sound hypotheses which ultimately will lead to discovering the relationships which link the formation of the solar system to the beginnings of life. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with planetary flight experiments, are clarifying the mechanisms of, and environments conducive to, the formation of essential biomolecules. The impact of the presence or absence of life on the subsequent evolution of a planet is just beginning to be realized.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Life sciences flight	15,700	12,900	16,600	19,200
Space transportation system operations.....	(2,500)	(2,800)	(7,500)	(12,000)

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to expand our understanding of the operant basic mechanisms and time course of biological and medical processes as they occur from exposure to zero gravity. The program includes the whole processes of experimental design, development, inflight execution and data analysis and reporting. Advanced hypotheses which require the unique aspects of the space environment for adequate testing, form the basis for the experiments flown. The current plan is to provide as much general purpose flight hardware as is feasible for the flight experiments, thus avoiding unnecessary duplication of development costs.

During FY 1979, over 360 proposals for Life Sciences Flight Experiments were reviewed and evaluated for scientific merit, engineering, cost and mission compatibility considerations. In October 1979, 82 of these investigations, 78 from the US and four from the international science community, were selected as candidate flight experiments for Life Sciences Spacelab Missions. After a six to nine month experiment definition phase, the candidate group will be narrowed down to 50–60 investigations. From this group, payloads for the first and second dedicated Life Sciences Spacelabs will be selected. It is estimated that approximately 15 to 20 investigations can be accommodated on each mission. The first dedicated Life Science Spacelab mission is currently planned to be flown in 1983, and the second is planned to be launched approximately 18 months later. The final payload for each mission will be selected about two years prior to launch.

Flight experiments for the first joint NASA/European Space Agency mission (Spacelab-1), are now proceeding through their final phase of development. Once this activity is completed, the hardware will proceed through integration, test and checkout activities at Johnson Space Center prior to shipment to Kennedy Space Center for final Spacelab integration and tests in support of a 1982 launch.

Life Sciences Flight Experiment hardware which will be flown on two of the Shuttle orbital flight test (OFT) missions, and on Spacelab-2, is also in the final stage of development. Delivery of this flight hardware will be completed in 1980.

On the second Shuttle OFT mission, a single hardware verification test will be conducted in support of a plant experiment scheduled for flight on Spacelab-1. A plant growth experiment will be conducted on both OFT-5 and Spacelab-:!. Spacelab-:! will also carry a blood experiment designed to investigate Vitamin-D metabolities and bone demineralization utilizing hardware developed for Spacelab-1.

Another element of the Life Sciences Flight Experiment program is our joint participation with the USSR which includes flying experiments aboard the Cosmos 1129 biological satellite which flew from September 25, 1979 to October 12, 1979. The flight specimens were received from the Soviets in November and the US scientists are now analyzing their material. Presentation of the results is planned in conjunction with a meeting of the International Congress of Physiological Sciences, July 1980, in Budapest, Hungary.

The next anticipated participation by the US in the Cosmos program will be a primate flight for 1981. The US has submitted six experiment proposals for consideration by the USSR.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $3.7 million in the FY 1980 current estimate for flight experiments reflects a restructuring of the Life Sciences program which involves the transfer of funds previously budgeted for the Vestibular Function Research to the Life Science Flight Experiments program where concept studies on a vestibular facility will be conducted.

BASIS OF FY 1981 ESTIMATE:

In early FY 1981, experiment selection for the first Life Sciences Spacelab Mission (LS-1) will be completed; subsequently, development phase contracts will be awarded to Principal Investigators who are selected for further definition. Experiment preliminary design reviews will be conducted followed by a payload synthesis exercise, after which final flight experiments selections for LS-1 will take place. Late in the year an integrated mission requirement review will be held.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Life sciences supporting research and technology.....	24,400	27,300	27,200	30,500

OBJECTIVES AND STATUS:

The Research and Analysis activities of the Life Sciences program represent the ground-based research in space-related biological and biomedical problem areas that have been identified in previous flights or have been determined to be highly probable in future flights and comprises five elements: (1) operational medicine, (2) biomedical research, (3) space biology, (4) exobiology, and (5) life support.

The Life Sciences operational medicine program is the catalyst 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 assurances that physical welfare and performance is preserved and that adequate treatment of in-flight illnesses or injuries is provided. In addition, the Space Transportation System and future generations of space vehicles will allow for a complement of crews of varied background, age and sex, who will work for different lengths of time in the unique environment of space. Thus, a new dimension of frequent and repetitive exposure to zero-gravity will be introduced. Such manifestations as "space motion sickness", fluid shifts, endocrine shifts (which can result in decreased performance in flight), decreased post-flight cardiovascular tolerance, and possible aggravation of latent diseases, will be carefully documented and, where feasible, prevented. To this end, specific operational requirements such as careful medical selection, periodic evaluation of health status (including'pre- and post-flight medical observations), in-flight monitoring of the time course of adaptation to and performance in the space environment will be continually reevaluated and updated. Significant emphasis is placed upon real-time testing of promising countermeasures developed by the research and analysis programs under controlled conditions.

The biomedical research program objective 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 expected to affect the human organism in prolonged or repetitive space flight. Thus, motion sickness, bone loss and hormonal disturbances are the subjects of a continued search for mechanisms and countermeasures. The program is largely dependent upon the use of ground-based analogues of space flight. Special regimens of bed rest, water immersion and centrifuge time are employed to evoke specific responses in both man and animals. New techniques such as tomography and radionuclide imaging are being perfected to study these changes in living organisms. Commencing in FY 1980, an integrated mathematical analysis of several physiological systems will receive major emphasis. The approach is expected not only to improve our capability to protect future space workers, but also to enhance our overall comprehension of physiology in health and in disease.

The space biology activity will explore the role of gravity in life processes and use 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 of 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 multi-generation reproduction of life in space. This program provides basic ground-based information in support of future space flight experiments and life support systems.

Exobiology is 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, affords a unique opportunity to address a most fundamental question regarding the existence of such processes beyond the Earth. Theories about chemical evolution and the origin of life are being refined to reflect results from the most recent planetary and astronomical explorations. The current research program also is uncovering an initmate association between the origin and evolution of life on Earth and the processes which shaped the evolution of the solar system itself. These discoveries have highlighted gaps in our knowledge which, when completed as the program expands, will ultimately allow tests of the concept of universality of biological processes.

The life support systems activity will focus on the continuing research and developmental efforts aimed at increasing and enhancing our ability to support long-duration manned space occupancy and maximizing astronaut and passenger-scientist productivity. Achievement of these goals is sought through improved habitability, man-machine relationships, as well as provision of direct supportive needs such as food, water, and a habitable atmosphere. For longer duration missions, the program will continue to study the capability for regeneration and reuse of water and air, as contrasted to the expendable-type life support currently available.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $100 thousand in the FY 1980 estimate is the result of a Congressional general reduction in the NASA FY 1980 R&D appropriation request.

BASIS OF FY 1981 ESTIMATE:

The operational medicine programwill continue to investigate the possible occupational exposures in zero-gravity, and the development of training and remedial preventative measures, together with modification of medical care procedures utilized on Earth to meet the unique requirements of the space environment.

The biomedical research program will continue to focus primarily on the motion sickness problem because of its relevance to Space 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 can be devised. Increased awareness and understanding of the radiation hazard has resulted in more emphasis being placed on the biological effects of high energy radiation and upon radiation protection. Major new avenues of research will deal with the psychological accompaniments of space flight and with mathematical modeling procedures.

The space biology program will continue to research 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 endocrine responses and basic biological control mechanisms will be expanded. The space biology program will continue to provide ground-based support data for future Shuttle/Spacelab flight experiments.

Exobiology research has identified a need to expand our understanding of events preceding what is classically called chemical evolution and following what is referred to as the origin of primitive life forms. Studies of the history of biogenic elements, the effect of extraplanetary and astrophysical events on evolution of complex life, and the distribution of life in the universe will be conducted to make the unifying scenario of life in the universe complete.

The life support systems program will continue to investigate basic biological processes and physical-chemical methods which can provide the capability to recycle waste, food, atmosphere and water.

SPACE AND
TERRESTRIAL
APPLICATIONS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE AND TERRESTRIAL APPLICATIONS

Programs	Budget Plan			
		1980		1981
	1979 Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)			
Space applications	274,800	332,300	331,800	381,700
Technology utilization	9,100	12,100	12,100	13,100
Total	283,900	344,400	343,900	394,800

SPACE
APPLICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Resource Observations	139.400	141.400	145.203	162.300	RD 7-9
Environmental Observations	67.750	117.200	109.470	137.600	RD 7-29
Applications Systems	13.950	20.300	24.547	18.100	RD 7-49
Technology Transfer	10.700	10.300	10.087	12.500	RD 7-50
Materials Processing in Space	20,400	19.800	19.768	22.200	RD 7-53
Space Communications	22.600	23.300	22.725	29.000	RD 7-58
Total	274.800	332.300	331.800	381.700	
Distribution of Program Amount by Installation:					
Johnson Space Center	24,146	31.150	25.330	41.990	
Kennedy Space Center	520	825	1.428	195	
Marshall Space Flight Center	26,412	29.525	28.705	23.950	
National Space Technology Laboratories	3,199	3.750	2.940	3.720	
Goddard Space Flight Center	159,076	184.100	182.320	198.770	
Jet Propulsion Laboratory	22,951	22.300	18.463	21.570	
Wallops Flight Center	3,114	4.125	3.915	4.390	
Ames Research Center	7,983	10.550	16.010	18.295	
Langley Research Center	9,789	19.125	14.548	12.805	
Lewis Research Center	5,294	5.125	10.368	17.000	
Headquarters	12,316	21.725	27.773	39.015	
Total	274.800	332.300	331.800	381.700	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Resource Observation:		
Earth Resources Tech. Satellites	Launch of LANDSAT-D	1981
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1981
Environmental Observation:		
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1982
Earth Radiation Budget Experiment	Launch of ERBS	1983
	ERBE instrument to be launched on NOAA F&G (Subject to NOAA call-up)	1984-1985
Halogen Occultation Experiment	HALOE instrument to be launched on Spacelab mission and ERBS	1982-1983
National Oceanic Satellite System	Launch of first spacecraft	1986
Materials Processing in Space:		
Sounding Rocket Missions	Launch 2 in 1980, 1 in 1981	1980-1981
	Flight of Materials Experiment Assembly	Beginning in 1982
Shuttle/Spacelab Payload Development	Spacelab Payloads	Beginning in 1982
Space Communications:		
Search and Rescue Mission	Instruments to be launched on NOAA (TIROS-N series) spacecraft	1982

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Reimbursable Missions:		
GOES*	Launch of GOES D through F	1980-1983 (Subject to call-up by NOM)
NOAA*	Launch of NOAA A-G	1979-1985 (Subject to call-up by NOAA)

*National Oceanic and Atmospheric Administration (NOAA) funded.

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Applications program is to conduct research and development activities that demonstrate and transfer space-related technology, systems and other capabilities which can be effectively used for down-to-Earth practical benefits. These activities are grouped in the following general areas: Resource Observations, Environmental Observations, Applications Systems, Technology Transfer, Materials Processing in Space, and Space Communications.

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 needs for information of vital economic value to the U.S. and of worldwide humanitarian concern required for management of the world's limited food, water, and energy supplies and for the identification of potential geodetic hazards. The principal objectives are to develop and demonstrate the use of space and space technology to provide the U.S. 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. Inherent in the pursuit of these objectives is the involvement of the users of space-derived information in the total program activities, from the planning to the development, test, verification, and application of the techniques.

Principal activities include the identification of user information needs, the development of remote sensing and information extraction techniques, provision for the acquisition of space data, and joint research, development and test projects with users, leading eventually to the establishment and routine use of global data collection systems. Currently, Landsat-3 is providing a wide variety of useful data. Landsat-D, with improved sensing capabilities, is under development and will be launched in late 1981 or early 1982. NASA will support the National Oceanic and Atmospheric Administration with its new responsibility for management of the operational land observing system. Magsat and the Heat Capacity Mapping Mission continue to provide valuable information for geophysical and geologic studies. Experiments designed to test the applicability of active microwave measurements, and of high resolution imagery for mapping investigations, are planned for flight on early Shuttle missions. Studies are also underway to define the appropriate space

systems for gravimetric measurements for solid earth studies, for global stereoscopic imagery for resource exploration, and 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 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 studied effectively (and sometimes solely) from space. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. NASA's research satellites give a special view of the radiative, chemical and dynamics processes occuring in the atmosphere and oceans.

The Environmental Observations Program includes studies and flight missions directed at all of the layers of the atmosphere from the highest layer of the upper atmosphere down to and including the upper layers of the oceans. The program areas include: (1) upper atmospheric research, (2) tropospheric air quality, (3) global weather, (4) severe storms, (5) oceanic processes (including ocean circulation, sea and glacier ice, coastal and inland waters, air-sea interaction and marine boundary layer), and (6) climate. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contributions of space-derived data.

Research into the chemistry of the stratosphere as it relates to ozone is beginning to pay dividends with the production of global ozone maps from NIMBUS data and a large collection of measurements of chemical constituents. These now make possible testing of mathematical models of the complex chemical system of the stratosphere. Advanced studies of the next remote sensing contributions to understanding the upper atmosphere and to observing tropospheric pollution are now underway.

In support of operational services the NOAA series and GOES series of satellites are well established. TIROS-N, NOAA-A and GOES-D, launched in 1978 and 1979, continue to provide National Oceanic and Atmospheric Administration with excellent data for incorporation into their forecasts. SEASAT, NIMBUS-7, and SAGE have provided and continue to provide important research information. Several other flight programs, such as the Earth Radiation Budget Experiment, the Halogen Occultation Experiment and a number of Shuttle/Spacelab

payloads, are being prepared for launch in the early 80's. Information from these experiments should provide a significant contribution to achieving a better understanding of climatological processes.

Programs of research and transfer of technology are well established in the area of weather and storms. Research and analysis of data from the flight demonstrations (such as SEASAT) of remote sensing of the oceans have been a major thrust in recent years within the Applied Research and Data Analysis program. Based on experience gained through the SEASAT mission and as part of the ongoing program in remote sensing of the oceans, NASA, DOD, and NOAA are jointly proposing a new initiative called the National Oceanic Satellite System (NOSS). NOSS is a limited operational demonstration consisting of two ocean-viewing satellites with a full ground data system that provides near real-time information to the operating agencies. NOSS will provide valuable information on global wind fields, wave height and spectrum, sea surface temperature, ice coverage, and ocean color.

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

Technology Transfer - The objective of the Technology Transfer program is to ensure that the maximum possible benefits are derived from the technology developed by NASA. There is a growing demand by an increasing number of public and private organizations to use space-based remote sensing technology as a tool to derive much of the resource information required for a variety of needs: to meet Federal, state and local requirements; to assist in the search for and development of critical energy resources; and, to meet numerous other requirements for synoptic, geobased information. The Technology Transfer program assesses national priorities and user needs which can benefit from remote sensing technology, informs users of existing and planned technological capabilities, and conducts cooperative projects with user organizations to verify and transfer remote sensing technology to operational use. Due to the extensive interfaces maintained with a wide variety of individual users as well as user representative groups such as the National Conference of State Legislatures, the Technology Transfer Program also serves as a valuable communication channel for the widespread dissemination of transfer project results and user experience which is synthesized and focused for planning of new technology programs.

Materials Processing in Space - The Materials Processing in Space (MPS) program emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of space-borne facilities in space environment for materials processing, 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 be conducted in 1980. These activities are intended to encourage early transfer of space activity in materials science to private sponsorship. Ground-based research in FY 1981 will continue the expanded effort initiated in 1980 and will be increased to accommodate an augmented effort in advanced technology development to meet needs identified in the ground-based research program, and definition studies on space experiment systems to perform investigations arising from MPS materials research. The program's initial STS payload equipment will be fabricated in FY 1981, leading to delivery for integration early in FY 1982. Principal Investigators will complete development of experiment plans and samples for the first flights of the several apparatus systems.

Space Communications - A new industry was built upon NASA's early pioneering work in satellite communications. Industry now offers strong support for a renewed NASA effort in satellite communications R&D in order to assure a large U.S. participation in a rapidly growing worldwide telecommunications market. In FY 1980, NASA is focusing on the development of technology to increase the usable capacity of the radio frequency spectrum, In particular, NASA is developing hardware and techniques for a new higher frequency satellite communications band, including multi-beam antennas and on-board switching. In FY 1981, user experiments and demonstrations on NASA's Applications Technology Satellites, ATS-1 and ATS-3 experimental satellites will continue. Although public service user experiments on ATS-6 and Communications Technology Satellite have been completed, the review, analysis and reporting on the four hundred experiments conducted will be supported in FY 1981. Significant effort is being undertaken to provide technical consultation and support to U.S. Government agencies that have participated in the 1979 General World Administrative Radio Conference to assess the impact of changes made in the Radio Regulations.

Work is continuing on the development of an experimental Search and Rescue Mission, This system will employ sensitive receivers and high gain antennas, carried on a spacecraft, to demonstrate the feasibility of obtaining a significant increase in the capability to detect and locate distress signals from general aviation aircraft and certain marine vessels. This program is being conducted with the Departments of Defense, Transportation and Commerce as well as jointly with Canada and France; and negotiations have been completed for participation by the Soviet Union. The launch of the first operational meteorological satellite equipped with the search and rescue instrumentation is planned for 1982.

Changes from FY 1980 Budget Estimate:

The FY 1980 estimate for the Space Applications program has changed only slightly in total - a reduction of $500 thousand as a result of a general congressional reduction in the NASA budget request. A number of adjustments have been made among the individual subprogram elements, however, in order to respond to technical

problems and other unforeseen circumstances, and to refine the budget structure in order to improve the budget presentation or to reflect internal organizational assignments. All of these adjustments have been accommodated within the total budget for the program, and in the context of balanced priorities.

There have been no major redirections in the FY 1980 Space Applications program budget. However, relatively significant funding adjustments have been required in three projects:

- Landsat-D resources were increased by $8.9 million to provide spacecraft telemetry tape recorders, additional ground equipment to permit dual (Landsat-D and D') spacecraft operations, and an improved spacecraft propulsion system for compatibility with Shuttle retrieval mission requirements.

- In response to a USAF offer to enter into a joint procurement with NASA for advanced high altitude aircraft, the TR-1 (NASA ER-2), it was decided to proceed with the procurement. The aircraft is a significantly improved version of the U-2 aircraft, with improved range, payload capacity, and flight handling characteristics. In FY 1980, $5.24 million has been reallocated from other projects to the Airborne Instrumentation Research Program for this purpose.

- The FY 1980 Budget Estimate for the Earth Radiation Budget Experiment (ERBE) of $23.0 million has been reduced to $17.0 million. The ERBE funding requirements for FY 1980 have changed due to a recent NASA/NOAA evaluation of the probable launch dates for the NOAA polar-orbiting, operational meteorological spacecraft, The launch dates for NOAA-F and NOAA-G, the spacecraft equipped with ERBE instruments, have been reassessed for 1984 and 1985. As a consequence, the launch date for the NASA ERBE spacecraft has been adjusted to late 1983; initiation of the spacecraft procurement has accordingly been delayed to the end of FY 1980. The reduction in ERBE requirements made it possible to meet the increased requirement for Landsat-D.

In addition to these project-level changes, some internal project adjustments have been necessary. Notably, as definition/development efforts have progressed and as STS flight schedules have changed, funding requirements for individual Spacelab payload instruments have tended to change from the original budget estimate. In particular, FY 1980 estimates for the Shuttle Imaging Radar, Atmospheric Cloud Physics Laboratory, and Atmospheric Trace Molecules observed by Spectroscopy experiments have increased, principally due to technical problems.

Several structural changes have been made in the Space Applications budget to aid in its presentation. These include:

- A separate breakout within Resource Observations of the interagency program, AgRISTARS, to highlight its importance. In the FY 1980 Budget, this agriculture research program was included within several subelements of the Applied Research and Data Analysis (Resource Observations) activity.

o The Data Management and Applications Data Service definition activities, carried as subelements in Applications Systems for the FY 1980 Budget, are included in the Space Communications request for FY 1981. Management of these activities was transferred to the Communications Division in 1979.

For comparability purposes, these structural changes have been incorporated in the FY 1980 Budget Estimate column of the funding tables for each program area.

In summary, there have been both programmatic and budget structure changes in the FY 1980 estimates as detailed operating plan requirements have become firm. These changes are discussed in the appropriate sections of the individual program justifications which follow.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

RESOURCE OBSERVATIONS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
LANDSAT-D	97,500	89,800	98,663	64,300	RD 7-12
Operational land observing system	---	---	---	16,000	RD 7-14
Magnetic field satellite	3,900	1,600	1,600	500	RD 7-16
Shuttle/Spacelab payload development	6,200	1,600	1,850	2,000	RD 7-17
Extended mission operations	358	1,500	1,582	2,700	RD 7-19
Geodynamics	8,200	13,100	12,600	24,800	RD 7-20
Applied research and data analysis	22,242	17,800	12,908	18,800	RD 7-23
AgRISTARS	---	16,000	16,000	33,200	RD 7-26
LANDSAT-3	700	---	---	---	
Heat capacity mapping mission	300	---	---	---	
Total	139.400	141.400	145,203	162.300	

OBJECTIVES AND STATUS:

The goal of the Resource Observations Program is to develop and demonstrate the application of space observations and space techniques to the acquisition of important information to assist in the management of the Earth's agricultural, water, land, mineral, and energy resources, and to acquire information on the dynamic characteristics and interior structure of the Earth to improve our understanding of the solid Earth and to enable the development of a more precise physical description of the planet. To achieve this goal, the program is focused towards: (1) the development of basic techniques for sensing the characteristics of the Earth's surface and for extracting useful information from the remotely-sensed data from space; (2) the development of techniques for the precise measurements of the movements of the Earth, its crust, and its potential fields to support research in crustal movement and deformation, rotational dynamics, and interior structure; (3) the conduct of joint research and development programs with elements of the Federal, public and private sectors that have major responsibilities and information needs in managing resources and are interested in the use of space-derived data to augment other information sources; *(4)* the provision of remotely-sensed data from space to a variety of users; and (5) the transfer of technology to the responsible organizations leading to an evolutionary development of the global space sensing capability for the routine dissemination and use of timely and comprehensive resource information.

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

Landsat-3 is operating and providing data routinely. LANDSAT-D development is proceeding with launch planned in late 1981 or early 1982. In addition to continuing the availability of Multispectral Scanner (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.

Improvements in the effectiveness of exploration for new mineral and energy deposits require the development of a global capability for efficiently determining the composition and geometry of crustal materials, and improvement of our understanding of the structure, composition and evolution of the Earth's crust. Remotely-sensed data in the visible, infrared, and microwave portions of the spectrum are useful for these purposes, but currently performing systems are somewhat limited in their contributions. New instruments, such as the Shuttle Multispectral Infrared Radiometer (SMIRR), the Shuttle Imaging Radar (SIR-A), and the Large Format Camera, are being developed to obtain, on an experimental basis, additional narrow band IR and microwave data which will be assessed for its applicability in aiding in resource exploration. Although there have been delays in the processing and distribution of data from the Heat Capacity Mapping Mission

(launched in 1978), those data are now being analyzed to determine their utility in discriminating the composition of crustal materials. Data processing delays appear to be solved and investigations are in process. Initial studies indicate that HCMM imagery may be used to map structural features that are partially obscured by overlying soils. The Magnetic Field Satellite (Magsat), launched on October 30, 1979, is now providing detailed scalar and vector magnetic field information for updates of maps and charts for public use, as well as for studies of crustal inhomogenieties that may be related to mineral and petroleum emplacements. Development of the SIR-A, the SMIRR, and the Ocean Color Experiment have been completed, and the instruments are now being integrated with the Shuttle Pallet for flight in late 1980. These instruments will provide new and unique data for studying terrain features and discriminating among rock types. Development of the Large Format Camera is proceeding on schedule with delivery expected in June 1980. It will be flown on a later Shuttle flight to obtain mapping quality imagery.

A major aspect of the Resource Observations Program is research associated with understanding and extracting the physical relationship of emitted and reflected radiation with vegetated and other surface features from remotely-sensed data; with 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 Agricultural and Resources Inventory Survey Through Aerospace Remote Sensing (AgRISTARS).

When the results of the research indicate, Application Pilot Tests arc used to test and expand the research concepts in the realism of the users' environment. AgRISTARS was initiated in FY 1980 with the Department of Agriculture, the Department of Commerce (National Oceanic and Atmospheric Administration), Department of the Interior, and the Agency for International Development to address priority information needs identified by the USDA. The Department of Agriculture information requirements cover a select group of crops and producing countries of significance to world trade and world nutrition.

In FY 1981, two Application Pilot Tests will be completed: an Urban Area Information System with the Bureau of the Census; and an Automated Crop Area Information System with Cotton, Inc. Four Application Pilot Tests will continue: with the California Department of Water Resources, the Pennsylvania Department of Environmental Resources, the Missouri Farm Association, and, the U.S. Geological Survey. Two or three new projects will be selected for initiation in FY 1981. Candidates include projects with applications such as range information, wetlands mapping, and soil mapping.

Studies to define the requirements for stereoscopic data for resource exploration and to develop technical and management implementation approaches will be carried out in concert with NOAA in FY 1980. Future funding and implementation decisions will be the responsibility of NOAA as part of their responsibility for operational terrestrial remote sensing systems.

Studies of the physical character and dynamic motions of the solid Earth are needed to address fundamental problems in geophysics and geodesy and to better understand the mechanisms associated with the accumulation and release of crustal strain. In the past, these studies have been severely limited by the accuracy and extent of measurement methods. The demonstration in the Geodynamics program of precise measurements of the locations of monitoring sites, separated by hundreds to thousands of kilometers, now makes it possible to acquire global, regional and local scale data to verify and extend models of tectonic processes. In FY 1980, under the Geodynamics program, and as part of a joint program with NOAA, the USGS, National Science Foundation, and Defense Mapping Agency, satellite laser ranging systems are being deployed in the U.S., the Pacific, and Australia, These lasers form part of a global network of U.S. and international laser systems for measurement of polar motion, Earth rotation changes, and plate motion. Regional measurements were initiated in California using mobile laser and microwave systems. Twenty-five investigations, including seven from Europe, were selected to begin studies using the laser data. Agreements for joint programs were implemented with Japan and discussed with Canada, Australia, New Zealand, Germany, and others. In FY 1981, these measurements will be continued and expanded to cover North and Central America, portions of the Caribbean, and Alaska. Modeling of Earth processes and methods for improved measurement of the Earth's gravity field will be studied.

Earth Resources Technology Satellite (Landsat-D)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Spacecraft systems and sensors	82,851	68,800	73,263	44,300
Ground system	14,400	20,500	24,900	14,100
Ground operations	---	---	---	4,800
Investigations	249	500	500	1,100
Total	97.500	89.800	98.663	64,300
Delta (Expendable Launch Vehicles Program)	(10,000)	(---)	(---)	(6,000)

OBJECTIVES AND STATUS:

The objective of the LANDSAT-D project is to continue the exploration of advanced techniques to understand and demonstrate the utility of satellite-based Earth resources remote sensing systems with the experimental Thematic Mapper (TM) and the flight-proven Multispectral Scanner (MSS). The initial LANDSAT-D launch is planned for late 1981 or early 1982; the backup spacecraft will be available for launch six 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 - on which development was initiated in FY 1977 - 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 MSS contract was awarded in March 1978, and the design changes necessary for the LANDSAT-D mission have been verified by ground tests during FY 1979. Activities on the protoflight and flight model are on schedule for delivery to the mission contractor in January and July 1981, respectively.

Thematic Mapper development is behind the scheduled delivery date largely due to a series of technical and management problems. The present adjusted schedule points to a February 1981 delivery to the mission contractor for spacecraft integration, which is consistent with a late-1981 or early-1982 launch of LANDSAT-D.

Work is continuing on schedule for the Multimission Modular Spacecraft (MMS). The integrated spacecraft bus is scheduled to be delivered to the LANDSAT-D mission contractor in May 1980. The mission-unique flight segment design is nearing completion, and the mechanical test model of the spacecraft will undergo vibration tests early in 1980. The various mission communication antennas have already satisfactorily completed testing to assure their design adequacy.

Ground segment design is proceeding, although some schedule change has occurred due to late computer deliveries and a more complex geometric correction software development than originally anticipated. However, the present schedule outlook still supports a ground system readiness date compatible with a late 1981 Landsat-D launch.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 funding for LANDSAT-D has been increased by $8.9 million. Technical changes include the installation of telemetry tape recorders which are required to operate LANDSAT-D in the absence of full operational readiness of the TDRSS, which, in turn, results from delays in the Shuttle schedule. Also included is FY 1980 funding for additional ground equipment to permit dual (LANDSAT-D and -D') spacecraft

operations. Provision has been made for increasing the performance capability of the LANDSAT-D propulsion system to be compatible with Shuttle retrieval mission requirements. The planned upgrading of the Delta launch vehicle capability permits incorporation of this change.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds will permit the completion and acceptance testing of the LANDSAT-D and -D' TM and MSS. Integration and checkout of all elements of the LANDSAT-D flight segment will be conducted during FY 1981. This includes the MMS, mission uniques (such as the solar array and wideband communication systems), and the instruments. The major integration activities associated with LANDSAT-D' will also take place during FY 1981. The LANDSAT-D ground system, including the operations control center and data processing system, will be completed and checked out during FY 1981.

Operational Land Observing System

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Ground data handling system modifications.....	---	---	---	10,000
Sensor parts procurement.....	---	---	---	6,000
Total.....	---	---	---	16.000

OBJECTIVES AND STATUS:

An extensive review was conducted during 1979 of the technical and institutional aspects of operational remote sensing systems. An outcome of that review was the assignment to the National Oceanic and Atmospheric Administration. (NOAA) of the management responsibility for land observing operational remote sensing systems. It was also decided that NASA should continue in its role of carrying out the research and development activities which advance the technological capabilities of these systems. NOAA has initiated the development of an implementation plan in concert with NASA and other Federal agencies to establish the performance objectives and programmatic requirements for the operational systems. Although this plan will not be completed prior to mid-1980, in readiness for the FY 1982 budget formulation process, NASA and NOAA identified several issues for consideration in the FY 1981 budget recommendations to the

President; specifically, the Administration agreed that provision should be made in the NASA and NOAA budget requests for both hardware procurement and study activities supporting the operational system development and formulation.

The NASA request in FY 1981 provides for funding to modify the ground data handling system for LANDSAT and to initiate procurement of long-lead-time parts for the Thematic Mapper and Multispectral Scanner sensors. The ground system modifications will enhance the reliability and operational characteristics of the LANDSAT ground data handling system. The LANDSAT-D system, currently under development, has been designed to meet the requirements of a research and development system and consequently lacks the redundancy and timeliness provisions which are required of operational systems. Modifications to the system are necessary in order to meet the operational requirements of 95% reliability and 48 hour throughput time. In addition, the long-lead-time parts procurement for the two sensors has been identified as a means of reducing the time span from initiation of development of follow-on spacecraft of the LANDSAT type to actual flight readiness. Sensor parts procurement undertaken in FY 1981 concurrently with the timing of a decision on the configuration of the operational system in the FY 1982 budget recommendations, ensures a flight readiness date for a transitional third LANDSAT-D type spacecraft which is compatible with the projected need in 1985.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds will be used to initiate modifications to the LANDSAT-D ground handling system and to initiate procurement of long-lead-time hardware for the Thematic Mapper and Multispectral Scanner. The Landsat-D ground system currently under development is of a serial, nonredundant design well suited to research and development, but vulnerable to any one of numerous single point failures. The requested funds will be used for the initial modifications required to partially upgrade the data handling system to meet operational requirements. Consideration of additional improvements to the system is an integral part of the implementation planning studies currently underway. Initiation of procurement of long-lead-time hardware for the Thematic Mapper and Multispectral Scanner in FY 1981 will enable a launch readiness date of 1985 for a follow-on spacecraft program to be initiated in FY 1982. Items to be procured include: Thematic Mapper elements - scan mirror blank, detectors, and high reliability electronic parts; Multispectral Scanner - photomultiplier tubes, scan mirror blank, and high reliability electronic parts,

Magnetic Field Satellite (Magsat)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	2,538	460	286	---
Experiments	1,009	840	863	500
Ground operations	353	300	451	---
Total	3,900	1,600	1,600	500
Scout (expendable launch vehicle program)	(1,400)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The Magnetic Field Satellite (Magsat) Mission was designed to measure near-Earth magnetic fields on a global basis. The objectives are to obtain an accurate description of the Earth's magnetic field; to obtain data for use in the update and refinement of world and regional magnetic charts; to compile global crustal magnetic anomaly maps and to interpret those maps in terms of geologic/geophysical models of the Earth's crust. The United States Geological Survey (USGS) plans to utilize the field models to update regional and global magnetic charts it will issue in 1980. The USGS also plans to use the field models and the basic magnetometer measurements to derive magnetic anomaly maps for use in Natural Resource Assessment Studies.

The Magsat was successfully launched on October 30, 1979 into a low Earth, nearly polar, orbit by the Scout launch vehicle. Deployment of the sensor boom and platform on which the scalar and vector magnetometers are mounted was completed on November 1, 1979. Data acquisition was initiated on November 3, 1979. Two anomalous conditions have been experienced. These are: 1) higher than expected temperatures in portions of the spacecraft; and 2) an interference with one of the cesium vapor lamps in the scalar magnetometer. Neither anomaly has impacted the Magsat mission objectives or scientific investigations. The Magsat mission duration, based on the actual orbit and solar conditions, is estimated at five months.

In 1979, 32 Magsat investigations were selected. Scientists from the United States and eight foreign countries - Australia, Brazil, Canada, France, India, Italy, Japan, and the United Kingdom will carry out investigations in six general categories: geophysics, geology, field modeling, marine studies, magnetosphere/ionosphere, and core/mantle studies. The first magnetic field model using Magsat data has been obtained

using measurements taken during the initial three weeks of operations. The model will be updated periodically as more data are acquired. The initial field model was delivered to the U.S. Geological Survey in mid-December.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The current FY 1980 funding requirements for Magsat remain unchanged from the budget estimate. Minor adjustments between project elements were based on up-to-date detailed schedule and contract requirements.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funds provide for data analysis, This will include the processing and distribution of data, final spacecraft orbit and precision attitude determination, and computation of the definitive field model. Support will also be provided for using the precision attitude determination and the vector data to generate magnetic anomaly maps and conduct studies, and for completion of the Magsat investigations.

Shuttle/Spacelab Payload Development (Resource Observations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Orbital flight test payload development.....	1,905	600	854	800
Large format camera.....	4,295	1,000	996	1,200
Total.....	6,200	1.600	1.850	2.000

OBJECTIVES AND STATUS:

The objective of this project is to develop, test, demonstrate, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for resource observations research. Three instruments are completing the development and test phase for flight on the second Shuttle orbital test flight mission, and one instrument is being developed for a subsequent Shuttle operational flight.

The Shuttle test flight instruments are: the Shuttle Imaging Radar (SIR-A) for evaluation of the applicability of spaceborne imagery radar for geologic exploration; a Shuttle Multispectral Infrared Radiometer (SMIRR) to conduct research for optimum spectral bands for geologic mapping; and an Ocean Color Scanner to assess the applicability of improved passive, color sensing techniques for mapping biologically-rich

(phytoplankton) areas in the ocean. The SIR-A is an adaptation of the Seasat Synthetic Aperture Radar and will be the first use of spaceborne radar specifically for landform analysis. These instruments are presently being integrated into the payload pallet for the second Shuttle test flight. The Large Format Camera (LFC) is under development for flight on a Shuttle operational mission. The LFC is a high resolution mapping camera with direct application to the mapping of large geographic areas for mineral and energy resources exploration. The camera unit will be completed in the summer of 1980 and is excepted to be flown in 1983. The Large Format Camera Interagency Working Group meets periodically to review camera design, evaluate pre-mission camera performance data, and determine initial mission coverage requirements; it will also prepare a post-flight data usefulness and system performance report.

Included in the overall project plan are efforts on a Synthetic Aperture Radar (SAR) fold and tilt antenna and a study of an attitude reference package for instruments such as the Large Format Camera. A SAR antenna with fold and tilt capability is fundamental to reducing the payload volume required for future spaceborne radar flights. This antenna would eventually support multifrequency, multipolarization radar research.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The change in Shuttle/Spacelab payload development activities in FY 1980 reflects increases in the payload development costs for the second Shuttle orbiter test flight.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, the Resource Observations payload will be flown on the second Shuttle orbital test flight. Following flight, the SMIRR, SIR-A, and Ocean Color Scanner will be recalibrated and refurbished where appropriate, The data will be processed, evaluated by the science teams, and research results published. The Large Format Camera operational control center software and hardware will be developed, and field support activities will be sustained in preparation for a Shuttle flight.

Extended Mission Operations (Resource Observations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Heat capacity mapping mission (HCMM)	200	600	600	300
LANDSAT-2 and -3	158	900	982	2,400
Total	358	1.500	1,582	2.700

OBJECTIVES AND STATUS:

The objective of extended mission operations is to capitalize on the expected continued performance of the LANDSAT-3 and HCMM satellites beyond the initiallyplanned mission duration. Data products from these missions are being used to support research 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.

LANDSAT-3 is a major source of space data for domestic and international users and an essential element of planned and continuing experimental demonstration activities. Some continuing needs of users (federal, state, and local government agencies; foreign users; and private industry) for LANDSAT data can be met by extending spacecraft operations and data processing activities for an additional year. LANDSAT-2, while still functioning, is experiencing attitude control problems and is not being used for data acquisition while possible corrective procedures are being tested. LANDSAT-3 continues to operate nominally.

The HCMM was launched in April 1978 and was initially planned for one year of operations; in FY 1980, funds were provided to extend spacecraft operations from April 1979 to October 1980. The mission provides thermal imagery which is being analyzed to assess the feasibility of using the thermal inertial characteristics of surface material to discriminate rock and soil types and for soil moisture studies. Recent electrical power problems have reduced the data acquisition rate from the planned seven daytime and seven night passes to seven daytime and one night pass.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

An increase of $82 thousand is needed to support continuation of services provided to LANDSAT users from March 1980 to October 1980.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funds provide for continuation of the LANDSAT-3 spacecraft operations, and data processing requirements for a full year. The HCMM funds provide for data processing and completion of approved principal investigators' studies.

Geodynamics

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Crustal dynamics project	5,400	10,100	9,600	12,600
Modeling and technique development	2,800	3,000	3,000	3,200
Laser network operations	(7,200)*	(8,400)*	(8,400)*	9,000
Total	8,200	13,100	12,600	24,800

*Funding responsibility transferred from Space Tracking and Data Systems to Space Applications in FY 1981; FY 1980 and prior funding not included in totals.

OBJECTIVES AND STATUS:

The objectives of the Geodynamics Program are to improve our understanding of the motion and deformation of the Earth's crust, the rotational dynamics of the Earth, the geopotential fields, and the Earth's interior structure. Understanding these processes has important implications in the study of earthquake and exploration for resources. Studies of the motion of the Earth's pole and variations in its rotational rate are important because of suspected causative relationships between these variations and weather and climate. The global gravity field provides information needed for understanding the mechanism that drive the motion of the Earth's crust, crustal processes associated with the formation. of mineral and petroleum deposits, and for studies of oceanic circulation and current systems.

The objectives of the Crustal Dynamics project are to detect and monitor the global motion of the tectonic plates that make up the Earth's crust; to understand how and why the plates are moving and to determine if deformation internal to the plates is related to the unusual occurence of major earthquakes away from plate boundaries; to map the accumulation of crustal strain in the vicinity of seismically active faults and plate boundaries; to understand how and where this strain energy is stored; and to observe the crustal motion prior to and after major earthquakes to understand how the accumulated energy is distributed and released. The results of this project are expected to contribute to the understanding of earthquake mechanisms and hence to the eventual development by other agencies of predictive techniques. The project is conducted jointly with USGS, NOAA, NSF, and Defense Mapping Agency. Joint programs have been discussed with scientists in about 30 countries, and an agreement has been formalized with Japan. In 1979, twenty-five investigators, including seven from Europe, were selected to analyze laser data for studies of polar motion, Earth rotation, solid Earth tides and plate motion-

NASA is collaborating with the National Geodetic Survey of NOAA in project Polaris which is intended to establish a three-station Very Long Baseline Interferometer polar motion network which will be operational in 1983. Also, under the auspices of the International Astronomical Union, NASA and other Federal agencies will be participating in an international project for Monitoring Earth Rotation and Intercomparison of Techniques (MERIT). A preliminary MERIT observation campaign is planned for August-October 1980.

The laser network now operational and acquiring data for geodynamics study includes nine mobile lasers and five fixed laser observatories in the U.S. and several other countries. Several radio observatories have been equipped with advanced electronic equipment to use radio signals from quasars to measure continental distances to a very precise accuracy (the very long baseline interferometry or VLBI technique). Two mobile VLBI facilities have been developed. The two types of observing systems are now being intercompared and validated. Earlier satellite laser ranging observations were made from opposite sides of the San Andreas Fault in California and in Bear Lake, Utah as a continuation of the San Andreas Fault Experiment (SAFE). This experiment, initiated in 1972 to measure the relative motion of the Pacific and North American plates, is the first long-term monitoring of plate motion, and is showing the plates to be moving at a rate of about nine -centimeters per year relative to each other.

The Geodynamics Modeling and Technique Development Program supports studies of physical processes associated with crustal deformation mechanisms, polar motion and Earth rotation, and new system concepts. In FY 1980 studies are being conducted of regional deformation in selected areas and of methods for improved gravity field surveying and global time transfer. Engineering prototypes will be constructed of small antenna systems which use Global Positioning System (GPS) signals in place of radio stars for geodetic surveying over distances of a few hundred kilometers.

CHANGES FROM IN 1980 BUDGET ESTIMATE:

The decrease of $500 thousand in the crustal dynamics project in FY 1980 is the result of delays in the initiation of some of the planned activities.

BASIS OF FY 1981 ESTIMATE:

In IN 1981, crustal dynamics measurement of regional deformation in Western North America will be continued. The motion of the Pacific, North American, Australian and European plates will be monitored and the internal deformation measured. Cooperative programs will be initiated with countries in Central America and South America. In support of these studies, laser operations at the **U.S.,** Pacific and Australia sites will be continued and other sites will be used as dictated by program needs. In the modeling and technique development activity, FY 1981 funds will provide for completion of the present gravity field and geoid modeling. Emphasis will be placed on derivation of models of crustal deformation and fault mechanisms, and of plate mechanisms. Work will continue on formulating the basis for the eventual evolution of a global model of the dynamic Earth which will have broad application to basic science and to our understanding of geophysical processes. Responsibility for funding of the laser network operations has been assumed by Space Applications in FY 1981 to facilitate management and integration of the overall Geodynamics program requirements.

Applied Research and Data Analysis (Resource Observations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Renewable resources	19,192	7,000	5,873	7,800
Non-renewable resources	1,500	3,600	3,300	3,900
Applications pilot tests	1,550	2,700	1,160	2,700
Operational earth resources system (OERS) definition	--	3,000	1,100	2,800
Advanced studies	--	1,500	1,475	1,600
Total	22,242	17,800	12,908	18,800

OBJECTIVES AND STATUS:

The goal of the AR&DA activities is to develop remote sensing capabilities through theoretical studies, ground-based research and flight instrument development that can aid in the management of renewable and non-renewable resources and can monitor the impact of man and his works on the natural environment. Observables include surface characteristics such as type and extent of vegetation; characteristics of exposed soil and rocks; snow and ice cover, water impoundments and soil moisture; geological structure and landforms; and the works of man such as urban and suburban developments, major facilities and surface mines. The program is closely coordinated with, and in many instances, developed in collaboration with other Federal agencies (such as the Department of Agriculture (USDA), Department of Interior (DOI), Department of Commerce (DOC), Department of Defense (DOD), Department of Energy (DOE), Agency for International Development (AID), state and local governments, and the private sector (e.g., the Geosat Committee)). This program supports the ground-based and aircraft-based activities for renewable and non-renewable resource observations research. The objectives of this effort are as follows: to improve machine-aided interpretation and classification techniques, and data handling techniques, which are needed to increase efficiency in the transformation of space-derived data into information for utilization by the user community; to test this capability with the users through Applications Pilot Tests; to develop new sensors operating in the visible, infrared, and microwave regions of the spectrum, with emphasis on the latter two, to analyse user requirements for new types of space-acquired data; to develop and demonstrate ground-based or airborne systems that are derived from space technology, processes, management techniques or operations that contribute to the timely solution of natural resources problems. Through FY 1981, emphasis will continue to be placed on developing techniques to interpret and use the visible and infrared data from Landsat-3, the active microwave data obtained from Seasat, the thermal data from HCMM, and aircraft data from visible, infrared, and microwave sensors. Studies

are underway to develop capabilities to analyze and interpret the data which will be obtained by future systems, such as the seven-channel, higher resolution data expected from Landsat-D, the multichannel data to be provided by the Shuttle Multispectral Infrared Radiometer (SMIRR), and the optimized look-angle radar data expected from the Spaceborne Imaging Radar (SIR-A).

Renewable Resources: The principal objectives are to develop remote sensing techniques; to monitor the spatial variability of soil and snow moisture and to perform associated hydrologic modeling; to improve land resources classification, modeling, change detection, and geobased information system interfaces; to develop improved remote sensing techniques and machine-aided interpretation; and to test the utilization of these information extraction techniques with user agencies.

Non-Renewable Resources: The principal objectives are to develop optimal spaceborne remote sensing techniques to discriminate geologic materials at the Earth's surface and for analysis of surface morphology and composition; to develop optimal spaceborne potential field techniques for analysis of subsurface crustal structure; and to develop geologic models for use with space-acquired data in mineral and energy assessment, exploration development, and management.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $4.9 million in the Resource Observations ARGDA FY 1980 estimate reflects deferrals of effort in the various activities, based on an assessment of priorities within available funding. The initiation of a small number of Applications Pilot Test projects, and certain research tasks, will be delayed until FY 1981.

Reallocation of Operational Earth Resources Satellite (OERS) definition and Non-Renewable Resources ARGDA funds was also required in FY 1980 to cover increased costs for development of Shuttle/Spacelab instruments and to support acquisition of the ER-2 aircraft. The decrease in the OERS definition activity is a result of a less extensive scope of work than anticipated.

BASIS OF FY 1981 ESTIMATE:

Renewable Resources: Principal efforts will be directed at continuation of on-going remote sensing technique development with the Federal, university and private research communities in the areas of water resources, land resources, and interpretive techniques and sensor development. These efforts include theoretical modeling, ground-based studies, and aircraft and spacecraft data analysis. Specific activities planned for FY 1981 include projects in coastal resource monitoring, radar land cover interpretation, interpretive techniques, and sensor development.

Non-Renewable Resources: Principal efforts will be directed toward improving our ability to detect geological structures and chemical composition and to understand geological processes, thereby enhancing exploration strategies for non-renewable resources. Included are: continuation of broadband spectral reflectance/thermal emittance measurements of rock types found in arid environments; continuation of NASA/Geosat Test Case studies to evaluate remote sensing techniques for geological mapping in different environments; continued development of methods to extract geological information from existing remote sensing data; a geobotanical research program to develop methods of determining rock/soil composition on the basis of the distribution and spectral properties of surface vegetation; development of geologic models for use with space-acquired data in mineral and petroleum exploration and in non-renewable resources assessment investigations; and expansion of the NASA radar program including reflights of the SIR-A, ground-based research and aircraft testing of sensors to obtain an understanding of the technology needed to develop a Shuttle payload for acquisition of landform data in cloud-covered areas.

Application Pilot Tests: FY 1981 funds will support eight to nine Application Pilot Tests (APT's); six on-going with the Bureau of the Census, California Department of Water Resources. Cotton. Inc., USGS, Pennsylvania Department of Environmental Resources, and the Missouri Farm Association; and two to three new APT's which will be initiated in the areas of range information, wetlands mapping, and soil mapping.

Operational Earth Resources System Definition: Support to the National Oceanic and Atmospheric Administration for definition of the OERS system, initiated in FY 1980, will be continued in FY 1981. The definition tasks include an analysis of data acquisition requirements and the subsequent derivation of system engineering parameters, conceptual designs of space and ground segments and identification of implementation options for both segments.

Advanced Studies: In FY 1981, definition studies will be performed for potential new initiatives--Gravsat, Soil Moisture Mission, Multispectral Resources Sampler, and Spacelab payloads. In addition, preliminary mission definition studies will be performed on promising future missions and sensors.

Agriculture and Resource Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Foreign commodity production forecasting.....	--	7,300	6,291	13,200
Supporting research.....	--	7,300	7,559	13,800
Early warning, soil moisture, domestic crop and land use, conservation pollution, and renewable resources.....	--	1,400	2,150	6,200
Total.....	--	16,000	16,000	33,200

OBJECTIVES AND STATUS:

Agriculture and Resource Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) is a joint research, development, and testing activity undertaken with the Department of Agriculture (USDA), the Department of Commerce (USDC), and NASA. FY 1981 is the second year of a six-year program to develop and test techniques using satellite-acquired remote sensing data to augment existing data sources.and to provide information not presently available. Primary emphasis will be placed on the two highest priority USDA items, early warning and commodity production forecasting.

The FY 1980 focus within the elements of the AgRISTARS program are:

- Early Warning/Commodity Condition Assessment Project: conduct data collection and analysis for soybeans, corn, small grains, rice and cotton; and, conduct research on selected early warning alarms for wheat such an winterkill.

- Foreign Commodity Production Forecasts Project: conduct an exploratory test of wheat/barley separation procedures in the United States and Canada and corn/soybeans in the United States in preparation for an FY 1981 Pilot Test. In the USSR, a barley production forecasting agronomic data base will be developed and pilot test areas selected. Data acquisition will be initiated in Brazil for separation and production estimation of corn and soybeans. Data collection will be conducted and research initiated for wheat in Australia.

- Supporting Research Project: complete installation of supporting research data system and conduct technique development for crop development stage and area estimation. Initiate development of crop spectral inputs for yield model development.

- Soil Moisture Project: continue field measurements with ground sensors to obtain a better understanding of the basic measurement capabilities. Continue analysis of 1978 Colby, Kansas, aircraft data sets, and continue profile modeling of root zone soil moisture.

- Domestic Crop/Land Cover, Renewable Resources Inventory, and Conservation/Pollution Projects: conduct limited start-up activities in these areas to prepare for conduct of pilot tests in FY 1981.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 estimate for AgRISTARS has not changed in total, but some adjustments have been made in the estimates for Foreign Commodity Production Forecasting, Supporting Research, and other research tasks to provide necessary support to the interagency research in the Conservation/Pollution, Domestic Crops/ Land Cover, and Renewable Resources Inventory Projects,

BASIS OF FY 1981 ESTIMATE:

The FY 1981 focus within the elements of the AgRISTARS program are:

- Early Warning/Commodity Condition Assessment Project: expand FY 1980 activities to develop and test techniques to quantify the damage to spring wheat caused by wind and/or excessive water; and, initiate R&D for rice, cotton, soybeans, corn and small grains. Initiate pilot tests in water stress assessment, adverse temperature/wind alarms for small grains and snow cover estimates.

- Foreign Commodity Production Forecasts Project: expand FY 1980 activities to conduct and evaluate pilot tests of techniques to forecast corn and soybean production in Indiana, Illinois and Iowa and to test and evaluate spring wheat/barley technology in the Northern United States Great Plains and Canadian test sites; and, to design experiments for corn/soybeans in Brazil; wheat, corn and soybeans in Argentina, and barley in USSR. Conduct problem solving for Australian wheat area determination.

- Supporting Research Project: develop research geocoded data base for historic, agronomic and remotely-sensed data. Conduct initial technique development for crop stage and area determination and test in the United States for rice/corn/soybeans; in Argentina for wheat/corn/soybeans; in Brazil for corn/soybeans; and in the USSR for barley. Continue development of spectral inputs for yield models for wheat, barley, corn and soybeans.

- Soil Moisture Project: conduct a major aircraft test to evaluate remote sensing determination of soil moisture in other climate conditions such as the humid east coast environment; and, continue root zone soil moisture profile modeling and conduct analysis of measurement effects such as vegetation cover, surface roughness, and soil type, etc., on remotely-sensed soil moisture measurements.

- Domestic Crop/Land Cover Project: provide major crop area determination in Iowa and Kansas and expand to two additional states to reduce variance of commodity forecasts in those states; and, develop techniques to improve efficiencies for full Landsat frame analysis.

- Renewable Resources Inventory Project: continue multi-resources inventory pilot tests and initiate new areas of research to conduct inventories and monitoring activities required by the Resources Protection Act.

- Conservation/Pollution Project: complete research and development activities required prior to FY 1982 pilot test of hydrologic watershed model and snowpack assessment model; and, continue development of water basin scale pollution model using remote sensing inputs. Initiate air pollution studies to determine effects on crops.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

ENVIRONMENTAL OBSERVATIONS PROGRAM

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of dollars)			
Upper atmospheric research program.....	(14,500)*	13,000	12,500	13,500	RD 7-32
Applied research and data analysis.....	33,726	49,900	48,670	56,400	RD 7-34
Shuttle/Spacelab payload development....	7,750	9,600	9,600	8,200	RD 7-39
Operational satellite improvement program.....	6,100	7,400	7,400	10,700	RD 7-42
Earth radiation budget experiment.... ...	7,000	23,000	17,000	29,000	RD 7-43
Halogen occulation experiment.....	3,600	8,000	8,000	6,000	RD 7-44
Extended mission operations..	1,250	5,800	5,800	8,000	RD 7-45
National oceanic satellite system.....	---	---	---	5,800	RD 7-46
Tiros-N....	1,200	---	---	---	
Nimbus-?..	3,624	500	500	---	
SEASAT..	3,500	---	---	---	
Total.....	67,750	117,200	109,470	137,600	

*Program transferred from Space Science to Space Applications, January 1979; FY 1979 funding not included in total.

OBJECTIVES AND STATUS:

Understanding the dynamics and limitations of our environment is essential to long-term survival and important to many day-to-day activities. The objectives of NASA's Environmental Observations program are to improve the understanding of processes at work in the atmosphere and oceans, to provide space observation of parameters involved in these processes, to extend the capabilities to predict environmental phenomena and to assess their interaction with human activities. The interactions among the processes and the interrelationship of the atmosphere, ocean, land and space environments can only be fully studied on a global basis from space. The application of remote sensing from space to environmental studies and services is the focus of the program.

To meet the objectives, a number of program elements are pursued in reasonable balance. They include: (1) research and development efforts; (2) the development and demonstration of new techniques; (3) research and demonstration flight missions; and, (4) operational prototypes and demonstrations in support of other agencies.

A number of significant events have occurred in the past two years and others are planned in the on-going program. Three research/demonstration satellites were launched in 1978 and 1979 (SEASAT, Nimbus-7, and SAGE). Nimbus-7 and SAGE continue to operate, and the SEASAT data is providing the basis for a number of new efforts, including a major new initiative, the National Oceanic Satellite System (NOSS). Three operational satellites were placed in orbit for the National Oceanic and Atmospheric Administration (NOAA) in 1978 and 1979 (Tiros-N, NOM-A, and GOES-3). These continue to provide excellent service to the NOAA weather forecasters. The Halogen Occultation Experiment (HALOE) will be launched in 1982 and 1983, and the Earth Radiation Budget Experiment (ERBE) instrument will fly on two NOAA meteorological satellites and a NASA dedicated spacecraft over the 1983-1985 timeframe.

NASA continues to study the upper atmosphere and stratospheric air quality with the objective of expanding our understanding of the upper atmosphere and developing our ability to assess potential threats to the ozone layer. The program combines field measurements from ground, aircraft, balloon and rocket platforms; laboratory studies; theoretical studies; and data analysis. In the past few years, NASA and others have measured key species involved in ozone photochemistry and now have adequate information to begin comparisons of field data with mathematical models. These comparisons will be a major advancement in understanding the chemistry of the stratosphere. Advanced planning includes the use of research satellites for the simultaneous and global study of the radiative, chemical, and dynamics processes occurring in the upper atmosphere.

It is now clear that air pollution problems must be solved on a regional basis, and that global chemical budgets (such as carbon monoxide) act both as tracers of transport processes and as a background for regional events. Because remote sensing offers the requisite large spatial perspective, the NASA R&D efforts in air quality and chemistry include joint support of field investigations with the Environmental Protection Agency and the National Science Foundation to focus on these two areas. Field analytical and laboratory studies will continue to emphasize the global carbon-nitrogen-ozone and sulfur-ammonia-aerosol chemical systems. NASA and the Environmental Protection Agency (EPA) have developed a cooperative plan to demonstrate synoptic coverage of regional air pollution using satellite data.

To provide improved systems for future operational satellite missions, NASA's global weather activities include both the analysis of intensive meterological observations and the development of improved sensors and calculation techniques. The Global Atmospheric Research Program (GARP) Global Weather Experiment conducted in 1979 provides a unique set of data that has never before existed for research purposes. NASA's numerical forecast models are now able to utilize satellite data, and some of the results show marked improvements (up to 20% improvement with SEASAT wind fields). Improved models are being investigated, and research is being conducted on improved temperature sounders, surface pressure instruments, passive and active microwave moisture sensors, wind sensors, and rainfall measurement techniques.

Severe storms, tornadoes, damaging downdrafts, and destructive cloud-to-ground lightning are the focus of a group of activities in the Severe Storms program aimed at improving both observation and forecasting of such events. Such studies will use the remotely sensed data from the Severe Environmental Storms and Mesoscale Experiment (SESAME) program conducted in 1979 - another unique set of data for research. Ongoing mesoscale modelling efforts for forecast improvement with machine interactive systems will lead to a joint project with NOAA at their National Severe Storm Forecast Center. This is similar to the successful NOAA/NASA frost-freeze warning system demonstration in Florida. The performances of an aircraft Doppler lidar system now under development for improved wind measurement and an improved meteorological temperature and moisture sounder now being installed on GOES-D will be evaluated in FY 1981.

NASA, DOD, NOAA and the oceanographic science community have realized the tremendous potential that satellites may bring to the study of the world's oceans. The observations collected during 99 days of SEASAT operation are currently being used in many oceanic and ice studies and provide the basis for a major new initiative (NOSS). The SEASAT, Nimbus and Geodynamic Experimental Ocean Satellite (GEOS) data have also pointed toward opportunities for future missions. NASA is beginning to investigate methods to obtain global ocean surface topography and measurements of the polar ice caps, the ice sheets and snow - the largest single yearly environmental variables on Earth.

The SEASAT sensors performed so well (winds to $\pm$ 2m/sec., significant wave height to $\pm$ 10%, and local sea surface elevation to $\pm$ 10 cm. or better) that NOAA, DOD and NASA are jointly proposing a major new initiative in FY 1981 - the National Oceanic Satellite System (NOSS). NOSS is a limited operational demonstration consisting of two ocean-viewing satellites with a full ground data system that provides near real-time information to the operational agencies. NOSS will provide valuable information on global wind fields, sea state (wave height and spectrum), sea surface temperature, ice coverage, and ocean color. By retrospective analysis, the SEASAT data now shows that such information will materially aid shipping, fleet operations, marine resource management and extraction and numerous commercial ventures.

In support of the National Climate Program, NASA is involved in those long-term global measurements and research areas where space systems can provide a significant contribution to achieving a better understanding of climatological processes. The earth's radiation budget was established early as one such area, and the Earth Radiation Budget Experiment (ERBE) is an on-going flight program aimed at studying the global dynamics of this portion of the atmosphere. Special studies are underway regarding air-sea interactions, hydrological processes, cryospheric processes, and aerosol effects. Climate sensitivity models now under development and the on-going pilot data base management study for precipitation and sea ice will be evaluated in FY 1981.

Building on this research base, the major thrusts in FY 1981 in NASA's Environmental Observations program are to: (1) initiate a joint NOAA, NASA and DOD program for demonstration of an operational system for ocean monitoring; (2) improve the understanding of the physics and chemistry of the stmosphere and detect any global

changes in stratospheric ozone; *(3)* improve operational measurements of atmospheric temperature, moisture, pressures, winds, and precipitation; (4) determine the dynamic behavior of water and ice (costal zone and deep ocean); and, (5) validate severe storm indicators and precursors.

Upper Atmospheric Research

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Research support..	(12,900)	11,400	10,900	12,400
Upper atmospheric research balloon program.....	(1,000)	1,100	1,100	1,100
Spacelab payload definition.....	(600)	500	500	---
Total.	(14,500)*	13,000	12,500	13,500

*Program transferred from Space Science to Space Applications, January 1979

OBJECTIVES AND STATUS:

The Upper Atmospheric Research Program was formulated in compliance with a Congressional mandate to NASA to develop and implement a comprehensive program of research, technology and monitoring of the phenomena of the upper atmosphere. The resulting program is aimed at improving basic scientific understanding of the upper atmosphere and the 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 effects 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.

Significant simultaneous measurements of numerous stratospheric species and several coordinated balloon flights have been completed which provide validation for some of the predicted 1-dimensional model results. Results from theoretical studies have emphasized the close coupling of the nitrogen, hydrogen and chlorine compounds. New laboratory results have provided improved data required for models and the interpretation

from our field measurements program. New measurement techniques have been demonstrated. A reaction rate panel has been established. An extensive workshop has assessed the status of the ozone depletion problem (current steady state CFM ozone depletion will be about 18%) and planning is underway for an Upper Atmospheric Research Satellites (UARS) program to provide a comprehensive investigation of the energetics, composition, and dynamics of the stratosphere and mesosphere.

The balloon support program supports instrument development and testing, and provides for a large number of direct and remote atmospheric measurements in the altitude range up to about 45 kilometers.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $500 thousand in the Upper Atmospheric Research Program reflects an internal adjustment of funds for the procurement of the ER-2 aircraft. The increased range and payload capability of the ER-2 as compared to the U-2 aircraft is especially important to studies in the upper atmosphere. It will enhance the ability to acquire data concerned with stratosphere-troposphere exchange and aerosol processes. This adjustment of Upper Atmospheric Research resources recognizes that the ER-2 will provide needed capabilitv for study of potentially important exchange regions such as the Southeast Asia monsoon area and the Antarctic, and for study of the effect of tropical cloud processes on stratosphere-troposphere exchange.

BASIS FOR FY 1981 ESTIMATE:

During FY 1981, NASA will continue the assessment and evaluation of man-made and natural perturbations of the stratospheric ozone layer. The development of models which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species will be extended; improvements in the laboratory kinetics and spectroscopy data base will be sought; and new and improved techniques will be developed for detecting additional trace species and remotely measuring winds. The research program will be extended into the mesosphere because knowledge of the coupling between the mesosphere and the stratosphere is necessary for understanding the complex interactions between radiation, chemistry, and dynamics in the upper atmosphere, and the relationship between solar variations and terrestrial weather and climate. Feasibility and definition studies for a future Upper Atmosphere Research Satellites (UARS) program will be continued.

The balloon program will be continued at a level of approximately 45 flights per year and will provide key measurements of the photochemically active trace species important in the stratospheric ozone balance. Evaluation and selection of atmospheric experiments for follow-on Spacelab missions will be completed. Definition studies for a Spacelab Light Intensification Detection and Ranging (LIDAR) system and a cryogenically-cooled, limb-scanning interferometer radiometer (CLIR) will be continued. These studies will continue our progress towards developing the spaceborne active and passive measurement capability to provide the global data on trace species, dynamic processes, and meteorological parameters needed in understanding the atmosphere.

Applied Research and Data Analysis (Environmental Observations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Applied research and data analysis in:				
Stratospheric air quality		4,800	4,800	5,800
Tropospheric air quality	6,636*	4,400	4,400	5,400
Global weather (including GARP)	8,239	10,700	10,600	11,600
Severe storms	3,382	5,200	5,200	6,600
Ocean processes (including water quality for FY 1980 and beyond)	9,895	13,300	13,140	17,600
Climate	4,489	8,500	8,400	9,400
System '85 definition	---	1,500	---	---
National oceanic satellite system (NOSS) definition	1,085	1,500	2,130	---
Total	33,726	49,900	48,670	56,400

*Includes all environmental quality: tropospheric, stratospheric and water.

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) program is the foundation for NASA's activities in Environmental Observation. It supports the basic studies that result in the understanding of the phenomena and processes of the atmosphere and oceans and their interactions. In the AR&DA program, hardware concepts are developed to produce sensors and instruments for demonstration; advanced studies are conducted for the definition of new systems and missions; and support is provided for the transfer of new technology to the user community. An integrated program, it focuses on the interrelationship among the classically diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics and oceanography.

Capitalizing on the global perspective of space, the AR&DA program objectives are to study tropospheric and stratospheric chemical composition and pollution; to model the radiative budget of our planet; 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 the 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 will be important in developing a long-term predictive capability.

To a varying extent, each of the elements of the program supports the development and demonstrations of remote sensing technology; the development of algorithms to extract geophysical parameters from remotely acquired data; suborbital and ground-based experiments to measure fundamental properites 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.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

Funding in FY 1980 has been reduced by $1,230 thousand, largely by deferring studies of the next generation meteorological satellite system (System 85) for two years following NOAA's decision to extend the present operational weather satellite system for the near future. These funds were applied to the Airborne Instrumentation Research Program to support the North Sea Experiment (NORSEX) which is part of the SEASAT data utilization activities ($200 thousand); to purchase an ER-2 aircraft to enhance data collection capabilities required by Environmental Observations programs ($900 thousand); ana to the general reduction to the R&D budget request by the Congress ($130 thousand). Internal reallocations provided for an increase in the planned funding for National Oceanic Satellite System (NOSS) definition activities to support earlier studies of instruments and algorithms where some extra development is required.

BASIS FOR THE FY 1981 ESTIMATE:

The FY 1981 AR&DA program will include both the continuation of and the logical extensions from present activities. Particular emphasis is being placed on ocean processes AR&DA because remote sensing of the oceans represents a major new area of application of space technology. All of the program areas will continue laboratory research, numerical modelling, field research, instrument development and studies of flight missions.

The stratospheric air quality program will continue to focus on the impact of ozone perturbation on stratospheric chemistry. In FY 1981, emphasis will be on support of satellite missions and measurements and analyses focused specifically on ozone. This work will complement the efforts on ozone study being conducted in the Upper Atmospheric Research program. Ground truth for analysis of the Nimbus-7 and SAGE observations and for the NOAA temperature soundings will be supported. Satellite ozone data will be analyzed for trends, variability, transport and model verification. New developments include an ozone calibration facility and an improved ground-based ozone measurement system. An advanced laser heterodyne spectrometer, CLIR, and LIDAR instruments will be studied for future flights on Shuttle.

In tropospheric air quality research, emphasis will be placed on Environmental Protection Agency (EPA) interests in regional pollution problems and on global chemical cycles. The latter will include a joint field experiment to be performed with the National Science Foundation (NSF). Airborne laser sensors and imagery from satellite systems will be used in the joint EPA study of Persistent Elevated Pollution Episodes (PEPE) in the northeastern United States. NASA in-situ and remote sensors will be utilized for the first time in the NSF's Global Atmospheric Measurement Experiment of Tropospheric Aerosols and Gases. Analytical laboratory and field studies will be conducted to improve our understanding of man's impace on the atmosphere, with emphasis on the global carbon-nitrogen-ozone and sulfur-ammonia-aerosol geochemical cycles.

During the past year, NASA, NSF, NOAA and others participated in the successful GARP Global Weather Experiment which was completed in December 1979. In FY 1981, emphasis in global weather will be on completing studies on the data sets collected, and assessing requirements for improved operational forecasting. Simulation and sensitivity studies will be performed to define future remote measurement requirements. NASA will pursue the development of a number of improved remote meteorological sounders, including (1) advanced passive temperature and pressure concepts in the infrared and microwave regions, (2) advanced techniques to derive rainfall over land, and (3) assessment of microwave moisture sounders and lidar techniques to measure temperature and pressure profiles. Support will be provided for an advanced array processor to investigate and assess the impact on forecast accuracy of both polar orbiter and geostationary satellite observations. Experiments will be conducted to examine instability development and wave propagation in a spherical, stratified atmospheric model.

In FY 1981, the NASA severe storms research will support studies to measure convective storm intensity, tropical cyclone motion and intensification, flash flood potential, and the relationship of lightning to

thunderstorm development. 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 downdrafts, and produce destructive cloud-to-ground lightning. Efforts in the numerical modelling of storms and their environments will be supported in order to enhance capabilities in computerized forecasting. The program will support forecast improvement on both NASA and NOAA man-interactive systems including installation of a Centralized Storm Information System (CSIS) at NOAA's Kansas City facility. Two new measurement techniques will be assessed with flights and ground truth in FY 1981. These are the Visible and Infrared Spin Scan Radiometer Atmospheric Sounder (VAS) to be flown on GOES-D and an airplane-mounted doppler lidar for mapping wind fields around storms.

In FY 1981, investigations into general oceanic circulation will provide a basis for viewing the larger-scale topography of the sea surface via radar altimetry. The studies will examine the dependence of altimetry on factors such as surface wave height, and derive the surface current field by combining surface topography with knowledge of the gravity field and precise orbit. Just as a knowledge of the wind velocity field is central to understanding the dynamics of the atmosphere, a knowledge of the surface current field is central to understanding ocean dynamics, as well as predicting the ocean's effect on climate variations, pollutant dispersal, etc. Emphasis in FY 1981 will be on using SEASAT and GOES-3 altimetry data to initiate studies of detailed surface topography in the northwest Atlantic where geoid is accurately known; exploring ways to combine altimetry-derived surface topography with models of oceanic circulation; examining follow-on altimetry mission concepts using the Global Positioning System (GPS) for precise orbit determination; and, completing definition studies for a combined topography/gravity mission.

Air-sea interaction investigations will provide an observational basis for further understanding the smaller-scale conditions across the sea surface boundary utilizing both active (scatterometry and synthetic aperature radar) and new passive (radiometry) microwave techniques; and will determine the detailed dependence of such techniques on rain, water vapor, foam, surface temperature, and surface roughness. Such an improved observational capability will benefit both shorter-term weather forecasting as well as leading to a longer-term understanding of the ocean's role in climate. Data from both Nimbus-7 and SEASAT instruments will be used to explore the limitations on deriving near-surface conditions. Work will be initiated on production of an atlas containing detailed SEASAT Synthetic Aperature Radar (SAR) ocean imagery, and on planning and executing SAR field evaluations to be sponsored jointly by the Office of Naval Research and the National Science Foundation. A coordinated plan, including land and ice applications, will be developed for a SAR instrument to be flown on Shuttle.

Studies of coastal and inland waters will establish an observztional basis for viewing water characteristics, primarily water color, and to use this information to permit the monitoring of pollutants, sediment transport, biological productivity, and water motion. The FY 1981 contribution to these goals will include completion of studies to evaluate the ability of the Nimbus-7's coastal zone color scanner to characterize biological productivity; completion of evaluation of an experiment utilizing remote sensing techniques to observe a controlled oil spill; and initiation of development of a ship-borne laser system to evaluate the performance

of future aircraft and satellite color scanners for biological monitoring.

Sea and glacier ice studies involve using a variety of active and passive microwave techniques to assist in making an unambiguous assessment of ice characteristics such as percent cover, thickness, age, and motion. In addition to providing a basis for understanding the relation of variations in ice/snow cover with climate variations, ice-observing capabilities are needed for numerous commercial ventures (shipping, petroleum, etc.) in near-polar regions. Nimbus-7 and SEASAT data are being used for this research. Additional tasks include production of an atlas of SEASAT/SAR ice imagery, initiation of a study using SEASAT/SAR imagery to evaluate the performance of models to predict deformation of the ice field under the influence of the surface wind field, and completion of definition studies for incorporation of ice-specific instruments on future satellites.

Marine boundary layer studies will provide a bases for improving the use of radar scatterometry to view the near-surface wind field. Studies will be supported for determining the dependence of scatterometry wind accuracies on factors such as the stability of the marine boundary layer, and for developing improved methods for the assimilation of this data into oceanic and atmospheric forecast models. During FY 1981, when final data tapes containing all SEASAT/Scatterometer winds become available, joint studies will be initiated with the Navy's Fleet Numerical Weather Central on the impact of SEASAT winds on the accuracy of atmospheric forecasts for both marine and land applications. Development will also be initiated on ocean mixed layer models capable of inputting SEASAT winds. Definition studies will be conducted to explore options for flying improved scatterometers on future missions.

Within the broader outlines of the National Climate Program, NASA will be taking the lead in solar and Earth radiation research. Accordingly, particular emphasis will be placed on the recently initiated special studies in radiation, extended cloudiness and aerosol effects. In FY 1981, measurements of the solar constant from the Shuttle will begin as a major step in developing a long-term program of solar monitoring. It is expected that the first global data set of stratospheric aerosols from satellite observations (Nimbus-7, SAGE) will be produced, and testing will begin of their importance in numerical model studies. Other special studies will continue in hydrological and cryospheric processes, and air/sea interactions recognizing their importance in the climate system. NASA's climate modelling activities, which will be enhanced by use of a new array processor, will focus on sensitivity studies needed to refine the requirements for future space observations of climate parameters. Advanced studies will be initiated for new sensors to measure precipitation, sea ice, and solar radiation.

Shuttle/Spacelab Payload Development (Environmental Observations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Measurement of air pollutants from satellites (MAPS)	500	800	500	100
Atmospheric trace molecules observed by spectroscopy (ATMOS) ..	3,750	3,200	3,650	600
Atmospheric cloud physics laboratory (ACPL)	3,500	3,400	4,300	2,800
Principal investigator instrument development and reflight program*	--	2,200	1,150	4,700
Total	7,750	9,600	9,600	8,200

*Formerly included in the Upper Atmospheric Research Program.

OBJECTIVES AND STATUS:

The Space Transportation System offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The Environmental Observations Program is incorporating this new capability in order to capitalize on three important facets: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use is in a long-duration monitoring system on a free-flying satellite; (2) short-term data gathering of atmospheric and environmental processes for basic reasearch and analysis where long-term observations are not necessary or are impractical; and (3) research into processes which cannot be accomplished effectively in ground-based laboratories because of the effects of gravity.

The measurement of air pollutants 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 has been developed and is presently being integrated onto a pallet at the Kennedy Space Center for flight on an early Shuttle orbital flight test.

The objective of the atmospheric trace molecules observed by spectroscopy experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane,) in the Earth's atmosphere using the techniques of infrared absorption spectroscopy. These data will allow the determination of the compositional structure of the upper atmosphere, including the ozone layer, and its spatial variability on a global scale. The instrument is in final assembly with environmental and qualification testing scheduled to occur in the mid-1980. Its first mission will be Spacelab-3.

The thrust of the atmospheric cloud physics laboratory program is to improve our understanding of microphysical atmospheric cloud processes by removing the gravitational effect from the experiment design. A unique multipurpose laboratory facility is being developed for flights in the habitable Spacelab module for low-gravity experimentation performed by payload specialists. The facility has recently undergone a detailed design review with assembly of subsystems scheduled to begin in the summer of 1980. It is assigned for flight on Spacelab-3.

Over the past summer, a selection process was conducted based on proposals in response to an Announcement of Opportunity. The experiments selected include reflights of some instruments under development for the Orbital Flight Test (OFT) series, Spacelab-1, and Spacelab-2, plus the development of a doppler interferometer for wind measurements and a microwave limb sounder for measuring minor species, pressures, winds, and temperatures. Development of these instruments has been initiated. Reflights and new principal investigator developments will continue the research activities in atmospheric chemistry, solar intensity and variability, and upper atmospheric winds.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The Spacelab Payload Development portion of the Upper Atmospheric Research Program has recently been combined with the Environmental Observations Shuttle/Spacelab Payload Development. The changes to the individual elements of this combination are as shown below:

Measurement of Air Pollutants from Satellites (MAPS) - The FY 1980 budget estimate for this instrument assumed that work would be initiated in FY 1980 on defining an investigation program for reflight of the MAPS. Since the definition of future missions and experimental objectives are not specific, this activity has been deferred and will be funded as required from the resources in the PI Instrument Development and Reflight Program. FY 1980 funding will support integration activities in preparation for launch on an orbital flight test. Science team activities will include preliminary algorithm development and testing.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) - The development of this instrument represents a significant advancement in the state-of-the-art of interferometric spectroscopy. The instrument design is now complete. A reassessment of the remaining effort has indicated that the cost will increase due to additional design effort, increased testing of the instrument, and the slip in Shuttle flight schedule.

Atmospheric Cloud Physics Laboratory (ACPL) - This project is also experiencing cost increases due to more complex design issues than originally expected.

Principal Investigator Instrument Development/Reflight Program - The adjustment is due to rephasing of the developments to cover the increased funding requirements of the other Shuttle instruments. Reflight studies have been delayed until FY 1981.

BASIS OF FY 1981 ESTIMATES:

Measurement of Air Pollutants from Satellites (MAPS) - FY 1981 funds will be used to support launch and mission operations and the interpretation of data gathered from the mission.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) - The instrument is scheduled for delivery from the contractor in August 1980. Subsequent to delivery, a verification and familiarization program will be performed by the experiment team to establish baseline characteristics of the instrument. Delivery of the instrument for integration into the Shuttle payload is scheduled for mid-1982.

Atmospheric Cloud Physics Laboratory (ACPL) - During FY 1981, the ACPL will be in the test phase of the development process. These tests include qualification of the hardware, principal investigator familiarization tests, payload specialists training for the Spacelab-3 experiments, and tests for generation of toxic substances or hazardous conditions.

Principal Investigator Instrument Development/Reflight Programs - A selection process for new Shuttle flight opportunities has been completed. The experiments selected included several instruments which will have flown in the early Shuttle/Spacelab flights. The instruments are: (1) an active cavity radiometer for solar irradiance measurements; (2) a solar ultraviolet spectral irradiance monitor; (3) an imaging spectrometric observatory for trace constituent measurements; and (4) a photometric imager for lightning research. Several foreign investigations which are complementary to the NASA programs have been selected; funding for these is provided by the foreign agency sponsoring the investigator. Activities to be accomplished include instrument refurbishment and reflight and instrument development of new multiple-flight instruments for long-term research purposes.

Development of a High Resolution Doppler Interferometer (HRDI) for measuring upper tropospheric windfields will continue. The detailed design of the microwave limb sounder will be completed and "bread-boarding" of high technology subsystems for proof of concept determinations will be continued. A definition study of solar irradiance measurements in the 168-365 nanometers spectral range will be completed. These instruments were also selected from the recent Announcement of Opportunity.

In 1981, selections from another Announcement of Opportunity will be made and new instruments/investigations initiated. New investigations and flight requirements with previously developed instruments will be defined.

Operational Satellite Improvement Program (OSIP)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Research and development for improvement of operational satellite systems	6,100	7,400	7,400	10,700

OBJECTIVES AND STATUS:

The objective of the operational satellite improvement program is to carry cut the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for present and future operational satellite systems.

Current developments as well as expendable launch vehicle include design modification to the NOAA polar-orbiting, operational-meteorological spacecraft for Shuttle compatability, development of the advanced Visible and Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS), development of the Nimbus Solar Backscatter Ultraviolet (SBW) instrument for deployment on future NOAA operational spacecraft, and modification and improvement of direct readout equipment for operational use.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funds will provide for temperature and moisture data assessment of the VAS experiment to be launched on the Geostationary Operational Environmental Satellite (GOES-D) in August 1980. Development of the Solar Backscatter Ultraviolet (SBW) instrument scheduled for flight on NOAA-F will be continued. The SBUV on NOAA-F is an important milestone since it will be the first operational monitoring of stratospheric ozone from space. An advanced microwave sounding unit with narrower and more accurate temperature and moisture profiles, and improvements in the High Resolution Infrared Radiometer/2 and Vertical Atmospheric Sounder instruments will be initiated to meet NOAA's operational requirements. Work will continue on modification of the NOAA operational spacecraft design to enable the spacecraft to be launched by the Shuttle or expendable launch vehicle.

Earth Radiation Budget Experiment

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	3,400	10,700	4,700	16,700
Sensors	3,300	11,800	11,800	11,800
Mission operations and data analysis	300	500	500	500
Total	7,000	23,000	17,000	29,000
Space Transportation Systems Operations	(--)	(--)	(--)	(300)

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 so as to transfer heat from warmer areas 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, atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment 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 insights as to reasons 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 more stringent calibration of the sensors. Two NOAA satellites of the Tiros-N series will be flown in sun-synchronous orbits equipped with identical Earth Radiation Budget instruments. One of the NOAA satellites will have a morning equatorial passage time, while the other will have a mid-afternoon passage time. Adequate mid-latitude and equatorial coverage requires an additional satellite. Therefore, a third set of instruments will be flown on a NASA dedicated spacecraft in a 46° inclined orbit plane. Each equatorial region must be viewed at least once each month at each hour of the day, and the orbit altitudes and instrument view angles must be known to permit geographical location of the radiometer footprints. Together, the three satellites will provide accurate measurements of the monthly average radiation balance with regional, zonal, and global resolutions. The planned launch dates are 1983-1984 for the NOAA satellites and 1983 for the NASA dedicated satellite.

The scientific objectives and measurement requirements have been developed by a joint NOAA/NASA team of scientists that include leading scientists from the university community and other non-Government organizations. These requirements have been reviewed by a committee of the National Academy of Sciences. During FY 1979 the ERBE instrument specification and associated Request for Proposal package was released to potential contractors; TRW was selected as the contractor in May 1979. Engineering design of the instruments is in process. Design modifications to accommodate the ERBE instruments on Tiros-N/NOAA spacecraft bus are underway and the request for procurement for the NASA dedicated spacecraft bus and Shuttle interface has been issued. Data processing algorithms are being defined by the ERBE experiment team, which was selected through an Announcement of Opportunity process in November 1979.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The FY 1980 funding estimate has been reduced by $6 million to provide funds for the development of a larger propulsion module required by LANDSAT-D to permit Shuttle retrievability. Because the lifetimes of the Tiros-N and NOAA-6 satellites will be greater than expected, the planned launch dates for the follow-on NOAA satellites will be delayed. This in turn will require a delay in the launch readiness of the NASA ERBE spacecraft because of the program requirement for simultaneous measurements by the ERBE-instrument-equipped NOAA spacecraft and the NASA spacecraft. This reduced funding requirements in FY 1980 for the ERBE spacecraft makes the reallocation to LANDSAT-D possible.

BASIS OF THE FY 1981 ESTIMATE:

FY 1981 funding will be used to complete the design and continue the development of the ERBE instruments, and to support the initial fabrication of the NASA dedicated spacecraft plus the design of the Shuttle/spacecraft interface hardware. ERBE experiment team members have been selected and funding support for data processing, algorithms and model software effort for the team will be continued.

Halogen Occultation Experiment

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Sensor development	3,600	8,000	*8,000*	*6,000*

OBJECTIVES AND STATUS:

The Halogen Occulation Experiment (HALOE) will provide global stratospheric vertical concentration profiles of key chemical species involved in the catalytic destruction of ozone due to chlorine compounds. These measurements will assist in estimating the depletion of stratospheric ozone due to natural and man-made causes involving chlorofluoromethanes (CFM's). Specific objectives of HALOE are: (1) to monitor globally the vertical profiles of concentrations of stratospheric hydrogen chloride, hydrogen fluoride, water and other trace gases of importance to the chlorine chemistry; and (2) to use the measured data (a) in obtaining horizontal and vertical maps of gas concentrations; (b) to perform a chlorine source analysis; (c) to validate chemical and dynamic models describing the effects of CFM's on the ozone layer; and (d) to aid in assessing ozone depletion and depletion rate due to chlorine build-up in the stratosphere.

An initial test of the engineering model instrument is being planned for flight on a Shuttle mission to demonstrate the validity of the measurement technique in a space environment and to evaluate the instrument operating parameters. A longer duration mission of one to two years will take place on the Earth Radiation Budget Experiment mission in 1983. Conceptual design of the HALOE instrument was accomplished under the Advanced Applications Flight Experiments (AAFE) program. Design of the spaceflight instrument is in progress and fabrication has been initiated. A science team was selected through the Announcement of Opportunity process in November 1979.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, fabrication of the engineering model unit to be flown on the Shuttle will be completed with delivery of the instrument for integration in mid-1981. Acquisition of major subsystems of the flight unit for the Earth Radiation Budget Experiment will be initiated. Science activities will be focused on modeling techniques and development of the inversion algorithms.

Extended Missions Operations (Environmental Observiations)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Operations for the extended missions of:				
Nimbus-5, -6, and -7	--	5,200	5,200	7,500
Stratospheric aerosol and gas experiment	700	600	600	500
Geodynamic experimental ocean satellite	550	--	--	--
Total	1,250	5,800	5,800	8,000

OBJECTIVES AND STATUS:

Nimbus-5, -6, and -7 were launched in December 1972, June 1975, and October 1978, respectively. They have provided years of global data regarding such things as sea ice, atmospheric chemistry and dynamics, the Earth radiation budget, and ocean temperature and color. They have also demonstrated a number of measurement techniques some of which have been adopted on operational satellite systems. Reduction and analysis of this valuable data is continuing and there are a number of areas where additional data is urgently needed. These include, among others, global precipitation, soil moisture, snow and ice cover and the radiation budget. Continuation of this data will support studies in the trends of world weather over several years, severe storm analysis and prediction, and improving numerical forecast models.

The satellite carrying the Stratospheric Aerosol and Gas Experiment (SAGE) instrument, launched in early 1979, continues to provide essential global monitoring of ozone and aerosols by solar occultation means.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding will support continued flight operations of Nimbus-5,-6, and -7 and SAGE beyond their originally planned lifetimes. It will provide maximum reduction and verification of the sensor data including the development of some special data processing techniques for existing systems. Digitizing, formatting, calibration, annotation and referencing of sensor outputs into data sets and subsequent archiving will be supported. Such information will contribute to the ozone data base and provide additional information for detecting ozone trends.

National Oceanic Satellite System (NOSS)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	--	--	--	2,000
Instrument development	--	--	--	3,200
Supporting activities	--	--	--	600
Total	--	--	--	5,800

OBJECTIVES AND STATUS:

The National Oceanic Satellite System (NOSS) will be an interagency project to demonstrate the capability of remote sensing of the oceans from space and the data processing and distribution necessary to meet the operational information needs of both the military and civil sectors--needs which range from operation of the Fleet to petrochemical exploration to management of marine resources. NOSS will also provide space observations of ocean conditions which are needed to improve our understanding of ocean processes and to extend the national capabilities to predict oceanic phenomena and to assess their interaction with human activities.

Both the Department of Defense and the Department of Commerce require timely, accurate oceanic information on a global scale. The United States Navy needs the NOSS data for the selection of operating areas, damage avoidance, ship routing, strategic submarine operations, logistic resupply, antisubmarine warfare accoustic predictions, and tactical ship routing. The National Oceanic and Atmospheric Administration (NOAA) needs this information to support such diverse activities as: (1) management and conservation of marine resources; (2) the prediction of weather; (3) the protection of life and property; (4) the preservation, conservation and development of the Nation's coastal resources; and (5) the provision of maps, charts, surveys, and specialized data for safe navigation. The NOSS data should be especially important in NOAA weather forecasting models. Provision of global ocean conditions data on a timely basis will improve the efficiency, safety and cost of ship operations, transportation, off-shore oil and gas exploration and drilling, platform operations, marine construction, commercial fishing, pollution monitoring, ice monitoring, and marine search and rescue.

The NOSS capability for remotely sensing the world's oceans and providing useful data to the user community in near real-time is not available by any other means. The vast majority of the world's oceans lie outside commonly traveled sea lanes and, thus, are unobserved by conventional methods. The capability of existing and planned meteorological satellites to measure characteristics of the oceans is severely limited. The collection of global and synoptic oceanic data by the deployment of more conventional techniques (e.g., ships and buoys) would require thousands of individual platforms. Such a technique would be prohibitive both logistically and monetarily.

The oceanic features to be observed by NOSS include directional wind stress, sea surface topography, ice cap profiles, significant wave height, directional wave spectrum, sea ice patterns, internal waves, ships, icebergs, sea surface temperature, wind speed, clouds, rain, and chlorophyll. NOSS will be designed to produce data products describing these features with typically no more than a three to twelve hour delay from acquisition of the data by the spacecraft. This will demonstrate the characteristics of the data system that user agencies would require in an operational system. Mission lifetime will be sufficient to allow user agencies to evaluate fully the data's utility in an operational environment.

The NOSS is planned to be a complete end-to-end oceanic monitoring system incorporating both microwave and optical oceanographic sensors, flown on two satellites, with a ground control, data processing, and distribution system. The initial NOSS spacecraft will be launched using the Space Shuttle in 1986.

The NOSS is a jointly defined and funded program. NASA has overall project management responsibility. NOAA and DOD are responsible for defining system requirements, data products and formats. NOAA and DOD will also operate the NOSS during the five-year demonstration period following launch of the first NOSS spacecraft. NASA and DOD will share the cost of developing and launching the initial spacecraft, and NOAA and DOD will share the cost-of developing and launching the second spacecraft and the ground control, processing and distribution system's development and operations. The planning estimate for the total NASA share of the baseline program is $145-190 million in dollars of the FY 1981 budget, excluding launch and supporting activities. The NOAA and DOD share of development costs is estimated at approximately $545 million, excluding launch costs. The cost for launching the two NOSS spacecraft is estimated at $80 million, to be shared by the three agencies. Overall program policy and guidance for the NOSS Program is provided by a tri-agency NOSS Steering Committee composed of one senior representative from each of the three major organizations. Steering Committee directives and decisions are converted into implementation guidelines by a tri-agency Program Management Team and, ultimately into hardware and software by the tri-agency NOSS Project located at GSFC.

The NOSS will be designed and developed under a competitive procurement process. The Request for Proposals for the Alternate Systems Concept Studies was released to industry on October 3, 1979; proposals were received in early January 1980; contract awards are anticipated in the spring of 1980.

BASIS OF THE FY 1981 ESTIMATE:

In FY 1981 funding will support the selection of a Mission Contractor for system development and implementation, and procurement of the spacecraft sensors. During FY 1981, design of the spacecraft bus, the primary processing facility, and the spacecraft sensors will be initiated. Breadboard hardware subsystems for the Large Antenna Microwave Radiometer will be fabricated and engineering testing begun. In addition, geophysical algorithm development for conversion of the remotely sensed data into useable engineering units will begin in detail.

BASIS OF FY 1981 FUNDING ,REQUIREMENTS:

APPLICATIONS SYSTEMS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Airborne instrumentation research program	6,530	10,300	15,547	18,100
Shuttle/Spacelab mission design and integration*	6,260	8,300	7,300	--
NASA integrated payload planning"	1,160	1,700	1,700	--
Total	13,950	20,300	24,547	18,100
Space Transportation System Operations	(--)	(18,000)	(6,600)	(12,600)

*Funding responsibility for FY 1981 and subsequent years has been transferred from Space Applications to Space Science.

OBJECTIVES AND STATUS:

The Airborne Instrumentation Research Program (AIRP) provides flight support to major segments of the Space Applications Program as well as to other NASA programs. The aircraft fleet presently consists of two U-2C's, one WB-57F, one C-130, and one CV-990. These aircraft provide support as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their being flown 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 U-2C's to acquire simulated thematic mapper data. A principal use of the WB-57F's and 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 is important in the Environmental Observation program where much interest exists regarding stratospheric transport mechanisms and where it is extremely desirable to penetrate the stratospheric region--which in the tropical interconvergence zone is normally found at altitudes of 60,000 feet and above.

CHANGES FROM FY 1980 BUDGET ESTIMATES:

The reduction of $1.0 million in Mission Design and Integration and the increase of $5.24 million in the Airborne program reflect internal program reallocations to provide for the initial funding of the acquisition of an ER-2 aircraft (U-2R). This aircraft will be obtained in conjunction with a United States Air Force procurement at a total estimated cost of $13 million and will replace one of the aging U-2's which will then be returned to the Air Force inventory. The ER-2 aircraft offers additional altitude and range capability and payload capacity over the U-2C. This enhanced capability should permit both more economical operation of the high altitude fleet and an improved capability to penetrate important regions of the stratosphere where there is considerable scientific interest.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funds are required to continue the operations of the aircraft fleet at approximately the same level as during FY 1980. In addition, the request includes $7 million to complete the procurement of the ER-2 aircraft.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

TECHNOMGY TRANSFER

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Applications systems verification and transfer	900	1,700	1,700	1,800
Regional remote sensing applications	3,500	3,800	3,657	4,100
User requirements and supporting activities	4,500	4,800	4,730	6,600
Civil systems	1,800	---	---	---
Total	10,700	10,300	10.087	12.500

OBJECTIVES AND STATUS:

The objectives of the remote sensing Technology Transfer program are to provide for the validation, transfer and widespread dissemination of proven technology applications to operational use.

The Applications Systems Verification and Transfer (ASVT) program conducts the demonstration, verification, and transfer of total applications systems in a representative user setting and with participating user organizations, emphasizing cost reduction and system compatibility with the user setting. The program is increasing the awareness and use of remote sensing by other Federal agencies, state and local governments, and private sector users. Projects are now underway with the National Park Service, the Corps of Engineers, the Pacific Northwest and Appalachian Regional Commissions, and the State of Texas. Additional projects will be undertaken in FY 1980 with the states of California and Alaska, and with regional water management districts in the state of Florida.

The Regional Remote Sensing Applications Program provides for broad assistance to state and local governments in evaluating and implementing proven Landsat applications in natural resource and environmental management. The program has provided major impetus to state use of Landsat data through data analysis training to over 750 state, local and Federal personnel and the completion of four multi-disciplinary state application demonstration projects. Additional projects with 21 states are presently being conducted. Follow-on technical assistance is leading to the establishment of operational Landsat data processing capabilities in over a dozen states as well as significantly increased technical communication and cooperation between states, and support for state use of private sector capabilities. Increased use of geobased information systems in the transfer projects has increased the relevance and utility of Landsat data utilization to other state programs. Other initiatives are expanding county and other local government exposure to and use of Landsat data both independently and through the use of established state capabilities.

Under User Requirements and Supporting Activities, continuing communications at the national level are maintained 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 Space Applications programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. In FY 1980 a dynamic user requirements planning function is being developed with particular emphasis on external drivers to technology use such as Federal and state legislation. The formal contacts with national user interest groups and change agents such as the National Conference of State Legislatures and the National Governors Association have continued to be valuable in focusing and accelerating state government interest in technology transfer through establishment of two-way communications, increase of user awareness, and participation in needs definition. A program to increase transfer to locally based private industries including architectural and engineering (A&E) firms, environmental and development consultants, and data processing companies, is being implemented through a network of community colleges. We are also continuing to encourage the development of geographically distributed university capabilities to demonstrate the practical benefits of remote sensing through the conduct of research, education and public service activities. Twenty-one universities are currently participating in the program, with recent additions expanding the technical areas of interest from remote sensing to include materials processing, geodynamics and geology.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The $213 thousand change in FY 1980 funding for Technology Transfer is the result of two actions: a reduction of $13 thousand in Regional Remote Sensing Activities as part of a general Congressional reduction in the Agency's budget; and, a reduction of $130 thousand in Regional Remote Sensing Activities and $70 thousand in User Requirements and Supporting Activities to be applied toward procurement of an ER-2 aircraft. This high altitude aircraft will provide support for the remote sensing requirements of both of these activities.

BASIS OF FY 1981 ESTIMATE:

Major emphasis for FY 1981 will be in the following areas:

ASVT projects with the State of Texas (Natural Resources Inventory/Monitoring) and the National Park Service (National Park Management) will be completed in FY 1981. In FY 1981, approximately three new ASVT's will be initiated. Program thrusts in FY 1981 will address private sector applications with architectural/engineering consultants in route and site locations, public utility companies in power demand prediction and agri-businesses in agricultural forecasting as well as new evolving Federal programs in the area of environmental quality. In addition, private industry service suppliers will be utilized more fully in conducting ASVT projects with user organizations.

Regional Remote Sensing Applications Program activities in FY 1981 will complete Landsat Multispectral Scanner (MSS) application demonstration programs with 15 state governments. In addition, demonstrations in the remaining four states not yet involved in NASA's technology transfer activities will be initiated in FY 1981. An additional six to eight projects with universities will continue the development of curricula and capabilities for independent training support to operational state government Landsat programs. Transfer of Landsat technology to state governments will continue with the introduction of new technology, including limited use of Return Beam Vidicon (RBV) data, and expanded use of geobased information systems. Increased emphasis will be placed on follow-on technical assistance to operational users through documentation of analysis software and application case studies, technology surveys, and involvement of private sector professional associations in developing user service capabilities. Technology transfer to substate governments will be expanded to national scale in FY 1981 through an estimated 20 to 25 projects with county governments (as well as regional government entities). This program will be undertaken in cooperation with national representative organizations (such as the National Association of Counties) to provide technology sharing and a multiplier effect among users. The program will continue with a selected number of representative users in succeeding years.

The User Requirements and Supporting Activities will focus on strategies to expand the involvement of the private sector in NASA's technology transfer efforts both as a supplier of remote sensing services and as an independent end-user of remote sensing. Studies will be performed to evaluate private user needs and address their major needs through joint transfer projects, thereby providing private companies an opportunity to use

remotely sensed data in increasing their own productivity. Emphasis will also be placed on increased use of private industry service suppliers as the technical arm in NASA's transfer projects with both public and private users. Market evaluations will be conducted to lay a foundation for transfer projects addressing new technology applications in the environmental quality and weather data areas. Formal institutional relationships with the National Conference of State Legislatures (NCSL), National Governors Association (NGA) and a substate user group will be continued and broadened to promote awareness and transfer of technologies in addition to Landsat. In addition, it is planned to continue to phase in additional universities in FY 1981 as some of the present university programs are completed. Selection of these universities and areas of application will be made in concert with the Remote Sensing Applications and ASVT programs in order to reinforce the establishment of state and local government capabilities to use remote sensing.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

MATERIALS PROCESSING IN SPACE

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Space processing applications rocket (SPAR) project.....	3,600	2,100	2,100	---	---
Applied research and data analysis.....	4,850	6,900	6,450	11,700	RD 7-54
Shuttle/Spacelab payload development.....	11,950	10,800	11,218	10,500	RD 7-56
Total..	20,400	19,800	19,768	22,200	
Space Transportation System Operations.....	(---)	(---)	(600)	(1,600)	

OBJECTIVES AND STATUS:

The Materials Processing in Space (MPS) program's emphasis is on the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of the space environment for materials processing and to provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. As these development, test, and demonstration efforts proceed, the technology will be transferred as appropriate to non-NASA users for their use.

Ground-based research, technology development, and payload definition activities in FY 1981 will concentrate on three major processing areas: crystal growth and solidification, containerless processing, and

fluid and chemical processing. These activities will provide the scientific basis for future space applications of materials processing technology. Several joint agreements will be negotiated during 1980 with industrial concerns through the Joint Endeavor mechanism developed in 1979: such projects are intended to facilitate early transfers of space activity in materials science and technology to private sponsorship. Also, a small advanced payload planning study of future orbital systems will be coordinated with the Office of Space Transportation Systems.

The Shuttle/Spacelab payload development project will provide opportunities to perform materials science experiments in an extended, microgravity environment. Critical design reviews for the payload equipment will be completed in the first quarter of FY 1981, and most of the work of fabrication and testing will be completed during that year. As currently configured, this equipment includes two systems which serve multiple Principal Investigators: the Fluid Experiment System, which is used to determine density gradients and fluid flows during crystal growth and other fluid processes, and the Solidification Experiment System, which is used to perform a wide range of controlled high temperature melting and freezing experiments. Also included is specialized equipment for experiments on vapor crystal growth of mercuric iodide and space production of polymer latexes with uniform particle sizes.

The Space Processing Applications Rocket (SPAR) project will be completed in 1980. Six SPAR flights were conducted over the past five years, two flights are scheduled for CY 1980, and the final flight is scheduled for 1981. The Materials Experiment Assembly (MEA), a system of interface hardware that will enable SPAR payload apparatus to be used in the Shuttle payload bay, will complete its development phase in 1980.

Applied Research and Data Analysis (Materials Processing)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Ground-based investigations, analysis, and studies.....	4,850	6,900	6,450	11,700

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 looking toward space enterprises involving private industry.

Most research projects in the AR&DA program are initiated as a result of unsolicited proposals from the scientific community, which are extensively peer-reviewed prior to selection. The FY 1980 funding augmentation has been used to initiate funding of a set of new three-year research projects proposed by leading members of the materials science community, and to establish a Materials Processing Center at the Massachusetts Institute of Technology (MIT) for work in areas of joint interest to NASA and industry. Current research, which will continue in FY 1981, 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, and containerless processing techniques. The commercialization effort includes studies of institutional, legal, and economic issues of joint NASA/industry ventures, information activities directed toward industry involvement in MPS projects, and negotiations with companies interested in undertaking joint space endeavors with NASA.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $450 thousand reflects both an internal program decision to increase the funding in the Materials Processing in Space Shuttle/Spacelab Payload Development project by $418 thousand for scientific investigators utilizing the Spacelab experiment systems and a $32 thousand reduction as part of a general Congressional reduction in the Agency's budget.

BASIS OF FY 1981 ESTIMATE:

The level of effort budgeted for FY 1981 will continue the expanded ground-based research program initiated in FY 1980 in response to recommendations from the National Academy of Sciences. The FY 1981 budget request will maintain the activities initiated in 1980 at MIT and elsewhere, which include investigations of crystal growth, self-generated flows in weightless fluids, separation processes for biological materials, controlled solidification processes, and containerless processing.

In FY 1981, the program's current principal equipment definition activities will continue. These include definition of scientific requirements and technology needs for floating zone crystal growth and acoustic containerless processing experiment systems, and system definition of a free-flying payload carrier which will allow extended time in orbit for materials processing payloads through interface with the 25-kw power module or other future free-flying host vehicles.

The AR&DA funding augmentation requested for FY 1981 will provide for increased effort in advanced technology development to meet needs identified in the ground based research program, and definition studies on space experiment systems to perform investigations arising from MPS materials research. New materials processing technology will be developed in the area of electromagnetic, acoustic, and electrostatic levitation, high temperature heat pipes, materials properties measurements, holography, and the production and purification of biological materials. Definition studies will be performed for future initiatives including the Electromagnetic Containerless Processing System, Bioprocessing System, High Gradient Furnace, and Space Vacuum Technology Demonstration.

Shuttle/Spacelab Payload Development (Materials Processing)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Payload development and operation.....	11,950	10,800	11,218	10,500

OBJECTIVES AND STATUS:

The Space Processing Shuttle Payloads project includes the design and development of a basic set of payload equipment for space experiments on materials and processes, and provisions for conducting experiments with this equipment on Space Transportation System (STS) flights. The first series of experiments to use the equipment will be flown on the Spacelab 3 mission in 1982 and a pallet mission in 1983. Investigations selected for these flights cover topics in crystal growth, fluid flow effects, physical metallurgy, specialized composite materials, and polymerization. All of the equipment will be 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.

Four equipment systems are under development and scheduled for Preliminary Design Reviews in FY 1980. Two of these are multiuser facilities: the Fluid Experiments System (FES), a sophisticated holographic optical measurement system to determine density gradients and fluid flows during crystal growth and analogous processes, and the Solidification Experiments System (SES), a versatile electric furnace system capable of performing a wide range of controlled high temperature melting and freezing experiments. In addition, two apparatus systems are being built specifically for individual investigations: the Vapor Crystal Growth system (VCG) will grow massive single crystals of mercuric iodide by evaporation and recondensation, and the Monodisperse Latex Reactor (MLR) will be used to study the kinetics of latex particle growth under conditions that produce particles of uniform size. The scheduled development of the Polymer Latex Reactor (PLR) and the Acoustic Containerless Processing Module (ACPM), planned for flight in 1982, has been deferred because of a combination of technology problems in the ACPM and higher than anticipated cost estimates for both systems.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $418 thousand reflects an internal program adjustment from AR&DA to meet current requirements for scientific investigators utilizing the Spacelab experiment systems.

BASIS OF FY 1981 ESTIMATE:

Critical Design Reviews for all four apparatus systems will be completed by late 1980, and hardware fabrication will be performed through FY 1981, leading to delivery for integration early in FY 1982. Principal Investigators will complete development of their flight experiment protocols and samples for the missions to be flown in FY 1983, and detailed development will begin on experiment protocols for new and deferred investigations that will fly experiments using the same apparatus on subsequent flights.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

ACE CATIONS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Search and rescue mission	8,000	5,000	5,000	2,300	RD 7-60
Technical consultation and support studies	3,100	3,000	2,982	3,200	RD 7-61
Applied research and data analysis	3,900	6,200	6,200	16,600	RD 7-62
Follow-on data analysis and operations	4,500	3,800	3,783	2,300	RD 7-64
Applications data service definition	100	2,400	2,400	3,000	RD 7-65
Data management	1,800	1,500	700	1,600	RD 7-66
Adaptive multibeam phased array (AMPA) system	1,200	1,400	1,660		RD 7-67
Total	22,600	23,300	22,725	29,000	

OBJECTIVES AND STATUS:

The objective of the Space Communications program is to provide for the most effective use of limited geosynchronous orbit and radio spectrum resources while promoting United States leadership by support of technology development in satellite communications. In FY 1981, the communications program will continue the development 'of a strong technology base--particularly in multibeam antennas and on-board switching techniques--from which future plans for new capabilities and flight test programs can be developed. It also will concentrate on the definition of systems techniques which provide data to users in a more timely and more useable manner. A primary thrust will be advanced technology development for communication spacecraft to operate in the frequency band at 30/20 gigahertz (GHz). Activities in FY 1981 will include development of critical subsystems technology, completion of pre-project studies, and development of experiment plans.

The communications research and development effort reflects the policies set forth by the President in 1978 which state that United States leadership in communications satellite systems will be supported by NASA and that selected technological opportunities to provide better frequency and orbit utilization and other longer-term opportunities will be pursued. This effort also responds to Congressional support for a revitalized Federal communications research and development effort. The advice of the communications industry has been incorporated and will complement private sector research and development, using NASA's unique capability to provide technology proof-of-concept testing in high risk areas. This will enable industry to more confidently approach future improved systems and less costly service offerings to all user communities.

FY 1980 funds will complete the development of the Adaptive Multibeam Phased Array (AMPA) antenna. This antenna will be used to conduct ground-based experiments in quickly forming, shaping, and pointing transmit and receive beams to ground users in various locations, while avoiding potential interference.

The experimental Search and Rescue program, which will use satellites to aid in the detection and location of distress beacons carried by ships and aircraft, will continue in FY 1981. During FY 1979, modification of the appropriate NOAA operational meteorological spacecraft (NOM-E, -F, -G) to accept Canadian and French equipment, and the development of the spacecraft antennas were initiated. Spacecraft modifications will be completed during FY 1980. Other activities in FY 1980 include building a ground station to accept satellite data, and developing a flight test program. This work will be done in conjunction with the Departments of Transportation, Commerce, and Defense and with France, Canada, and the USSR.

Technical consultation and support studies will continue to provide the necessary technical information concerning the growth of existing satellite services and the inclusion of new satellite applications. Special emphasis will be placed on orbit and spectrum utilization studies and on assessing the impact of the General World Administrative Radio Conference (GWARC) on present and future telecommunications and remote sensing. Orbit and spectrum utilization studies 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.

FY 1981 funds will support the continued operations of Applications Technology Satellites-1, and -3, while providing for the orderly phaseout of the Applications Technology Satellite-6 and Communication Technology Satellite public service user experiments and demonstration. These funds will also provide for the transition of federal public service communications activities from NASA to the National Telecommunications and Information Administration (NTIA) within the Department of Commerce. During FY 1981, work will continue with the NTIA and its Interagency Committee on Satellite Telecommunications Applications, representing 18 Federal agencies, undertaking technology development which will enable industry to meet more effectively the growing communications needs of Federal agencies.

FY 1981 funds will support definition of the Applications Data Service (ADS), a data sharing network service, to meet future user data access and integration needs. Pilot demonstrations defined in FY 1980 will be implemented to evaluate ADS standards and concepts. In addition, FY 1981 funds will support generalized data systems studies as well as specialized data management technique development tasks.

Search and Rescue Mission

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Search and Rescue Mission.	8,000	5,000	5,000	2,300
Atlas (expendable launch vehicles program)	(---)	(2,000)	(1,200)	(---)

OBJECTIVES AND STATUS:

The objective of the Search and Rescue Mission is to demonstrate the feasibility of using satellites to provide a significant improvement in the capability for search and rescue forces to detect and locate distress signals from general aviation aircraft and certain marine vessels during emergencies. Systems studies have shown that satellites flying at an 850 kilometer altitude can detect the emergency beacons presently carried by aircraft and ships. Preliminary calculations indicate that the satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers (based on the presently employed emergency frequencies, 121.5 and 243 MHz), and could position a proposed new beacon (using the recently allocated 406 MHz frequency), with its stronger signal, to about 5 kilometers. The experiment will permit rescue forces to arrive at the accident scene more quickly than is presently possible, because of the more comprehensive coverage a satellite system can provide using conventional frequencies, and the combination of improved performance and added coverage using the new frequency.

This interagency program is being conducted jointly with Canada and France; negotiations with the Soviet Union for the operation of a compatible spacecraft system have been completed. The U.S. will provide the spacecraft, launch vehicle, and the U.S. ground stations; the Canadians will provide the space telecommunications equipment and ground station in their country; and France will provide an onboard processor and receiver. The Soviet Union will launch and maintain in orbit two spacecraft operationally compatible with the U.S., French, and Canadian system and will operate their own ground station. In addition to NASA, the Departments of Defense and Transportation are expected to purchase and operate ground stations and participate in the program test and evaluation phase while NOAA is providing the spacecraft for modification.

The design of the spacecraft modification to accommodate the Search and Rescue instrumentation and the design of the required spacecraft antennas have been completed. Fabrication of the spacecraft and antennas has begun. A new improved 406 MHz Emergency Locator Transmitter is currently being developed. The Local User Terminal is being procured, with development planned to begin in mid-FY 1980.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will support the integration and test of the Search and Rescue instrumentation with the NOM-E, -F, and -G spacecraft; continue the development of the Local User Terminal, the Emergency Locator Transmitter and the necessary modifications to the NOAA ground stations; and begin the development of the demonstration and evaluation test plans.

Technical Consultation and Support Studies

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Technical Consultation and Support Studies	3,100	3,000	2,982	3,200

OBJECTIVES AND STATUS:

The objective of this program is to provide technical consultation, special studies, and experiments on frequency and orbit utilization for NASA and other US. Government agencies. Studies and experiments being performed help provide the necessary technical information concerning the growth of existing satellite services and the inclusion of new satellite applications. The effort is grouped into three main categories: orbit and spectrum utilization; satellite systems support; and communications satellite application system studies.

Orbit and spectrum utilization includes 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 the efficient use of the geostationary orbit and radio spectrum. Satellite systems support includes design and flight readiness reviews and technical assessments on Intelsat and Domsat systems for the Federal Communications Commission (FCC) and special studies on high priority FCC and NASA program office requests. Communications satellite application system studies are primarily structured to meet statutory and regulatory requirements and to ensure compatibility of NASA flight programs with other space and terrestrial services.

These studies and experiments'have supported U.S. preparations for and NASA participation in the 1979 General World Administrative Radio Conference. Our preliminary assessment of the 1979 GWARC is that the results were generally favorable, inasmuch as almost all of the positions sought and staffed by NASA were successfully obtained. In FY 1980, a more detailed assessment of the results of the GWARC with respect to

NASA, national, and international implications has been initiated. A draft of the Propagation Design Handbook for satellite system designers has been completed and is currently being reviewed by industry and universities. Propagation effects measurements at 30/20 GHz using COMSTAR are continuing at four university locations.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

As part of an overall Agency adjustment due to the general Congressional reduction in the Agency Research and Development Appropriation request, a minor reduction was made in the funds allocated for this project.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, emphasis will be placed upon assessing the results of the 1979 General World Administrative Radio Conference (GWARC), and their implications for U.S. telecommunications. Studies will be expanded in support of the 1983 Region 2 (Western Hemisphere) Conference on Broadcast Satellites and the proposed International Conferences on Space Services Planning (geostationary orbit and frequency assignment planning).

Studies and experiments will also be continued in the areas related to the use of active and passive microwave sensors essential to resource and environmental observations; broadcast and mobile satellite services; emergency and disaster communications; energy transmission from space; and techniques, models, and strategies for improving the use of the radio frequency spectrum and the geostationary orbit.

Applied Research and Data Analysis (Space Communications)

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Wideband 30/20 GHz definition	--	1,200	1,200	1,200
Applications pilot tests	497	---	---	---
Advanced communications research	3,103	5,000	5,000	5,400
Advanced technology [illegible]	---	---	---	10,000
Development of advanced flight experiments	300	---	---	---
Total	3,900	6,200	6,200	16,600

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) activities consist of system studies, development of technology for proof-of-concept flight programs, and experiments which provide new technology and technique concepts to aid private industry in offering new, improved and affordable communications services.

The communications traffic forecasts conducted by communication common carriers for NASA predict that the capabilities of current technology communications satellites will be saturated about 1990. In order to provide growth beyond that time, new frequency bands, multiple beam spacecraft antennas providing frequency re-use, and on-board switching systems must be developed. While these systems show great promise, they also entail high technical risks because of the uncertainties involved in rainfall attenuation at the 30/20 GHz band, and in the cost of development and tests of new transmitters and receivers, multibeam antennas, and on-board switches and signal processors. The focusing of NASA efforts upon this program will provide for a clearer understanding of the technology developments and verification testing needed to reduce the perceived risks of commercial utilization of these technologies. These activities will resolve development uncertainties (performance, schedule, and cost) in all major subsystems for future experimental missions. They will also advance U.S. industry's capabilities well beyond that available elsewhere in the world. Further, they will establish the feasibility of unique new communications capabilities involving vastly greater bandwidths (2.5 GHz versus 0.5 GHz) for point-to-point applications, and direct-to-customer services that will benefit from small antenna diameters, low cost earth stations, and locations in metropolitan areas. The former capabilities will alleviate spectrum-orbit congestion, while the latter will allow entirely new communications services to develop.

BASIS FOR FY 1981 ESTIMATE:

The primary thrust of AR&DA is focused on the design and development for the critical subsystem technology required for a 30/20 GHz communications satellite, with frequency reuse in multiple beam spacecraft antennas, and on-board switching systems to permit interconnections between multiple beams. FY 1981 funding will support critical component technology development required for a 30/20 GHz communications satellite. These critical components include an advanced multibeam antenna system for direct-to-user applications, an advanced multibeam antenna system for point-to-point trunking applications, a radio frequency switching matrix for interbeam switching of analog signals, a baseband switching system for interbeam switching of digital signals, a high power transmitter for the 20-GHz downlink from the satellite, and a low noise receiver for the 30-GHz uplink to the satellite.

Follow-on Data Analysis and Operations

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Follow-on Data Analysis and Operations	3,996	3,000	2,983	1,400
Applications Pilot Tests	504	800	800	900
Total	4,500	3.800	3.783	2.300

OBJECTIVES AND STATUS:

The objective of this program is to continue experiment support for ATS-1, -3, and -5; and 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 communications experiments using the ATS series and CTS have been successfully conducted during the extended lifetimes of these satellites to provide user experience for making decisions regarding their communications 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. Complete reports on experiment results will be prepared for use by the many interested groups that could not directly participate. Public service user experiments on ATS-6 and CTS were completed on June 30, 1979. ATS-1, -3, and -5 experimentation continues.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $17 thousand in FY 1980 is a result of an overall Congressional general reduction in the FY 1980 Research and Development appropriation request.

BASIS OF FY 1981 BUDGET ESTIMATE:

FY 1981, funding will provide for continued support of the ATS-1, and -3 experimentation and support activities. Public service user experiments on ATS-6 and CTS were completed on June 30, 1979. FY 1981 will complete the phasedown years, during which results of 400 experiments performed since 1969 will be compiled so that the results may be of value to future communications activities. The results of these experiments will continue to support the National Telecommunications and Information Administration's (NTIA) efforts to

transfer the public service satellite communications community to commercial satellites and services. A continuing activity in this support will be the Systems Architecture Study in which a thorough and careful investigation of all practical commercial communications links for the Public Service user is made. Additional support to NTIA will include Technology Transfer Policy Analysis and Public Services Policy Analysis.

In the Applications Pilot Test program, NASA will continue to support the public service communications project with the Public Service Satellite Consortium to provide for technology transfer of satellite communications applications.

Applications Data Service Definition

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Applications Data Service Definition	100	2,400	2,400	3,000

OBJECTIVES AND STATUS:

The objective of the Applications Data Service (ADS) definition activity is to analyze approaches for economically and efficiently meeting future applications data access and integration needs. In the 1980's effective use of information gained from multiple sources is key to the users success in dealing with large scale modeling in agriculture, ocean studies, and weather and climate forecasting. This requires timely access to and integration of data from a dozen or more interdisciplinary sources.

The ADS will build upon existing and future applications data systems, encourage the convergence of those systems and their products into a compatible and integrated structure through the definition of data and data systems standards, and develop a network service for data transmission and integration.

ADS preliminary requirements and concept studies presently are underway and will be completed by late 1979. FY 1980 studies will define initial standards as well as a pilot activity to test/demonstrate ADS concept feasibility.

BASIS OF FY 1981 ESTIMATE:

FY 1981 funding will be used to implement two to three small ADS pilot activities which will test/demonstrate ADS standards and data system concepts as applied to specific NASA applications. FY 1981-82 pilot

activities will focus and validate ADS standards and concepts, providing required definition material for support of full-scale network service implementation. Full-scale ADS implementation could begin as early as FY 1983 in anticipation of having a fully operational system by the mid-1980's.

Data Management

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Data Management	1,800	1,500	700	1,600

OBJECTIVES AND STATUS:

The objective of the data management effort is to define and help meet the Applications Program needs for extension of current data system technology or techniques. Trends toward increasing data volumes and complexity coupled with more stringent data timeliness requirements make the successful identification and development of such technology key to future Applications Programs/user success. The completion of cluster coding technique development and test will occur in FY 1980; in addition, the initial results from a data base/management systems study and panel review will be available.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease in FY 1980 reflects a reallocation to provide funds for the procurement of the ER-2 aircraft. Lower priority data management activities to be deferred include identification of common data requirements among Space Applications disciplines, planning for future data systems analysis and workshops, and a system analysis study to identify spacecraft attitude control technology to aid in image data registration for mapping.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, generalized systems studies as well as specialized technique development tasks will be continued or initiated. Analyses will consider new systems structures which take advantage of data or system requirements common to multidisciplines. Technique development work will continue for specific areas of data base/management systems as well as for the processing of Synthetic Aperture Radar data. Study efforts will begin on cross-correlative multidisciplinary data/information overlay techniques and auto-mosaicking of multispectral imagery.

Adaptive Multibeam Phased Array (AMPA) System

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Adaptive Multibeam Phased Array (AMPA) System...	1,200	1,400	1,660	---

OBJECTIVES AND STATUS:

The objective is to develop a promising communications system that will capitalize on the unique properties of adaptive phased arrays to provide satellite communications capability to small low cost mobile Earth terminals.

An adaptive multibeam phased array (AMPA) can form, shape, and point several independent transmit and receive beams quickly to small ground areas in different geographic locations, while avoiding interference. This allows a large number of low cost ground user terminals to be served on demand, by reusing frequency within a limited frequency spectrum. This type of antenna has direct application for service to small mobile earth terminals that might be used on cars, trucks, boats, or data collection platforms.

In 1980, work will be completed on the development of an experimental AMPA system under contract with the Airborne Instrument Laboratory. In 1981, ground-based performance verification and preliminary application tests will be conducted in-house. No FY 1981 R&D funding is planned for this activity. The program is proceeding smoothly and the system will be ready for overall operational performance tests in 1982.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase in the FY 1980 budget reflects an internal adjustment of funds to meet current requirements. Plans for a Spacelab mission have been deferred and the AMPA development will be completed in FY 1981. Laboratory tests, to be conducted in 1982, will be undertaken as part of the development contract. This laboratory testing of the experimental AMPA system will allow continued technology progress and permit easier modification of the instrument design to Shuttle specifications if a flight test is decided upon for the post-1982 timeframe.

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Technology dissemination	3.200	3.800	3,800	4.100	RD 8-4
Technology applications	4.500	4.400	4.400	4.800	RD 8-4
Program evaluation and support	1,400	1.500	1.500	1.600	RD 8-4
civil systems*	(1.800)	2.400	2.400	2.600	RD 8-5
Total	9,100	12,100	12,100	13,100	
Distribution of Program Amount by Installation:					
Johnson Space Center	145	200	100	150	
Kennedy Space Center	100	150	100	150	
Marshall Space Flight Center	562	500	550	540	
National Space Technology Laboratories	---	50	100	75	
Goddard Space Flight Center	865	900	800	880	
Jet Propulsion Laboratory	569	1.700	1,700	1.990	
Wallops Flight Center	4	200	300	375	
Ames Research Center	733	1.000	920	1.250	
Dryden Flight Research Center	54	60	37	50	
Langley Research Center	710	1.000	800	890	
Lewis Research Center	415	400	800	750	
Headquarters	4.943	5.940	5.893	6.000	
Total	9,100	12,100	12,100	13,100	

*Prior to FY 1980. this effort was included in Space Applications.

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

Technology Utilization program objectives encompass the transfer of new knowledge and innovative aerospace technology resulting from NASA R&D programs for application and use in the private and public sectors of the U.S. economy. Important public sector areas include medicine, transportation, environment, urban development and public safety. Specific program objectives are:

(1) To accelerate and facilitate the application and use of new technology, shortening the time between generation of advanced aeronautics and space technologies and their use in the economy;

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

(3) To understand more fully the technology transfer process and its impact on the economy, and to manage and optimize the process in a systematic way; and

(4) To develop applications of NASA's aerospace expertise - its technology, technologists and unique facilities - to priority nonspace needs of the nation.

Aerospace technology is transferred to the public and private sectors of the nation's economy through a variety of established mechanisms developed and managed under the NASA Technology Utilization program. These mechanisms or project areas include: publications and announcements, Industrial Applications Centers, the Computer Software Management and Information Center (COSMIC), State Technology Applications Centers, applications teams/applications engineering projects, and civil systems projects.

OBJECTIVES AND STATUS:

User response to the NASA Tech Brief journal this past year has dramatically increased with nearly 180,000 industrial inquiries received by NASA for technical details concerning new technologies announced therein. This three-fold increase in inquiries over the previous year has also been accompanied by a steady growth rate of the journal mailing list during 1979 of 1,800 industrial recipients per month compared to 1,300 per month the previous year. Such response and interest by U.S. industries continues to reflect the importance of the NASA Tech Brief journal in the Agency's technology transfer programs.

The NASA sponsored Computer Software Management and Information Center (COSMIC) and the NASA Industrial Applications Center (IAC) network continued to provide U.S. industry with relevant information services and computer programs as evidenced by the industrial support to these activities. Total IAC industrial income for services rendered by these centers reached $2.8 million in 1979 compared to $2.2 million the previous year. This 27 percent increase continues to indicate a strong growth pattern in industrial use of aerospace technology, particularly in small, high technology business firms. In this regard, NASA has continued its cooperative project with the Small Business Administration during this past year to provide IAC services to small businesses in the northeastern, midwestern and western regions through IAC's located in those areas.

Evidence of technology transfer has been systematically documented and evaluated as part of NASA's continuing transfer research and impact studies activities. Selected cases of transfer and use are published and disseminated in the annual "Spinoff" report to industry and the general public, in order to create widespread awareness of program activities and results of NASA technology transfer programs. Program evaluation efforts continued to increase the efficiency and effectiveness of NASA's transfer programs and projects during this past year.

Over seventy applications engineering projects for adapting existing aerospace technology to defined needs in the public sector were active last year. These projects, which are jointly funded by NASA and user agencies such as the Departments of Transportation and Health, Education and Welfare and the Environmental Protection Agency, include: the portable firefighting module developed for the U.S. Coast Guard; a highly reliable water quality monitor for EPA; and a human tissue stimulator being developed in conjunction with Johns Hopkins University Medical Center (Pain Center) and the National Institutes of Health. Continuing attention will be devoted to the problems of the handicapped, with special emphasis placed on developing aids for assisting the aged and for rehabilitation work.

Transfer of the Civil Systems program to Technology Utilization consolidated all NASA Terrestrial Applications engineering projects for public and private sector organizations. Current projects include: the Advanced Ocean Technology Development Platform (AOTDP) for use in evaluating and generating new deep ocean instrumentation and sensors; and environmental sensors and systems to detect and analyze air and water pollutants. A systems design will be accomplished for a sea bed lander as part of the Office of Naval Research/Woods Hole Oceanographic Institute High Energy Benthic Boundary Layer Experiment (HEBBLE). This project will investigate a broad range of physical phenomena accompanying high velocity currents at the sea floor/ocean interface at depths of 4,000 to 6,000 meters.

Documented evidence of technology (i.e., the annual "Spinoff" report) is continually recorded, evaluated and disseminated to industry and the general public as a means of creating widespread awareness of program activities and available NASA technology transfer services. Efforts continue on methods and procedures to increase the efficiency and effectiveness of all programs.

BASIS OF FY 1981 ESTIMATE:

Technolopy Dissemination

In FY 1981, NASA plans to meet the growth demands of the Tech Brief journal (up to an estimated level of 75,000 industrial recipients) and maintain the continued operation of NASA's information dissemination network, including the seven Industrial Applications Centers, the State Technology Applications Centers in Florida and Kentucky, and the Computer Software Management and Information Center (COSMIC). NASA plans to continue its joint program with the Small Business Administration to provide NASA information dissemination center services to small business firms. A similar joint program for minority businesses will be sought during FY 1981 with the Minority Business Development Agency of the Department of Commerce. Additionally, NASA will continue its efforts in FY 1981 to increase and accelerate the flow of NASA technology into selected industrial sectors through interactive efforts with industrial and trade associations.

Technolopy Applications

In FY 1981, NASA plans to continue operation of its three Biomedical Applications Teams as well as its application teams in transportation, public safety and manufacturing to identify national problems and needs in these public sectors which can be addressed through the application of aerospace technology and capabilities. Additional emphasis will be placed on problem identification and solution in environment and water quality during FY 1981 as well as those noted above. Multiyear application projects, such as a gas analysis instrument to detect toxic substances for firefighters and nickel-zinc battery developments for prosthetic devices for the handicapped, will be supported during FY 1981 in cooperation with user agencies.

Program Evaluation and Support

In FY 1981, NASA will continue transfer research and impact studies to identify benefits and economic impacts resulting from its technology transfer programs. Program evaluation and socio-economic assessments will be continued to determine the most effective transfer mechanisms and to focus on selected opportunities for increasing the benefit of those program efforts. Scientific and Technical Information (STI) data base support for NASA Industrial Applications Centers will continue as will publication inquiry support at the NASA STI Facility.

Civil Systems

In N 1981, NASA plans to continue most of its Civil Systems projects already initiated with other Federal agencies including, for example, environmental monitoring and control and agricultural productivity. In addition, the program will allow for a limited degree of flexibility in the selection of new projects that explore innovative applications of aerospace-derived technology to other non-aerospace-oriented disciplines. Specific projects include the extension of our automated water monitoring system to measure contaminants in potable water and monitoring the quality of natural water bodies. In the area of ocean technology, continuing demonstration of the Advanced Ocean Technology Development Platform (AOTDP) in the deep ocean environment and the application of remote sensing techniques to studying the sea floor will be pursued.

AERONAUTICS AND
SPACE TECHNOLOGY
PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1981 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

Programs	Budget Plan			
		1980		1981
	1979 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Aeronautical research and technology.....	264,100	300,300	308,300	290,300
Space research and technology.....	107,300	116,400	115,800	115,200
Energy [illegible].....	5,000	3 ,000	3 ,000	4,000
[illegible]	376,400	419.700	427.100	409.5 00

AERONAUTICAL
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Research and technology base	109,700	117,500	119,000	131,100	RD 9-4
Systems technology programs	154,400	182,800	189,300	159,200	RD 9-20
Total	264,100	300,300	308,300	290,300	
Distribution of Program Amount by Installation:					
Johnson Space Center	1,245	700	495	200	
Marshall Space Flight Center	1,113	900	725	800	
Jet Propulsion Laboratory	1,489	1,100	830	800	
Wallops Flight Center	614	700	600	500	
Ames Research Center	48,564	51,900	54,800	53,400	
Dryden Flight Research Center	8,903	13,400	13,300	13,200	
Langley Research Center	92,171	115,300	115,800	109,900	
Lewis Research Center	106,960	113,000	117,450	108,100	
Headquarters	3,041	3,300	4,300	3,400	
Total	264,100	300,300	308,300	290,300	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

The FY 1981 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 and external assessments, industry, advisory groups, and other users of technology within and outside the Federal Government. Emphasis will be placed on improving aircraft energy efficiency and performance; reducing noise and pollution; improving safety and terminal area operations; and advancing long-haul and short-haul air transportation concepts.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $8 million is the result of Congressional actions which provided additional appropriations of $5 million for advanced rotorcraft technology and $3 million for variable cycle engine technology. A transfer of $1.5 million from the Systems Technology programs to the Research and Technology Base was made to more appropriately budget planned activities. This transfer is explained under the individual programs involved. In addition, the Aeronautics budget structure has been changed to provide for more effective and efficient program management. This change in the budget structure, which is consistent with the new OAST organization that went into effect in the fall of 1979, did not result in any programmatic changes. Programmatic changes are described in the individual program narratives.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 activities are designed to maintain a strong Research and Technology Base in the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human factors, materials and structures. Strength in this fundamental research and technology is essential to the future development of new, improved aeronautical products. The aeronautics program also provides focused technology development

activities for each of the major classes of aeronautical vehicles, i.e., transport aircraft, rotorcraft, general aviation aircraft, vertical/short take-off and landing (V/STOL) aircraft, supersonic cruise aircraft, and high performance aircraft.

In the area of transport aircraft technology, progress in the aircraft energy efficiency efforts will continue toward the goal of providing, in the 1980's, the technology advances leading to a major reduction in aircraft fuel requirements. In the Energy Efficient Transport program, work will continue with the major airframe contractors to develop and evaluate advanced aerodynamic and active control technologies for derivative and new subsonic transport aircraft. Included are wind tunnel tests of advanced winglet concepts. In the Laminar Flow Control program, emphasis will be on completion of critical high speed wind tunnel tests and on evaluation of practical structural and surface material concepts. The safety efforts will be continued with emphasis on human-vehicle interrelationships, crash fire hazards, lightning effects, and ice accumulation protection.

Rotorcraft technology activities will be emphasized, addressing rotor aerodynamics, structures, avionics, flight dynamics, terminal operations, engines and drive systems, and rotor system design, and with new focus on analytical modeling and verification of selected systems and on augmenting the rotorcraft data base in critical areas. Flight research on the Rotor Systems Research Aircraft (RSRA) vehicles will be continued. Proof-of-concept and concept evaluation flight tests on the XV-15 Tilt Rotor Research Aircraft will be completed.

General aviation research and technology will continue to emphasize increased safety, improved utility and greater energy efficiency. Principal activities will include stall/spin alleviation, drag reduction, engine and propeller improvements, and avionics systems concepts for safer and simpler single pilot operations.

V/STOL technology efforts will emphasize broad-based technology for future military and civil aircraft applications. Flight research on the Quiet Short-Haul Research Aircraft (QSRA) will continue with emphasis on handling qualities and control laws development for short take-off and landing (STOL) operations at very high lift coefficients.

Supersonic cruise research will continue in all critical discipline areas. Emphasis will be placed on aerodynamic refinement for improved low speed, high lift characteristics, advanced noise suppression technologies, and advanced titanium fabrication and structural design.

In the area of high performance aircraft, efforts will continue on advanced multivariable digital control system concepts for aircraft and propulsion control, and on preparation for NASA/Air Force flight research on the variable-camber, variable-sweep AFTI-111 aircraft. Flight testing of Highly Maneuverable Aircraft Technology (HiMAT) concepts will be continued, employing subscale remotely piloted vehicles.

In the Advanced Propulsion Systems program the design, fabrication and testing of individual components to validate the technology for use in next-generation, high-bypass turbofan engines will continue in the Energy Efficient Engine program. The Variable Cycle Engine technology program will include new emphasis on development and demonstration of the critical lower speed and lower temperature technologies unique to variable cycle propulsion systems for future advanced supersonic cruise aircraft.

BASIS OF FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Fluid physics research and technology	18,500	21,240	22,240	24,800	RD 9-4
Propulsion research and technology	25,500	26,900	26,900	30,900	RD 9-6
Materials and structures research and technology	15,200	16,100	16,100	17,800	RD 9-9
Avionics and flight control research and technology	4,000	4,800	4,800	5,400	RD 9-11
Human factors research and technology	5,000	5,700	5,700	6,500	RD 9-12
Multidisciplinary research and technology	3,600	3,260	3,760	4,300	RD 9-13
General aviation research and technology	6,800	7,000	7,000	7,500	RD 9-14
Low speed aircraft research and technology	11,100	11,200	11,200	11,500	RD 9-16
High speed aircraft research and technology	14,000	14,800	14,800	15,300	RD 9-17
Transport aircraft research and technology	6,000	6,500	6,500	7,100	RD 9-18
Total	109,700	117,500	119,000	131,100	
Fluid Physics Research and Technology	18,500	21,240	22,240	24,800	

OBJECTIVES AND STATUS:

The objective of the Fluid Physics Research and Technology program is to develop a technology base which will enhance our capability to predict aerodynamic phenomena enabling aerodynamic optimization of advanced aircraft during the early design stage. This objective is being pursued through an integrated approach involving computational, analytical and experimental methods.

The technology base in computational fluid dynamics continues to expand with an increased capability to predict realistic flow situations and configuration geometries. During the past year, new numerical methods have been tested and incorporated into codes which solve the unsteady, compressible Navier-Stokes equations. New fast methods have been developed for generating transformed coordinate meshes for use in finite difference solutions of the fluid dynamics equations, and large-eddy simulations of turbulent flow have been carried out for simple flow geometries. Also, work was started in developing and verifying three-dimensional transonic codes using various turbulence models.

Progress has been made in other research areas as well. An experimental data base was developed for unsteady aerodynamic loads and pressures at higher Reynolds numbers and frequencies than previously achieved; pilot studies of an adaptive transonic wall test section showed real promise of achieving a three-dimensional capability; anticipated gains in maximum lift coefficient and drag-rise Mach number €or a family of rotorcraft airfoils have been achieved experimentally; the cryogenic test technology base has expanded in the areas of model construction and instrumentation development; and it was demonstrated that net reductions in turbulent drag of exposed surfaces were possible by devices which reduced the size of the turbulent eddies in the flow.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $1 million reflects a transfer of budgetary responsibility and funds from the Low Speed Aircraft Systems Technology program to the Fluid Physics Research and Technology program for the planned improvement of the Ames Research Center ILLIAC computer memory.

BASIS OF FY 1981 ESTIMATE:

Expanded efforts in computational fluid dynamics will continue in FY 1981. Computer codes will be developed to calculate inviscid, laminar and turbulent flows with limited and extensive regions of separation, with emphasis on the transonic speed regime. Advanced vector processing computers (the ILLIAC IV and CDC STAR) will be used to generate pilot codes to solve the time-averaged Navier-Stokes equations for a variety of two- and three-dimensional geometries with various turbulence models, and work will proceed to calculate turbulence from first principles. Efforts will be made also to include coupling of potential flow codes with advanced boundary layer codes capable of predicting flow separation more rapidly and less expensively. Methods will be developed for automatically generating meshes about complicated aerodynamic wings and bodies and to integrate their use into steady and unsteady codes in such a way that the convergence and resolution properties of these codes are not degraded.

In the area of high lift aerodynamics, theoretical methods will be developed to analyze and design multielement airfoils and wings, and tests will be conducted to verify the analyses. The work will involve Reynolds stress modelingof multielement airfoil drag problems and the determination of the effects of

transverse pressure gradients on the boundary layers and wakes. In the area of airfoil development, expanded efforts will concentrate on natural laminar flow airfoils, and on the production of airfoil designs applicable to high altitude, low speed remote controlled aircraft. A more intensive research program in wake vortex alleviation, in conjunction with the Federal Aviation Administration, will focus on aerodynamic design information to minimize wake vortex effects at the source with minimum deleterious effects on performance and noise.

The development of nonintrusive flow measurement methods and instrumentation such as holographic interferometry, laser velocimetry and infrared photography to provide data otherwise unobtainable, to improve data collection efficiency, and to gather data in a form more amenable to on-line analysis will be expanded in N 1981. Work on the integration of theory and experiment will continue, with emphasis concentrated on computer code validation, high incidence forebody vortex flow problems and the use of airframe/propulsion blending techniques to provide a data base for more efficient hypersonic aerodynamic configurations.

Research and technology activity will continue in the accelerated development of cryogenic test technology for full-scale Reynolds number simulation. Intensive efforts include model construction, instrumentation development, and pressurized cryogenic wind tunnel control and operation. An expanded activity in the development of wind tunnel walls to eliminate three-dimensional wall interference effects in transonic flows will be conducted. This activity will permit the testing of larger models with greater accuracy and productivity.

Exploration of viscous drag reduction schemes will be continued and the most promising will be studied in depth. In particular, large-eddy break-up devices have shown substantial promise and additional work will study the underlying phenomena and potential applications.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Propulsion Research and Technology.....	25,500	26,900	26,900	30,900

OBJECTIVES AND STATUS:

The objectives of the Propulsion Research and Technology program are to increase aircraft propulsion system efficiency; to improve engine performance; to reduce fuel consumption and dependence on rigid fuel property specifications; to improve the reliability and durability of engine components; to reduce engine noise and exhaust pollution to environmentally acceptable levels which are economically and operationally sound; and to evaluate the potential of advanced, new propulsion system concepts. The

efforts include research on gas path components, mechanical components, control systems, fuels, computational methods, instrumentation, emissions, and noise. These activities provide advanced technology that supports propulsion system improvements for all vehicle applications ranging from small, general aviation private aircraft to commercial transports and helicopters to military aircraft of all types. The effort in this program also provides a technology base in noise and emissions for use by the Government in establishing aircraft environmental regulations.

Increasing emphasis on internal flow computational fluid dynamics, small turbine engine components, and broad-specification fuels research continues in FY 1980. In the area of aircraft engine noise, considerable progress has been made toward establishing and understanding the effects of large-scale turbulence and forward velocity on jet and fan noise, and in coannular nozzle noise reduction research. Turbomachinery component research continues to explore concepts to improve fan, compressor, and turbine efficiency and reduce secondary flow and clearance losses. Advances have been made in evaluating lean prevaporized, premixed combustor concepts to determine their stability, autoignition, and NO_x formation characteristics. As part of an expanding effort in fuels technology, the impact of hydrogen content on flame radiation, liner temperature, and soot formation were identified and the effect of freezing point on fuel pumpability continues to be explored.

BASIS OF FY 1981 ESTIMATE:

Fuels research will continue in response to the growing concern over current jet fuel shortages. Broadening the allowable deviation in jet fuel properties would provide a more flexible and reliable supply of fuel and would reduce energy required for specialty refinement. Activity will continue toward developing a better understanding of the effects of fuel property variation on aircraft and engine fuel systems and evaluating advanced design concepts to accommodate these fuels. Fuel characteristics such as flame luminosity, soot formation, thermal stability, and freeze point will be investigated in FY 1981 for both petroleum-derived and synthetic-based fuels in coordination with related combustion and emissions research.

In FY 1981, noise research will reflect increased emphasis on the development of rotor and propeller noise prediction capabilities. Further investigations of the potential for jet noise reduction with coannular exhaust nozzles will be conducted and the assessment of installation and forward velocity effects on in-flight noise generation and propagation will be continued.

Research on inlets and nozzles will concentrate on development of analytical techniques which will accurately predict localized internal flow phenomena, including shock wave/boundary layer interactions in the presence of boundary layer bleed. Detailed, small-scale experimental investigations will verify these fundamental internal flow processes.

Research in computational fluid dynamics for turbomachinery will continue to receive increased emphasis in FY 1981 with efforts to improve computing speed and accuracy of codes developed for inviscid and viscous and two- and three-dimensional flows. Of particular importance will be the work done in establishing critical empirical turbulence correlations needed to accurately model complex viscous flows through turbomachinery blading.

Trends towards higher operating temperature and pressures in commercial turbofan engines will be paced by advancements in turbomachinery. Continuing research in fans, compressors, and turbines in FY 1981 will concentrate on fundamental technology to improve performance and durability of these components. In combustion and emission reduction research, efforts to develop techniques for improving liner durability and reducing emissions will continue with increased emphasis directed towards understanding the fundamentals of combusion and pollution formation. Of particular importance are the efforts to extend advanced technology features developed for large gas turbine engine components down to smaller propulsion systems suitable for helicopter, commuter, and general aviation aircraft.

In N 1981, instrumentation research on high pressure and high temperature measurement techniques, clearance sensing between rotating and stationary machinery, vibration and stress measurements, and non-intrusive gas path flow measurement and visualization techniques will be conducted. Considerable emphasis will be placed on thin film strain and temperature measurements on metal surfaces and on high temperature electronics for on-board engine processing of experimental data.

Power transfer research will continue to focus on evolutionary technology improvements in gears, seals, bearings, and lubricants. Emphasis will be placed on improving the understanding of basic mechanical wear phenomena and on developing the technology for advanced power transmissions for helicopters and advanced turboprop systems.

In FY 1981, engine dynamics and controls research efforts will continue to investigate advanced control concepts such as nonlinear control theory, advanced sensors and actuators, signal transmission and severe environment electronics, failure accommodation controls, and reliable control software. Analytical modeling techniques to predict the dynamic behavior of engine compression systems will continue, and experimental efforts will determine the distortion sensitivity of a small helicopter engine.

Advanced propulsion system research will continue to focus on the development and validation of computational methods to predict inlet flow fields and combustion kinetics associated with hypersonic propulsion. Fabrication will be completed and tests will be initiated to study the performance of an improved supersonic combustion ramjet configuration.

Promising advances in propeller performance can be achieved through application of recent developments in computational methods, high strength composite materials, and fan, gearing, and advanced control

technologies. In FY 1981, fundamental propeller research will focus on efforts to improve analysis and design procedures for advanced propeller supporting applications ranging from general aviation to commercial transport aircraft. The performance of selected advanced designs will be verified through scale model wind tunnel tests.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Materials and Structures Research and Technology.....	15,200	16,100	**16,100**	17,800

OBTECTIVES AND STATUS:

The objectives of the Materials and Structures Research and Technology program are to develop advanced metallic, ceramic, polymer and composite materials and structural concepts; and to develop analytical techniques to define critical loadings, response, and stability behavior of these structural concepts. This technology will provide significant improvements in the performance, safety, durability and economy of commercial, military and general aviation aircraft. Areas of emphasis include high temperature engine and airframe materials and structural concepts, including composites and life prediction procedures; improved prediction methods for structural loads, thermal and dynamic response, and aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

Improvements are being made in the properties of several high temperature metal alloys, ceramics and composites that promise increased performance and efficiency in gas turbines and aircraft structures. Advances also are being made in the capability to predict the life of composites and metals which will improve the reliability of aeronautical systems. Flight evaluation of an active flutter suppression system on a research wing of a drone flight vehicle is underway in FY 1980 and will supplement wind tunnel data for the validation of both concept and design methodology. A "decoupler pylon" concept for the passive flutter suppression of high performance military aircraft with stores is being validated by wind tunnel tests and design studies leading to future flight validation. Continuation of a U.S. program to measure unsteady pressure distributions on a variety of wing configurations is leading to a fundamental understanding and comparison with newly developed unsteady transonic flow prediction methods. A program was initiated in FY 1980 to define transport airframe response and failure during a crash, the forces transmitted to occupants, and the technology needed to improve crash safety.

BASIS OF FY 1981 ESTIMATE:

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During FY 1981, materials processing and design technology will continue to be developed for an oxide dispersion alloy and a tungsten fiber reinforced superalloy which have

potential for hollow turbine blade applications. A manufacturing method will be developed to produce a low cost, dual property disk alloy having improved mechanical properties. Basic research on the mechanisms of corrosion and oxidation of turbine alloys will continue. Ceramic materials will continue to be developed, with emphasis on improving high temperature strength and impact resistance.

Research will continue on the fatigue and fracture behavior of metallic, ceramic, and composite materials in both benign and active environments. Research will be accelerated to extend existing life prediction techniques and analyses. Studies will continue on the mechanism of hydrogen embrittlement of steels with the objective of developing hydrogen-resistant alloys. To predict service durability of composites, a damage growth law will be developed.

Research on composites will continue to be emphasized in the development of stiff, lightweight, strong structural materials. In FY 1981, studies will continue on low cost fabrication processes, and applications of composites in fixed-wing aircraft. Study emphasis will be placed on methods for evaluating and increasing the durability and damage tolerance of composite components. Exploratory research will be initiated on new resins that will permit the development of tougher, impact resistant, more processable composites. The fabrication and evaluation of advanced composites for high performance engine blades will continue in FY 1981. A data base and fundamental understanding will continue to be developed for the combustion characteristics and the thermochemical, thermophysical, and photochemical properties of new and advanced polymers.

In loads, dynamics and aeroelasticity research, the FY 1981 program will continue to develop improved methods for the prediction of unsteady aerodynamic loads for engine fan, compressor and turbine blades, and for aircraft wings and control surfaces operating in the transonic speed regime. Experimental validation of these methods will be accomplished through wind tunnel tests of two-dimensional airfoil models, rectangular and high aspect ratio supercritical wing models, and wing-tail combination models. Nonlinear analysis methods applicable to the rotating subassemblies of engines and the crash behavior of composite airframe structures will also be examined in N 1981. Methods for predicting transient high temperature thermostructural design loads will be developed in FY 1981, and the reliability and efficiency of three actively cooled airframe concepts will be demonstrated through wind tunnel tests.

Development of integrated analysis/synthesis methods in FY 1981 will focus on methods for simultaneous optimization of the structural and aerodynamic performance attributes of airframes that incorporate new technologies such as active controls and advanced composite materials. An ongoing program to develop a prototype finite element computational device using microprocessor components will be continued in N 1981 toward eventual hardware demonstration in FY 1982.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Avionics and Flight Control Research and Technology...	4,000	4,800	4,800	5,400

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Research and Technology program is to support the development of advanced electronics for applications to both civil and military aviation. Major efforts are directed toward enhancing utility, safety and efficiency, while reducing costs, in the areas of navigation/guidance, cockpit displays, controls and systems integration techniques.

A spectrum of navigation schemes is being investigated for the development of concepts for use in improving traffic flow in the national airspace system. Cooperative tests with the Department of Transportation and the State of Vermont are underway to evaluate the use of LORAN-C for aircraft operations in mountainous areas. Simulations are being conducted to investigate precision time-controlled guidance concepts supplemented by appropriate cockpit displays to enhance the orderly and efficient mix of four-dimensional equipped and unequipped aircraft in the Air Traffic Control environment without costly delays in time and fuel consumption. Innovative ideas based on hybrid concepts are being studied for improving both enroute and terminal area navigation/guidance functions. New concepts based on high cost inertial measurement system technology are being investigated to reduce the complexity and cost, for application to a broad class of aircraft exposed to only moderate acceleration levels and limited altitude variations. In the cockpit avionics area, promising approaches are being examined to provide appropriate contrast control and drive circuits for enhancing the application of flat panel liquid crystal displays, and exploratory research is being conducted into the use of thin film electroluminescent displays. A programmable display generation system has been developed as a laboratory system for simulations and analysis in conjunction with advanced flat panel display media for evaluating advanced cockpit concepts.

In controls research, a technology base program has been initiated to focus on the development of highly reliable electronic control devices and architecture for use in future engine power plants. A technique for recovering from a generic software failure in redundant flight control systems is being developed for evaluation in FY 1981. In the area of systems integration, the development of system reliability assessment tools is progressing and preliminary tests have been completed on the potential effects of lightning strikes on digital systems so that realistic, nondestructive test techniques can be devised.

BASIS FOR FY 1981 ESTIMATE:

Results of a recently conducted in-depth assessment in avionics and controls indicate promising opportunities for major technological advances in several areas. The program will examine design concepts for the development of an ultrareliable flight control system using low cost microprocessor techniques. Simulations will be completed on an experimental network data bus using fiberoptics to improve reliability and maintainability. Increased emphasis will be placed on the functional and physical integration of avionics and controls hardware and software providing innovative system architectures based on very large scale integration (VLSI) concepts. Coupled with human factors considerations, "hot bench" laboratory evaluations will be initiated to evaluate conceptual designs of advanced cockpits for enhanced management efficiency. Laboratory model tests will be completed in the design and siting of emergency locator transmitter (ELT) antennas on civil aircraft. As a follow-up to last years lightning effects testing, hardening concepts which have been developed for digital control systems will be validated.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Human Factors Research and Technology.....	5,000	5,700	5,700	6,500

OBJECTIVES AND STATUS:

The objective of the Human Factors Research and Technology program is to provide a research and technology base for solutions to the human factors related problems which influence the growth, efficiency, and safety of air transportation. The program has three areas of emphasis: flight management, flight simulation technology and human response to noise.

During FY 1980 a number of research studies are being conducted within the major areas. Included are joint programs with the Federal Aviation Administration (FAA) to enhance aircrew performance and alleviate the potential for human error.

The Head Up Display (HUD) research has completed its basic laboratory and simulation tests and has begun the full crew mission simulation evaluation of two candidate HUD systems. A second NASA/FAA program is the Cockpit Display of Traffic Information (CDTI). NASA and the FAA have drafted a joint, multiyear program plan for CDTI research. The plan is in the final stage of negotiation and should be signed early in 1980. NASA's CDTI research in FY 1979 developed a candidate display and performed a preliminary evaluation of pilots' ability to interpret the display. A third NASA/FAA program is the Aviation Safety Reporting System (ASRS). During FY 1980, the ASRS accomplished 39 investigations of safety related problems including: runway

incursions, near midair collisions, clear air turbulence and altimeter deviations. The simulation technology research program has developed and performed preliminary evaluations of techniques for use of multiple computers in aircraft simulation. These distributive computer techniques, which will be given full evaluations in the coming year, hold a great deal of promise for increasing all aspects of simulation fidelity. In the human response to noise rsearch effort, studies have been conducted on "time-of-day" vibration effects and on community response to helicopter noise.

BASIS OF FY 1981 ESTIMATE:

In the flight management area, joint NASA/FAA programs will continue in FY 1980. Included are studies concerning Head Up Displays (HUD) and Cockpit Display of Traffic Information (CDTI). This includes completion of the full mission simulation evaluation of alternative HUD displays, and development of a methodology for measuring crew workload with and without the CDTI, devising and evaluating procedures for using CDTI and determining the utility of a CDTI in typical wide-body aircraft. Work will continue in the development of models characterizing information processing and decision making processes which are necessary to establish human factors guidelines for automating cockpit systems. The development of the CDTI referred to above will continue. Oculometer research is continuing to develop quantitative parameters for advanced cockpit design. The Aviation Safety Reporting System (ASRS) will continue and new research investigations, based on problems identified from the ASRS data base will be initiated.

Flight simulation technology will include an investigation of total simulator training for pilots, simulator motion washout requirements, the effect of reduced visibility on approach and landing and distributive computer configurations for simulators. Studies will be conducted to quantify and apply objective pilot performance measurement techniques.

The human response to noise effort will continue to assess the utility of community response models through laboratory and field studies. This work is designed to produce a model for use in evaluating the noise abatement resulting from aircraft modifications, aircraft operations and land use strategies.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary Research and Technology.....	*3,600*	*3,260*	*3,760*	*4,300*

OBJECTIVES AND STATUS:

The objective of the Multidisciplinary Research and Technology program is to conduct novel, long-range, high risk basic research investigations in engineering and physical sciences related to aeronautics. This research is conducted at universities through the Fund for Independent Research, which supports

unsolicited proposals and proposals received in response to announcements of research opportunities in specific areas, and through the Graduate Program in Aeronautics, which supports graduate studies where the thesis research is performed, at least in part, at a NASA Research Center using NASA facilities.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $500 thousand reflects a transfer of budgetary responsibility from Aeronautical System Studies, which is in the Systems Technology program. This increase supports a Post-Baccalaureate Associate program designed to encourage graduate engineers to perform research at the universities and at the NASA Centers which is mutually desirable to both the parent university and to NASA.

BASIS OF FY 1981 ESTIMATE:

The Fund for Independent Research will continue to support basic research at universities. The Graduate Program in Aeronautics will be increased substantially to: (1) initiate up to three university institutes in Computational Fluid Dynamics to increase the number of scientists trained in this rapidly developing and important discipline; and (2) expand the graduate programs in aeronautics to encourage more newly graduated engineers to enter the aeronautics profession by offering greater opportunities for them to train with NASA senior research staff members at the Research Centers.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
General Aviation Research and Technology.....	6,800	7,000	7,000	7,500

OBJECTIVES AND STATUS:

The objective of the General Aviation Research and Technology program is to provide the technology base for achieving important 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, avionics and human factors.

In aerodynamics research, airfoil leading edge modifications to reduce the severity of stall and to prevent the development of unrecoverable flat-spin modes have been demonstrated in flight tests of a representative low wing aircraft type, and emergency spin recovery systems for flight test aircraft were developed. Stall/spin research is being extended to investigate high wing and T-tail aircraft configurations. Wing drag reductions using airfoils which extend the region of natural laminar flow over both upper and lower surfaces have been demonstrated in wind tunnel tests. Research on flapped airfoils continues, in preparation for the

design of a practical experimental natural laminar flow wing for full-scale flight test investigation. Progress has been made also in developing techniques for characterizing and utilizing wing wake flow fields for improved agricultural aerial applications, and preparations are underway for flight evaluation of wake modification and drag cleanup design improvements on an agricultural airplane. In structures research, energy-absorbing seat designs have demonstrated that peak loads transmitted to occupants during simulated crash tests can be reduced by fifty percent. Further design improvements are being made for test evaluation, as well as energy-absorbing fuselage subfloor structural modifications. In propulsion research, techniques for measuring cooling drag of internal combustion engine installations were developed, and laboratory tests of several spark-ignition air-cooled engine design improvements indicate promise for near-term applications to lower fuel consumption by ten percent while reducing both exhaust emissions and cooling air requirements. Longer-term engine design improvements were also studied, and the potentials of unconventional internal combustion engine types, including stratified charge rotary combustion and diesel types, were explored. Studies of low horsepower gas turbines revealed technological opportunities for improvement in fuel consumption and cost, both of which must be achieved if this highly attractive power plant is to achieve more extensive use in general aviation. Propeller research validated a new low speed noise generation theory, and studies were initiated to define technological opportunities for simultaneous improvements in propeller efficiency, noise and structural properties. Studies have been initiated in the areas of human factors and avionics systems, with particular emphasis on improving single pilot operations under instrument flight rule conditions.

BASIS FOR FY 1981 ESTIMATE

Aerodynamics research in FY 1981 will include important extensions of previous stall/spin investigations, expanding the data base with tests of additional configurations. Additional emphasis will also be placed on the development of analytical methods and design techniques for improved stall/spin characteristics of light aircraft. The design of a natural laminar flow wing for flight test will commence, as will the planning of appropriate flight experiments. Further research on aerodynamically integrated aerial applications systems will also continue. In structures, the development of nonlinear methods for the analysis and design of improved crash load alleviating aircraft structure will proceed, guided by empirical data from extensive simulated crash testing in recent years.

Propulsion research will continue to assess the effectiveness of several air-cooled reciprocating engine improvements designed to achieve greater energy efficiency for near-term applications. Technology for more efficient and higher pressure ratio turbo-superchargers will also be pursued. Studies of longer-term improvements through advanced engine concepts and unconventional designs will continue. Studies of the comparative merits and regimes of optimal application for each new engine type will be completed to assist in focusing further engine research and plans for future systems technology programs. Similarly, ongoing focused research on low speed propellers for general aviation plus results of studies to define technology opportunities and design tradeoffs will be utilized in developing plans for necessary future systems technology demonstrations for a range of general aviation applications. Avionics and human factors research will continue to study concepts and techniques to improve general aviation single pilot operations.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Low Speed Aircraft Research and Technology.....	11,100	11,200	11,200	11,500

OBJECTIVES AND STATUS:

The objective of the Low Speed Aircraft Research and Technology program is to provide technology advancement in the areas of (1) rotorcraft structures, dynamics, aerodynamics, flight dynamics, controls, avionics, and man-system integration; and (2) vertical and short take-off and landing (V/STOL) aircraft propulsion, aerodynamics, and flight dynamics.

The noise and performance characteristics of several large-scale rotor systems, including the XV-15 Tilt Rotor, the circulation control rotor, and the X-wing stopped rotor, have been measured in the 40-by 80-foot wind tunnel. Initial large-scale model studies were completed on a representative current hub/pylon configuration aimed at gaining a better understanding of means of reducing rotorcraft drag and improving cruise performance. Work is continuing to develop improved methods of predicting the aerodynamics of V/STOL aircraft, including basic studies of the effect of the ground on deflected jet flows during low speed and hover flight and the effect of inlet and exhaust flow interactions on V/STOL configurations in subsonic, transonic, and supersonic flight.

Tests were completed of the system noise of the NASA Quiet Clean Short-Haul Experimental Engine (QCSEE) mated with typical wing flap configurations during simulated powered-lift aircraft approach and take-off operation; information was obtained for over-the-wing and under-the-wing blow-flap configurations.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, rotorcraft research will include large- and small-scale wind tunnel model tests to verify the capability of predicting rotorcraft loads, vibration, aeroelastic stability, and performance; ongoing research on multicyclic control of controllable twist rotors (for vibration alleviation) will be extended to conventional rotors. Contracted and in-house investigations to develop improved analytical prediction methods will be expanded. Increased emphasis will be given to the provision of practical data on the noise of current and promising advanced rotor concepts, and to the verification of the capability of predicting such noise characteristics. The conceptual design of a total automatic flight control system to reduce guidance and control problems of helicopters during terminal area operation will be completed. Initial studies will be completed to explore the comparative advantages of auditory and visual displays to the pilot for the presentation of obstacle information during low level rotorcraft

flight. Small-scale wind tunnel tests will be carried out on a hybrid rotor/airship configuration to assess such design variables as rotor size and location and hull shape, as well as to examine propulsion/aerodynamic interactions, check scale effects, and verify drag levels.

V/STOL research activity in FY 1981 will continue to develop compact propulsion simulators for use in tests of small-scale wind tunnel models of high performance V/STOL configurations to examine all major high speed propulsion system/airframe interactions. Evaluation of the performance of a full-scale advanced exhaust nozzle for use on supersonic V/STOL configurations will be conducted in an engine altitude test chamber. An investigation will be initiated to compare the relative merits of flight director versus situation perspective displays for improving pilot/vehicle performance during V/STOL aircraft operation in the terminal area.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
High Speed Aircraft Research and Technology.....	14,000	14,800	14,800	15,300

OBJECTIVES AND STATUS:

The objective of the High Speed Aircraft Research and Technology program is to generate technology advancements needed both to achieve safe, reliable, and economical high speed civil aircraft and to establish and maintain technological superiority in military vehicles and systems.

In the area of flight dynamics, significant advances are being made to achieve the capability to design new high performance aircraft with satisfactory high angle-of-attack flying qualities and spin resistance. During the past year, in cooperation with the military services and the aircraft industry, extensive analyses, wind tunnel and free-flight model tests were performed on new configurations to establish the effects of aerodynamic factors and flight control system characteristics on stall departure, spin entry and spin recovery behavior. In the area of missile aerodynamics, an assessment in three different wind tunnels of Reynolds number effects on high angle-of-attack longitudinal and lateral-directional characteristics has shown that test Reynolds numbers an order of magnitude below expected flight values will be satisfactory to establish the correct force, moment and surface pressure values, thus easing test requirements.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, the flight dynamics effort will continue to explore the high angle-of-attack behavior and maneuverability of unique aerodynamic configurations, such as canard designs and swept forward wings, as well as new control concepts such as the use of vectoring two-dimensional nozzles.

The combat vehicle and missile aerodynamics activities will concentrate on promising concepts such as monoplanar missile configurations with high speed cruise and maneuver capability, high aspect ratio nonaxisymmetric nozzles for thrust vectoring and reversing, and supersonic maneuver wings. Analyses and wind tunnel testing will be performed to generate an aerodynamic technology data base for efficient stores integration, carriage and separation at supersonic speeds. Advanced aerodynamic wing design concepts will be evaluated, with emphasis on the trade-offs of optimum features in different speed regimes.

In N 1981, as part of the interagency and industrial assistance and testing effort, wind tunnels and simulators will be used to provide support for a broad range of aircraft and missile developments. Joint activities with other Government agencies and with the aircraft/missile industry will be conducted to insure the preeminence of current and future U.S. military and civil high speed air vehicles.

The N 1981 remotely piloted research aircraft technology activities will continue to concentrate on the development of new concepts for the high speed testing and recovery of remotely piloted research vehicles, including enhancement of the ground controller's management of the flight operation.

Flight experiments support activities will be conducted to provide a broad base of high speed research vehicle support, including chase operations and remotely piloted vehicle air drops.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Transport Aircraft Research and Technology.....	6,000	6,500	6,500	7,100

OBJECTIVES AND STATUS:

The objective of the Transport Aircraft Research and Technology program is to provide a broad base of safety-oriented technology for understanding and dealing with aeronautical safety hazards and their consequences, and improving criteria for design of systems and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment.

Significant progress is being made in understanding the effects of meteorological phenomena on aircraft safety. A specially equipped F-106 airplane has initiated flights to obtain measurements of lightning, winds, and turbulence for characterizing severe storm hazards and providing the basis for establishing aircraft protection criteria. A computer code has been developed with potential for predicting convective storms. Microwave radiometry studies have indicated good potential for detecting, warning, and providing avoidance of clear air turbulence, which accounts for many in-flight injuries. Digitized flight

load measurements are being obtained and analyzed for updating operating practices and aircraft structural design criteria. An icing research program has been initiated to define the ice accretion problems in aircraft, particularly rotorcraft, and determine the effectiveness of deicing concepts.

Considerable progress has been made in enhancing our knowledge of crash-fire dynamics, which will be utilized in the development of various fire-modeling and fire testing techniques. A NASA-developed fire resistant airplane window, which offers improved fire protection to passengers, is being evaluated in test. Advanced dry chemical fire suppression agents have demonstrated effectiveness in extinguishing simulated, in-flight, nacelle fires and delaying reignition. Rheological studies to characterize the quality of antimisting kerosene (AMK) are continuing, and a determination of AMK-engine compatibility has been initiated.

In landing systems technology, wear, friction and temperature characteristics of several tire tread elastomers have been obtained, and a NASA formulation has demonstrated improved friction characteristics. Work has been initiated in analytical tire modeling, active control landing gear development, and ground handling simulator development.

BASIS OF FY 1981 ESTIMATE:

FY 1981 research will include gust gradient measurements for providing previously unavailable, information in support of flight simulation and updating of structural design criteria. Lightning discharge phenomena will be studied to provide the basis for design criteria applicable to advanced avionics, materials and structures, and fuel systems. New ice protection concepts will be evaluated under simulated and natural icing conditions.

Modeling of crash-fire scenarios will continue. Further rheological studies of antimisting kerosene characteristics will continue and the assessment of practicability of using antimisting kerosene in modern turbine engines will be completed. A much needed data base of aircraft interior, fire-resistant materials will be established.

Operating characteristics of braking systems will be determined, including factors affecting tire casing strength. Additional attention will be given to the dynamics and effect of blown tires and failed wheels on stopping performance. Work will continue on active control and air cushion landing systems to establish their behavior characteristics and develop design methodology.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Materials and structures systems technology					RD 9-21
Propulsion systems technology		6. 700			RD 9-22
Avionics and flight control systems technology		2. 850	2. 850		RD 9-23
Aeronautical system studies	4. 825	4. 600	4. 100	4. 600	RD 9-25
General aviation systems technology		800	800	100	RD 9-26
Low speed aircraft systems technology	14. 970	19. 250		23 450	RD 9-27
High speed aircraft systems technology	9. 800	14. 800	14. 800	16. 800	RD 9-29
Transport aircraft systems technology	44. 750	58. 545	58. 545	40. 500	RD 9-31
Advanced propulsion systems technology		69. 500	72. 500	56. 200	RD 9-33
Aerodynamic vehicle systems technology	900	200	200	---	---
Total	154. 400	182. 800	189. 300	159.200	

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Materials and Structures System Technology..	3,300	5,555	5,555	9,600

OBJECTIVES AND STATUS:

The objective of the Materials and Structures Systems Technology program is to accelerate the transfer of advanced structures and materials technologies to application in the design of aircraft and engines.

The Materials for Advanced Turbine Engines (MATE) effort involves the identification of promising high temperature materials for production and development of engineering data, followed by engine testing. In the MATE FY 1980 effort, large powdered metallurgy superalloy turbine disks have been hot isostatically pressed to shape, 300 advanced directionally solidified eutectic turbine blades are being fabricated, and single crystal turbine blades are being fabricated. These blades and disks will be used in subsequent engine testing.

The Aeroelasticity of Turbine Engines (ATE) technology activity is a joint Air Force/NASA effort to improve the understanding and prediction capability for aeroelastic instability phenomena in turbine fan stages. In the ATE activity, significant progress has been made in developing analyses to predict supersonic and stall-flutter instabilities of turbine blades and flutter boundary mapping of engine fan blades.

The Integrated Program for Aerospace Vehicle Design (IPAD) efforts in FY 1980 include the detailed design of all first-level software components and completion of the preliminary version of the data base management system, which will be released for industry evaluation.

The Turbine Engine Hot Section Technology (HOST) activity is to provide the technology base for improved life assurance and life management of the 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 system technology program is an outgrowth of past basic research and fundamental technology development, such as combustor and turbine blade durability analyses and laboratory experiments.

BASIS FOR FY 1981 ESTIMATE:

During FY 1981, the emphasis in the MATE effort will be on demonstrating the performance in engine test of single crystal turbine blades, an advanced powdered metallurgy disk, an advanced directionally solidified turbine blade, and an advanced turbine blade erosion coating. The goal is to reduce the specific fuel consumption in engines by 15 percent using these materials.

The FY 1981 ATE effort will include correlation of analytical predictions with experiments on the vibration modes of blade, shroud, and disk systems of advanced fans and compressors and completion of the development of a prediction technique for blade flutter and comparison with experimental tests.

The IPAD effort is to develop the preliminary design and prototype computer software system for the management of aerospace vehicle design processes. In FY 1981, the first level IPAD data base management system performance will be evaluated by NASA and industry applications. Enhancements needed will be identified and work initiated for improvements to the data base management system.

During FY 1981, the initial emphasis of the HOST 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, elastoplastic 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 needed improvements. 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, vanes and blades, disks, gas path seals and static structure. These simulations will provide documented test conditions and durability data for use in model formulation and subsequent predictive methods evaluation.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Propulsion Systems Technology	3,600	6,700	6,700	6,400

OBJECTIVES AND STATUS:

The objective of the Aeronautical Propulsion Systems Technology program is to provide focused systems oriented activity to achieve improved performance, reduced environmental impact, lower fuel consumption, improved durability and reliability, and fuel flexibility for advanced propulsion systems €or application to a broad range of vehicle systems through the integration of advanced components.

The Helicopter Transmission Systems Technology effort is providing a systems evaluation of many advanced technology components which have been under investigation for a number of years. The design of a high ratio, traction-drive transmission is nearing completion and fabrication will be initiated in FY 1980. The Broad Specification Fuels Technology activity is aimed at demonstrating the compatibility of future aircraft fuels, which were defined and characterized in the Research and Technology Base, for operation in current and next generation jet engines. Combustor design requirements and criteria have been established and tests of selected combustor concepts will be initiated in FY 1980. The Advanced Low Emissions Combustion effort establishes and demonstrates the technology necessary to reduce exhaust emissions from modern gas turbine aircraft engines consistent with the requirements for improved durability, performance, and fuel flexibility. Design and fabrication of the most promising combustor concepts have been completed and experimental evaluations continue.

BASIS OF FY 1981 ESTIMATE:

The Helicopter Transmission Systems Technology efforts will continue in FY 1981 with initiation of testing of a low ratio traction-drive transmission, a high ratio traction-drive transmission and an advanced technology gear-type transmission. In the Broad Specification Fuels Technology activity in FY 1981, tests of conceptual combustors and fuel systems operating with experimental broad specification fuels will be completed. Testing of optimized designs based on conceptual combustor evaluations will be initiated. The Advanced Low Fmission Combustion effort will focus on the experimental screening of combustor concepts. Upon completion of screening, the most promising concepts will be further refined and evaluations will be initiated to assess durability and fuel flexibility.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Avionics and Flight Control Systems Technology	3,000	2,850	2,850	1,550

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Systems Technology program is to apply the 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.

In recent years, a significant increase in the implementation of digital systems has been made by the aircraft design community to take advantage of benefits in size, weight, power consumption and the ability to perform more sophisticated functional operations. This trend is expected to accelerate and has necessitated an improvement in the understanding of software system verification/validation technology to facilitate the checkout and certification process. A joint program with the Federal Aviation Administration is underway based on NASA's past experience with digital systems and simulation technology. Reliability and failure effects surveys have been completed, workshops conducted to apprise the Federal Aviation Administration personnel of current technology, and the development of a validation system based on laboratory simulation techniques has been initiated.

Flight demonstration tests are being completed on an analytic redundancy management technique to minimize the sensor complement and enhance the reliability of digital control systems. This represents the final element of our highly successful F-8 Digital Fly-By-Wire program.

BASIS OF FY 1981 ESTIMATE:

The principal emphasis in the joint Federal Aviation Administration activity will be the completion of the development and checkout of the laboratory simulation system and the initiation of tests leading to techniques for improving the systems verification/validation process as applied to transport aircraft. The overall program is expected to provide optimum configurations to reduce flight test requirements and costs associated with the certification process.

In the controls area, flight evaluations will be completed on a technique in which backup software is embedded in the primary software structure to protect redundant flight control systems against generic software failures. To improve the fault tolerance of redundant aircraft computers, flight demonstrations will be conducted on a "reset" concept which detects momentary computer outages and restores the unit to its normal function unless a true or "hard" failure is present.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Aeronautical System Studies	4,825	4,600	4,100	4,600

OBJECTIVES AND STATUS:

Aeronautical System Studies are conducted as a means of identifying the need for, and assessing the impact of, technology advances. The objectives of aeronautics system studies are to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies integrate the mutual effects of technology and a wide range of related factors.

Significant recent results include identification of technology requirements and evaluation of technology benefits for small commuter transports, multirole large transports for civil cargo and military airlift applications, and several new rotorcraft applications. Feasibility studies have also been conducted on high altitude, long-endurance sensor or data-relay airborne platforms, and on potential aircraft applications of electromechanical technology advances employed in the Shuttle program.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $500 thousand reflects the transfer of budgetary responsibility in support of the Post-Baccalaureate Associate program to the Multidisciplinary Research and Technology program where it is more appropriately budgeted.

BASIS FOR FY 1981 ESTIMATE:

In FY 1981, rotorcraft studies will emphasize the development of modeling techniques for assessment of far-term technology advances, preliminary evaluation of advanced rotorcraft control integration concepts, and low cost navigation aids for remote area operation. Studies of the Vertical/Short Take-Off and Landing (V/STOL) and hybrid heavy lift airship vehicle concepts will be conducted.

Long-haul transport studies will continue and will include additional focus on alternative fuels, variable geometry designs, application of advanced materials, and assessment of new vehicle and avionics concepts.

High speed systems studies will continue to concentrate on advanced supersonic cruise and maneuver, high performance combat aircraft and advanced technology considerations related to high performance missile carriage, separation and flight. The technology studies will be directed at identification of technology needs consistent with anticipated future military applications.

Advanced propulsion systems studies will address potential turboprop applications for future small as well as large aircraft and will define desirable options for experimental verifications of advanced propulsion systems, such as variable cycle engines and turboprop systems.

General aviation studies will explore the feasibility of advanced vehicle and avionics concepts and evaluate the benefits of potential propulsion system and propeller advances.

Short-haul transport studies will continue to assess the technology needs of this class of aircraft, relying heavily on the technologies being studied and developed in the long-haul and general aviation areas as well as the impact of advanced turboprops on such an aircraft system.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
General Aviation Systems Technology.....	3,000	800	800	100

OBJECTIVES AND STATUS:

The General Aviation Systems Technology program purpose is to demonstrate and verify the feasibility and availability of new technology for general aviation, thereby promoting the earliest possible transfer to and utilization of new technology by industry. Objectives of program elements include improvements in safety, utility and energy efficiency.

With the successful conclusion of the Quiet, Clean, General Aviation Turbofan program at the end of FY 1979, program emphasis in FY 1980 is concentrated on avionics and human factors in the General Aviation Demonstration Advanced Avionics Systems. The objective is to provide the critical information required by industry to proceed with the design of a reliable, low cost, advanced avionics system which can enhance the safety and utility of a majority of general aviation aircraft, particularly for single pilot operation. System design was completed, and fabrication, installation and checkout of the flight system is proceeding.

BASIS OF FY 1981 ESTIMATE:

Checkout and flight test of the Demonstration Advanced Avionics System will be conducted during FY 1981, and evaluations by NASA, industry and selected guest pilots will be initiated.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Low Speed Aircraft Systems Technology.	14,970	19,250	23,250	23,450

OBJECTIVES AND STATUS:

The objective of the Low Speed Aircraft Systems Technology program is to accomplish focused ground-based and flight research to generate required engineering and operational design criteria data on promising systems for future civil and military applications. The aircraft categories involved include rotorcraft and vertical/short take-off and landing (V/STOL) aircraft. The broad areas of concern include propulsion; configuration optimization and modeling; integrated flight controls, guidance, and navigation; and structural systems involving aeroelasticity, vibration, acoustics, and advanced lightweight materials applications. The activity involves coordinated research efforts in analysis, model testing, and flight testing or rotorcraft and V/STOL and STOL aircraft.

The two new Rotor System Research Aircraft (RSRA) vehicles have been accepted by the Government and are undergoing baseline flight tests. The second XV-15 Tilt Rotor Research Aircraft is proceeding well in its proof-of concept flight test program. Extensive flight envelope documentation has been completed for the Quiet Short-Haul Research Aircraft (QSRA). The consolidation of NASA experimental helicopters at the Ames Research Center has been accomplished. Emphasis on V/STOL systems technology in FY 1980 has been on propulsion control analysis, and on experimental evaluation of configuration concepts in both the low speed V/STOL and the high speed cruise/maneuver flight regimes. The ground-based flight simulation capabilities at the Ames Research Center are being enhanced to perform complete real-time simulation of rotorcraft and V/STOL aircraft in their complex terminal area flight regimes.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $4 million is the net result of two unrelated actions: (1) a budgetary realignment and the associated transfer of $1 million of Low Speed Aircraft Systems Technology funds to the Fluid Physics

Research and Technology program for the planned improvement of the ILLIAC computer memory; and (2) a Congressional approval of an additional $5 million for advanced rotorcraft technology.

BASIS OF FY 1981 ESTIMATE:

Flight tests of the Rotor System Research Aircraft (RSRA) in FY 1981 will expand and document their basic flight characteristics with their delivered five-blade 5-61 rotors. Adaptation will begin of an existing modern four-blade rotor system for evaluation on RSRA, and studies will be undertaken of more advanced rotor system concepts that may warrant future large-scale wind tunnel and flight evaluation on RSRA. Detailed pressure and flow measurements will be made in highly instrumented blade tip regions of an AH-1G helicopter in flight for a better understanding of complex tip aerodynamics having powerful effects on performance and acoustics.

Proof-of-concept and concept evaluation flight tests will be completed with the XV-15 Tilt Rotor Research Aircraft to validate its flight characteristics throughout its flight envelope, to provide design and operational data upon which certification and design criteria can be established and to evaluate the general potential of the tilt rotor concept to perform military and civil mission profiles. Studies will be continued of advanced rotor and control systems for possible future evaluation on the aircraft.

On rotorcraft operating systems, ground-based simulation and flight research will continue on airborne radar systems for terminal area approach guidance, on a NASA airborne V/STOL guidance and navigation system (used primarily for V/STOL aircraft) coupled to a ground-based microwave landing system, on ring laser gyros as sensors in guidance systems, and on overall integrated flight systems optimization. Flight test vehicles include the UH-1H, SH-3A, XV-15, and CH-53A.

A focused effort will be initiated in the area of advanced rotorcraft technology with emphasis on analytical modeling and verification of selected systems through ground-based and flight testing. The FY 1981 activity will build on the ongoing program and address the critical technology needs of rotorcraft. Advanced rotor modeling will address new concepts for reduced noise and improved performance from hover to high speed flight. Small- and full-scale wind tunnel tests will provide the basis for selection of follow-on flight testing. In the area of structural systems, a special task team will define the state-of-the-art of unified airframe vibration prediction and assess specific needs for future research tasks. Additional activities will address structural vibration reduction techniques by active and passive means and define selected techniques for internal noise reduction. All-weather operations will be addressed with attention to the remote site and high density terminal area environments. Selected modern guidance, navigation, and display components and system concepts will be assessed to define selected simulation efforts and follow-on flight investigations of advanced systems. The critical aspects of human factors and aircraft icing will be considered. Analyses and modeling of advanced rotorcraft propulsion systems will be conducted as a precursor to future component and

system ground-based research. Frnphasis will be placed on scaling down new technology available in larger engine designs to foster the improvement of moderate and small engine performance, efficiency, and reliability. The special problems of analytical modeling of large, very high power transmissions will be defined and appropriate ground-based research tasks will be defined as a basis for selected, follow-on testing activities.

A generalized mathematical model will be generated that can represent all significant details of V/STOL propulsion system controls in a real-time, dynamic environment. Preliminary high speed wind tunnel evaluations will be completed for four V/STOL fighter-type configurations designed around different thrust/lift propulsion concepts. Preparations will continue to incorporate sophisticated propulsion simulators in the models for follow-on test of propulsion system/airframe interactions. Also, effectiveness of a vented, rotating nozzle for vectoring V/STOL thrust from propulsive force to lifting force will be investigated using a TF-34 turbofan engine on a static test stand.

Flight experiments with the Qiet Short-Haul Research Aircraft (QSRA) will focus on research that can only be performed with that aircraft due to its very high lift performance and low noise in terminal area STOL operations. Included will be the initiation of an effort to validate handling qualities criteria and develop control laws for such operations at lift coefficients up to 5.5.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
High Speed Aircraft Systems Technology	9,800	14,800	14,800	16,800

OBJECTIVES AND STATUS:

The objective of the High Speed Aircraft Systems Technology program is to generate engineering and design data applicable to the advancement of high performance, high speed aircraft for military and civil applications. The objective is accomplished by performing detailed and extensive analysis and experimental research, including wind tunnel tests, ground-based simulation studies and flight tests.

The Supersonic Cruise Research activity is a continuing focused and detailed activity addressing the high potential technologies in the critical aircraft disciplines of aerodynamics, propulsion, high temperature materials, lightweight long life structures, and engine/airframe integration. Significant progress has been recently demonstrated in advanced titanium fabrication processes and structural design concepts. The Flight Experiments efforts will provide an extensive data base in a number of areas.

The F-15 airframe/propulsion interactions have been established to provide a baseline for the advanced controls concepts to be flown on the aircraft in future years. The F-14 aircraft incorporating the NASA developed aileron-to-rudder interconnect is in flight test and will be evaluated jointly by NASA and Navy personnel. Planning support for both the Advanced Fighter Technology Integration-16 and the UTI-111 joint programs with the Air Force has continued with wind tunnel testing to refine final configurations along with preparation of NASA instrumentation systems to be included in each aircraft during construction. The major accomplishment in the Highly Maneuverable Aircraft Technology (HiMAT) effort was the initiation of the flight research activities with the first flight in July 1979. The flight envelope expansion activities are continuing in preparation for the extensive research flights to begin later this year.

BASIS FOR THE FY 1981 ESTIMATE:

In FY 1981, the Supersonic Cruise Research efforts will continue in all discipline technologies. The aerodynamics technologies will receive special attention with construction of several new wind tunnel models to study refinement of planform and low speed/high lift concepts to cover the full speed range. The propulsion system/airframe integration activities will address both advanced noise suppression technologies for the inlet and nozzle along with a wind tunnel experimental test of noise suppression and low speed performance of an axisymmetric inlet. The materials and structures activities will continue to emphasize the titanium fabrication and structural design with broadly based work in superplastic forming and diffusion bonding, adhesive bonding techniques for titanium honeycomb, cold forming of the beta alloy and fabrication of a small primary structural element. In addition, an activity in advanced flight procedures for low noise with improved aerodynamics and handling qualities will be expanded.

The Flight Experiments efforts in FY 1981 will address a broad array of technologies using a variety of high performance aircraft available for research purposes. The F-15 aircraft is dedicated to flight evaluation of advanced full authority multivariable digital propulsion control concepts. Several concepts, evolved in laboratory demonstrations performed by DOD and NASA, will be installed and integrated to the twin-(F-100)-engine F-15 aircraft for flight testing. The joint NASA/Air Force UTI-16 aircraft incorporating an advanced digital multivariable fly-by-wire control system and extensive flight-test instrumentation will be delivered to NASA in late FY 1981; flight test planning will be completed and a first flight is anticipated in early 1982. The AFTI-111 program is also a joint NASA/Air Force effort. Construction of the complex variable-camber, variable-sweep wing will be completed along with the installation of the extensive, NASA supplied, instrumentation system. NASA research flight planning will continue through the year converging with delivery of the complete aircraft in early 1982.

The HiMAT effort will be into the flight research phase in FY 1981. Both aircraft will be utilized in evaluation of the technologies designed into these aircraft with detailed studies of the advanced aerodynamics of the closely coupled wing/canard and the aeroelastically tailored performance of the graphite

composite wing/canard structure. These tests will be conducted at various altitudes, over a range of high speeds, at high angles-of-attack and under maneuvering flight conditions. The utility of the Remotely Piloted Research Vehicle (RPRV) technique for low cost flight research purposes will be assessed during the year.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Transport Aircraft Systems Technology.....	44,750	58,545	58,545	40,500

OBJECTIVES AND STATUS:

The objective of the Transport Aircraft Systems Technology program is to develop and demonstrate advanced technology for enhancing aircraft energy efficiency, providing operational compatibility with the future national aviation system, and accelerating application of advanced fireworthy materials.

The Laminar Flow Control effort will develop and demonstrate a practical, reliable, and maintainable boundary layer control system for viscous drag reduction of future subsonic transport aircraft. Emphasis in FY 1980 is being placed on initiation of contracted work in support of leading edge systems flight test and for manufacturing development of wing suction surface systems components, and continuation of Phase II of in-house technology development in key areas such as aerodynamics, structures, and suction systems.

The Energy Efficient Transport activity will develop and evaluate advanced aerodynamics, propulsion/airframe integration, and active controls technology for near-term application to derivative and new transport aircraft. In FY 1980 advanced aerodynamics and active controls technology programs for selected transport design concepts are being continued by three major airframe manufacturers, a flight evaluation of drag-reducing winglets will be completed with a KC-135 aircraft, and contractor test and evaluation of two fault-tolerant computer models will be completed. In-house efforts include wind tunnel tests of advanced winglet concepts and completion of a high Reynolds number evaluation of the low speed aerodynamic characteristics of a basic wing and high lift system.

The objective of the Composite Primary Aircraft Structures effort is to accelerate the introduction of weight and cost saving composite secondary and medium primary structures in future derivative and new commercial transport aircraft by designing, developing, and certifying six representative composite components. During FY 1980, development of the two remaining secondary composite components (B-727 elevator

and L-1011 aileron) will be completed. Predicted weight savings of 26–29 percent have been validated. Manufacturing development and testing of medium primary composite structures (L-1011 and DC-10 vertical fins and B–737 horizontal stabilizer) will continue. Final results of the carbon fiber risk assessment showed that the free carbon fiber risk from aircraft application of composites is insignificant.

The objective of the Terminal Configured Vehicle Systems effort is to identify and validate aircraft system and flight management technology that will benefit conventional take-off and landing aircraft terminal area operations in the future national aviation system environment. This technology program involves analytical studies, simulations, and application of advanced technology through the hardware flight test phase to reduce risk to the point where the technology will be accepted and applied to future aircraft configurations for safer and more productive flight operations. During FY 1980 this effort will continue experiments in close cooperation with the Federal Aviation Administration with systems under development for the future air traffic control system such as the Microwave Landing System and the Discrete Address Beacon System.

The objective of the Fire Resistant Materials Engineering (FIREMEN) effort is to accelerate the development of materials with improved flammability resistance and low smoke and toxic yield in civil aircraft through development and systems testing of new and modified fire-resistant materials and material systems. During FY 1980 evaluation of material systems developed earlier will continue, providing materials data needed by designers for interior panels, enclosures, windows, seat fabrics, moldings and cushioning. Full-scale fire testing of material systems under the FIREMEN Phase I effort will be completed.

BASIS OF FY 1981 ESTIMATE:

In Laminar Flow Control, efforts will continue to develop the technology for a practical, reliable, and easily maintained system. In FY 1981, design and development will be underway on suction surface and ducting, insect protection/removal, and deicing systems for a spanwise section of the leading edge of a wing back to the front spar. Flight testing of two promising systems will commence in FY 1983 at representative flight conditions and in an operational environment. Wing suction surface panel structural design activities for large transports will be emphasized following award of two industry contracts for alternate designs in late FY 1980. During FY 1981, the first phase of Laminar Flow Control swept wing supercritical airfoil high speed model wind tunnel tests will be completed in-house.

In the Energy Efficient Transport effort, work will continue with major airframe and engine manufacturers to develop, refine, and evaluate advanced aerodynamic, airframe/propulsion integration, and active control technologies. During FY 1981, advanced computer evaluations will continue for application to high reliability/high maintainability active flight controls, including an initial demonstration of the software-implementable fault tolerance concept. Airframe/propulsion integration investigations will examine the effects of internal/external aerodynamics, static/dynamic loads, and other factors on installation efficiency,

performance gains and deterioration. Airframe manufacturers will continue investigation of the integrated application of active controls technology to advanced energy efficient transport designs, and will continue development activities which will lead to separate flight evaluations of drag-reducing wing tip winglets and a reduced area horizontal tail on wide-bodied aircraft during FY 1982.

In the Composite Primary Aircraft Structures effort, three of the six component activities will continue in FY 1981. Manufacturing development of the composite B-737 horizontal stabilizer will be completed during that period. The DC-10 composite vertical stabilizer ground test unit will be subjected to fatigue, vibration, and other environmental tests, while fabrication and assembly of flight test and flight service units continue. The simulated 20-year durability test program to demonstrate production readiness for the L-1011 vertical fin will continue during FY 1981 with spar and cover environmental chamber cyclic flight profile tests, and with static and dynamic loads ground test of completed vertical fin assemblies. In support of larger composite primary structures, small subcomponents will be designed and fabricated for investigation of fuel integrity, crashworthiness, and durability.

During FY 1981, the potential of cockpit displayed traffic information will continue to be explored in the Terminal Configured Vehicle effort with simulation and flight experiments. Automatic flight control system improvements and new concepts for flight and turnoff guidance will be demonstrated and validated for greater precision of touchdown in windshear conditions and reduced runway occupancy times. A study to redefine the B-737 research airplane flight deck for greater crew efficiency will be completed in FY 1981.

In the Fire Resistant Materials Engineering area, full-scale testing of improved fire resistant fabrics and cushion materials for aircraft seats will be completed in FY 1981. Development of test methods and conditions will continue, in conjunction with the Federal Aviation Administration, National Academy of Sciences, and National Bureau of Standards, in the search for relevant toxicological evaluations of the pyrolysis products of aircraft materials under typical aircraft fire conditions.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Advanced Propulsion Systems Technology	66,255	69,500	72,500	56,200

OBJECTIVES AND STATUS:

The objectives of the Advanced Propulsion Systems Technology program are to achieve improved performance, lower fuel consumption, and reduce noise and emissions in advanced aircraft engines through the integration of advanced propulsion components.

The component development and integration phase of the Energy Efficient Engine (EEE) program continues. The detailed design of major engine components was completed, and full-scale engine component rig tests have been initiated. In the Engine Component Improvement effort, development of performance improvement concepts continues, and orders have been placed by airlines for four of the improved technology components. In the Advanced Turboprop (ATP) program, efforts are continuing to address aerodynamic, acoustic, and structural problems related to advanced turboprop propulsion systems. Emphasis in FY 1980 will focus on the establishment of a design data base developed from small-scale prop-fan models. In the Variable Cycle Engine (VCE) technology effort, performance and emissions testing of the duct burner system over its full operational regime will be completed in late FY 1980. Fabrication of the core-driven fan test system will be completed and aero/acoustic testing will be in progress by the end of FY 1980. An assessment of exhaust stream a acoustic suppression provided by thin sheath thermal shielding will also be in progress.

CHANGES FROM FY 1980 ESTIMATE:

The $3 million increase reflects Congressional action to add $3 million to the Variable Cycle Engine technology effort for FY 1980.

BASIS OF FY 1981 ESTIMATE:

The Energy Efficient Engine (EEE) full-scale component tests of the fan, high pressure compressor, full annular combustor, and high pressure turbine will be completed in FY 1981. Fabrication of the core system and integrated core and low spool system will be initiated. Supporting technology activities that verify advanced EEE concepts such as the thermal barrier coatings and shroudless hollow fan blades will be completed. The results of the FY 1981 experimental activities will provide for the second major update of the EEE Flight Propulsion System.

The Variable Cycle Engine technology effort will focus on development and demonstration of the critical low spool technologies unique to variable cycle propulsion systems for future advanced supersonic cruise aircraft. In FY 1981, new concepts will be investigated and promising concepts identified in prior years will be developed further with emphasis on advancing the technology required to achieve noise reductions greater than have been demonstrated to date. Selected designs of these components and additional flow modulation and acoustic suppression techniques will be integrated into system demonstrations to verify critical component/system performance. Efforts will be initiated on the design, fabrication, and component testing of coannular/suppressor nozzle systems, flight-type duct burners, and an advanced variable flow fan.

The Advanced Turboprop (ATP) program will emphasize the technology necessary for advanced high speed propellers capable of providing up to 25 percent fuel savings relative to current high-bypass-ratio turbofan engines. In FY 1981, efforts will continue to address aerodynamic, acoustic, and structural problems in

order to provide the essential data base not only for advanced turboprop-powered commercial transports but also for short-haul and commuter aircraft. Major emphasis in FY 1981 will be directed toward the design of large-scale, high speed propellers and the development of wind tunnel test methods to evaluate the structural dynamics of these propellers.

SPACE
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1981 ESTIMATES
BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Research and technology base	86.277	99.300	99.785	103.400	RD 10-3
Systems technology programs	12.023	14.100	11,015	9.700	RD 10-17
Standards and practices	9.000	3.000	5.000	2.100	RD 10-20
Total	107,300	116.400	115.800	115.200	
Distribution of Program Amount by Installation:					
Johnson Space Center	5.284	9.440	10.045	8.200	
Marshall Space Flight Center	9.279	6.500	6.642	7.150	
Goddard Space Flight. Center	9.656	9.300	8.848	9.400	
Jet Propulsion Laboratory	20.918	24.600	22.673	20.800	
Ames Research Center	9.904	9.840	9.881	9.800	
Langley Research Center	24.472	27.400	27.882	30.000	
Lewis Research Center	22.866	25.420	23.694	25.900	
Headquarters	4.921	3.900	6.135	3.950	
Total	107.300	116.400	115.800	115.200	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Research and Technology program are to provide the technology base necessary to support current and future space activities; to formulate technology options for the future; and to advance technology for further reducing the costs of space activities.

The FY 1981 program supports these objectives by stressing the technology areas judged to be most critical by advisory groups, a special in-house assessment, and in-house users of the technology needed to enhance planned missions and to enable future missions which are beyond current capabilities. Emphasis is on increasing performance and reducing cost and risk in both fundamental technology and in the areas of information systems, spacecraft systems, and transportation systems. When required, the program demonstrates the readiness of new technology by space experiments to assure its acceptance for utilization on planned missions.

CHANGES FROM FY 1980 BUDGET ESTIMATES:

The Space Research and Technology program has been restructured to provide for more effective and efficient program management, These changes are consistent with the new OAST organization implemented in the fall of 1979, and simply reflect new locations within the overall program structure rather than changes in emphasis. Changes in emphasis are explained under each related program justification.

BASIS OF FUND REQUIREMENTS:

In FY 1981, activities are designed to maintain a strong research and technology base in the disciplinary areas of materials and structures, electronics and automation, entry fluid physics, chemical propulsion, and space power and electric propulsion, and in the systems areas of information, spacecraft, and transportation. These efforts will continue to provide the technology base for future missions.

Systems technology efforts include studies to focus the technology activities in directions which provide maximum benefits to future space programs. Other systems technology efforts are directed at developing the technology for advanced space communications systems and for conducting selected experiments in space. During

FY 1981, experiment integration into the Long Duration Exposure Facility (LDEF) will continue, and the LDEF will be maintained ready for integration with the Shuttle. The development and integration of experiments to be conducted on early Shuttle, Spacelab, and free-flying missions will be continued,

In the standards and practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and improvement of program practices, concentrating on such areas as specifications, testing, and flight project analysis.

BASIS OF FY 1981 ESTIMATE:

RESEARCH AND TECHNOLOGY BASE

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Entry fluid physics research and technology	5,200	5,400	5,400	6,100	RD 10-4
Chemical propulsion research and technology	8,600	8,900	8,900	9,300	RD 10-5
Materials and structures research and technology	16,400	16,400	16,400	16,500	RD 10-6
Electronics and automation research and technology	8,200	8,550	8,550	8,800	RD 10-8
Space power and electric propulsion research and technology	17,000	19,750	19,750	20,300	RD 10-9
Multidisciplinary research and technology	2,000	2,700	2,700	2,900	RD 10-11
Information systems research and technology	16,308	20,600	20,600	22,600	RD 10-12
Spacecraft systems research and technology	5,495	7,250	7,250	8,700	RD 10-13
Transportation systems research and technology	7,074	9,750	10,235	8,200	RD 10-15
Total	86.277	99.300	99,785	103,400	

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Entry Fluid Physics Research and Technology	5,200	5,400	5,400	6,100

OBJECTIVES AND STATUS:

The objective of this effort is to improve the understanding of the aerothermodynamic, gasdynamic and flight mechanic problems of spacecraft designed for Earth orbital missions and planetary exploration. This knowledge will be used to improve the safety, reliability and efficiency of such spacecraft.

In the area of space vehicle configuration and aerothermodynamics, technology assessment studies have indicated that for advanced, heavy lift, single-stage-to-orbit vehicles, the far aft center of gravity location (75 percent of length) is a major design issue that must be addressed and solved before the advantages associated with advanced technology can be realized. In the area of planetary entry probes, the capability has been developed to calculate the turbulent flow field about a massively ablating sphere/cone entry body during descent through the atmosphere of Jupiter. In the flight data analysis effort, several experiments to be conducted on the Shuttle Orbiter are under construction. These experiments will provide research-quality data for use in evaluating theoretical and experimental methods.

BASIS OF FY 1981 ESTIMATE:

In the area of space vehicle configuration and aerothermodynamics, efforts are aimed at improving vehicle performance and reliability and reducing costs for a variety of potential space missions. In FY 1981, continued emphasis will be placed on development of theory, advanced computational methods, and computer codes for predicting vehicle flow fields and performance; development of improved ground-based experimental techniaues, 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 planetary probe technology effort provides the aerothermodynamic base which supports current and future scientific missions to study the atmospheres of Venus, Mars, the outer planets and certain of their satellites. This technology base is used in the design, development, and verification of planetary probe configurations, and provides the flight mechanics data in support of the atmospheric reconstruction experiment. In FY 1981, theoretical and experimental efforts will be pursued in the areas of shock-layer radiation, ablation product radiation and absorption, lightly-blown shock-layers, probe flight mechanics, and mass loss and shape change.

These studies will be pursued to develop a data base to be used to minimize 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 understand phenomena which cannot be simulated in ground facilities, to develop techniaues for extrapolating ground facility results to flight conditions, and to verify analytical and computational prediction techniques. In FY 1981, analysis techniques and associate software will be developed and the data base will be defined in preparation for analysis of flight data.

	1979 Actual	1980 Budget Estimate	1980 Currect Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Chemical Propulsion Research and Technology.....	8,600	8,900	8,900	9,300

OBJECTIVES AND STATUS:

The objective of this activity is to advance the technology of high thrust chemical propulsion systems in order to achieve significant reduction in the development, production and operations costs and to improve the performance capability of future space transportation vehicles and long-life spacecraft systems.

Significant technological progress has been made during the past year, both in advanced space transportation system propulsion and in long-life spacecraft systems. The regenerative cooling capability of liquid oxygen was demonstrated as was the efficient operation of oxygen-hydrocarbon primary combustors and turbine drive gas generators at high pressures. Heat sterilization of a solid propellant formulation designed for planetary launch vehicles was also demonstrated.

BASIS OF FY 1981 ESTIMATE:

Technology demonstrating long service life for small oxygen-hydrogen systems is being completed. In FY 1981, the technology efforts will be oriented toward evaluating small oxygen-hydrogen engine concepts designed for very low thrust operations. Systems under consideration include single engines, designed for both high thrust and low thrust, and engines designed for low thrust operation only.

Research and technology on high density fuel engines for advanced Earth-to-orbit vehicles will continue to emphasize simplified servicing and maintenance techniaues, component designs for long service life, combustion, heat transfer and cooling, and expansion nozzle configurations designed to maximize specific impulse over a variety of engine operating conditions and altitudes.

Long-life spacecraft propulsion technology activities are directed toward systems designed to operate reliably over long periods of time, up to 10 years in space, without benefit of repair or refurbishment. These research and technology efforts include planetary retropropulsion, deorbit, atmospheric entry, landing, and launch propulsion systems, as well as spacecraft auxiliary propulsion. Work has been initiated evaluating small pump-fed retropropulsion for more efficient placement of science payloads in orbit around the planets. Technology investigations focused on ways to produce oxygen from the Martian atmosphere for use as an Earth-return vehicle propellant will continue. The test firing of a complete solid motar following heat sterilization will be conducted in FY 1981.

Basic research to expand understanding of the chemical and physical processes that occur in rocket propulsion system will be continued. The search for advanced propulsion system concepts that will provide a new level of capability beyond conventional chemical systems will also continue. In FY 1981, the efforts will include continuation of combustion studies; exhaust plume definition; and analyses of effects, performance prediction techniques, solid propellant polymers and viscoelastic properties, behavior of fluids in a low gravity environment, and laser propulsion feasibility studies.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Materials and Structures Research and Technology	16,400	16,400	16,400	16,500

OBJECTIVES AND STATUS:

The objective of this activity is to 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 and 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 structural composite materials, both metallic and nonmetallic, in the space environment and identifying the significant damage mechanisms so that synthesis of resistant materials may be achieved. Work is continuing on high temperature resin matrix composites and new fibers for metal matrix composites to achieve higher performance levels in space structures. Fundamental work on friction and wear, directed at higher temperature longer life bearings and seals, continues to demonstrate that improvements are possible. Several products previously developed are now being used in critical areas of the Space Shuttle Orbiter. Advanced thermal protection systems for both space transportation systems and planetary probes have been developed and are under evaluation. Several advanced insulation systems have progressed to the point that the technology can be incorporated into the Space Shuttle. Other advanced systems offer application options for the future. In N 1980, a dynamic, acoustic, thermal experiment (DATE) was initiated for flight measurements of the Shuttle payload environment. This experiment has as its major objective the development and validation of advanced technology for prediction of the environment and associated payload responses in cargo areas of space vehicles. The secondary objective of the DATE experiment is to improve current knowledge of environments for design of Shuttle payloads. Nonlinear analysis and synthesis techniques for dynamic and thermal response, stability and control, and structural design, including optimization, are being developed for advanced space transportation systems, payloads, large space structures, and spacecraft. Erectable and deployable platform configuration concepts have been developed, and a ground test program to verify deployment dynamics and assembly techniques is in progress.

BASIS OF FY 1981 ESTIMATE:

Basic research activities in FY 1981 will include corrosion, chemisorption, catalysis, hydrogen embrittlement, fiber-matrix interface properties, and lifetime prediction in elastomeric systems. An improved understanding of these phenomena and processes will provide the foundation for improving performance of space materials. In FY 1981, increased attention will be given to the effect of the space environment on the properties of composite materials. Materials which have good long-term resistance to space radiation will be identified. Aluminum matrix composites will be evaluated for the feasibility of low cost forming and enhancements possible with new fibers such as aluminum, silicon carbide and specially-coated boron. Liquid and solid lubricants will be studied for their stability at high temperatures and in vacuum. High pressure seal concepts will be evaluated in a simulated turbopump. Studies will be initiated to examine the characteristics of intermetallic aluminides for high strength to density applications.

Thermal protection concepts and materials will continue to be evaluated for the protection of re-entry vehicles and planetary probes. In FY 1981, emphasis will be on obtaining better understanding of fundamental material surface behavior through the application of computational chemistry. For insulating heat shields, the emphasis will be on evaluating refractory fibers capable of withstanding temperatures as high as 3500°F. Candidate heat shield materials for planetary and solar probes will also be developed and tested to evaluate their performance.

In FY 1981, research and technology efforts will continue the evaluation of selected structural concepts for deployable and erectable space systems and the identification of design and qualification procedures required to meet possible future mission requirements.

In the area of integrated analysis and synthesis methods, emphasis will be on improved computational efficiency and continued development of structural modeling and analysis methods to meet the design needs of future space systems, including nonlinear behavior due to large deformations and nonisotropic composite material application, fatigue life of advanced metallic and composite materials, and structural/controls dynamic interactions.

In loads, dynamics, and aeroelasticity, the focus will include the adaptation of payload loads and vibroacoustic design methods to Shuttle-type vehicles, the development of concepts for control of structural dynamic modes of space systems, and improved methods of dynamic model testing.

The high temperature structures effort will continue development of metallic structures for Earth entry vehicles capable of withstanding temperatures of 1500°F or more, metallic multiwall thermal protection systems, and validated thermal stress prediction methods.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Electronics and Automation Research and Technology	8,200	8,550	8,550	8,800

OBJECTIVES AND STATUS:

The objective of the Electronics effort is to provide advanced electromagnetic concepts technology and special devices needed to improve the electronics, sensing and detection capabilities required for future planetary and Earth-orbiting- spacecraft missions, The program emphasis is shifting from-that of completion of the development of existing concepts to exploration of new concepts. The Automation activity provides the theoretical and technology base needed to expand the application of automation to greatly increase the productivity and effectiveness of humans, spacecraft, space operations and facilities. This is accomplished through basic research and synthesis and adaptation of nonaerospace automation technology to space oriented problems. Basic theories of automated general problem solving are being developed to the stage that they can treat realistic space automation-type situations, such as automatic experiment sequence generation, for use in planetary probe missions.

BASIS OF FY 1981 ESTIMATE:

The Electronics program will continue to investigate the physical phenomena associated with microelectronics and detectors and develop new concepts, models and components to provide significant advances in laser technology, solid state imaging techniques, high density and high reliability integrated circuits, and mission cost-effectiveness by optimizing component functions. This and related technologies in sensing and detection will considerably increase system sensitivity and extend observable wavelength capabilities into the far infrared regime and greatly increase data recording capacity. During FY 1981, emphasis in the Automation effort will be on establishing the technology base for the full range of automatic decision making in a synthesized form so that adaptability to high potential cost/benefit activities can be explored. In particular, automatic sequence generation activities for space missions and automatic process control of support functions for Earth orbital missions will be examined.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Space Power and Electric Propulsion Research and Technology.....	17,000	19,750	19,750	20,300

OBJECTIVES AND STATUS:

The objectives of this activity are to provide the research and technology for major advances in the generation, conversion and transmission of energy, and in high specific impulse electric propulsion systems. Advances in all of these areas are needed to extend our capabilities in near-Earth space and in the exploration of the solar system.

Advances in battery separators, electrodes, internal components and reconditioning procedures have been demonstrated, which can more than double the cycle life of alkaline batteries for space use. In the photovoltaic area, progress in understanding radiation damage and thermal annealing behavior in silicon solar cells has increased the potential of overcoming the degradation in performance experienced with current solar arrays. Innovations in surface treatment of the electrodes of thermionic converters have continued to increase the conversion efficiencies and available voltages of these devices.

The Air Force SCATHA (Spacecraft Charging at High Altitudes) satellite, designed to investigate the buildup of electrical charges on spacecraft on high Earth orbits, was successfully launched from KSC on January 30, 1979, and 'has experienced electrical charging during several electromagnetic substorms. The NASA Spacecraft Charging

Analyzer Program (NASCAP) is being used to reduce and interpret the SCATHA charging data in a cooperative NASA/USAF effort,

Ion thrusters and power processors have been fabricated, acceptance tested, and assemble into a preprototype electric propulsion system in preparation for functional, thermal vacuum, vibration, and other evaluations. Endurance tests to establish a thruster operational life capability in excess of 15,000 hours have been initiated.

BASIS OF 1981 ESTIMATE:

Photovoltaic research and technology will continue efforts which improve conversion efficiency, reduce mass, reduce cost and increase operating life of photovoltaic converters and arrays. In the area of cells, attention will be focused on demonstrating the feasibility of an 18% silicon cell and evaluating thin cell approaches for gallium arsenide. Work will continue on understanding radiation damage and thermal annealing in order to increase operating life. Blanket and concentrator technology will continue for high concentration ratio arrays for high power-to-weight ratios. Alternate photovoltaic approaches such as thermophotovoltaic and spectrophotovoltaic technology will be evaluated, and emphasis on thin substrates, covers and encapsulants will continue for both lightweight and low cost technology.

In the area of advanced energetics, assessments will continue on advanced concepts for space energy generation, conversion, storage and distribution and development of key technologies required to determine their feasibility. Work will continue on investigations of direct conversion of fission and solar energy into laser radiation, on novel means to convert solar and laser radiation efficiently to electricity, on photochemical cell technology and on laser welding and annealing of solar cells.

In electric propulsion, the performance of mercury ion thrusters will be extended to higher power and thrust density, and the range of useful specific impulse will be broadened. A theoretical and experimental study of ion sputtering and its effects on ion thrusters will be completed. An evaluation of magnetoplasmadynamic thruster performance and internal erosion characteristics will be completed, and the feasibility of inert gas (argon and xenon) thrusters will be examined.

In power management, work toward advanced components such as transistors, inductors and power transfer devices will continue and the design of a solar thermoelectric generator will be completed. The spacecraft charging activities will be completed, and a cooperative effort with the Air Force on high voltage space plasma interactions will be initiated.

In thermal-to-electric energy conversion, the demonstration of improved energy conversion efficiencies in thermionic diodes and in thermoelectric materials will continue, and a preliminary evaluation of alternative conversion technologies for nuclear electric propulsion applications will be made.

Research aimed at understanding fundamental life-limiting mechanism in nickel-cadmium space batteries will be intensified, leading to the development of improved processing specifications. Development of the technology for high capacity energy storage required for future high power missions will continue, with emphasis on fuel cell electrolyzers and high capacity battery cells. In addition, work on very high energy-density storage systems, based on lithium and sodium, will also continue.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary Research and Technology.....	2,000	2,700	2,700	2,900

OBJECTIVES AND STATUS:

The objective of the Multidisciplinary Research and Technology effort is to conduct novel, long-range, high-risk basic research investigations in engineering and physical sciences related to space. This research is conducted principally at universities through the Fund for Independent Research and the Physics and Chemistry Experiments in Space (PACE) program. The Fund for Independent Research is supporting basic research on many topics of fundamental importance, such as materials properties at high pressures, development of a free-electron laser, energy storage by spin-aligned (triplet) hydrogen, precision cryogenic maser capable of testing the general theory of relativity, molecular binding between materials and ceramics, TV real-time imagery, crosslinking on polymeric membranes, optical constants of transition metals, and nonlinear interactions in superfluid dynamics. The PACE program supports basic studies leading toward the development of experiments that need the unique characteristics of the space environment to make fundamental new discoveries about materials properties and processes. Some of the work supported includes immiscible liquid drops, mass transfer, surface driven convection, concentric rotating drops, granular soil behavior, superfluid helium lambda point measurement, and combustion.

BASIS OF FY 1981 ESTIMATE:

The research supported under this activity provides the opportunity to study innovative ideas that underlie and cut across the established disciplinary structure, and thus contribute to long-term growth in space technology.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Information Systems Research and Technology.....	16,308	20,600	20,600	22,600

OBJECTIVES AND STATUS:

The objectives of the Information Systems Research and Technology program are to provide advanced sensor and instrumentation systems that will improve the data acquisition capabilities of future space application and science missions and to provide processing, reduction, and distribution systems to convert that data for effective and timely user information exchange. Solid state focal-plane array technology is being developed to improve the infrared observational capabilities of remote sensing systems. Lasers and electro-optical systems are being developed for acquiring specific data related to terrestrial and atmospheric properties. Both passive and active microwave systems are being developed for a near all-weather, 24-hour per day remote sensing capability. Instrument pointing research aims at new concepts and components to provide accurate pointing and onboard video landmark tracking capability. Cooling systems technology is being advanced in the area of ultra low temperature refrigeration systems for cooling of sensors, and experiments in space.

Design and testing of a cold field emission cathode power amplifier for space communications systems has resulted in a new amplifier system with increased power capacity and virtually unlimited life.

The first charge-coupled device (CCD) linear imaging array capability in the long wavelength infrared region has been developed and tested. A submillimeter wavelength radiometer was developed and flight tested to provide near all-weather, 24-hour-per-day sensing capability to measure upper atmospheric water vapor.

The second phase of the NASA End-to-End Data System (NEEDS) program was initiated during FY 1979. The current NEEDS program emphasizes technologies of sensing through archiving and focuses on real-time data management. During the past year an improved method of handling space-derived data was developed. Data from each sensor are separated into complete, self-contained "data packets", Each packet includes sensor identification and auxiliary data, such as time of observation, location and spacecraft attitude. These autonomous, correlated records are developed onboard the spacecraft instead of by the current method of after-the-fact generation at ground processing facilities.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, in the area of advanced sensors and instrumentation systems, linear and area array focal-plane systems will be developed covering the spectral range from 1 to 120 μ-meters. Laser ranging systems, laser heterodyne receivers, and active laser ultraviolet and visible lidars will be developed for crustal motion

measurements and detection of atmospheric constituents and pollutants. Millimeter-wave, submillimeter-wave, and synthetic aperture radar systems will be developed for investigating oceanographic, stratospheric, and terrestrial properties of the Earth and other planets. The Annular Suspension and Pointing System (ASPS) will be tested to demonstrate pointing accuracy of 0.01 arc seconds. Laboratory prototypes for a 5-Watt, long-life (~ 1 year) mechanical cooler will be demonstrated.

Data systems concepts will be modeled and evaluated to provide improved end-to-end data systems efficiency and effectiveness. During FY 1981 a distributed microprocessor based data system will be fabricated and tested. An advanced onboard data processor concept will be evaluated to provide real-time multispectral data classification. High speed data transfer technology is focused on providing the technology and techniques to enable high rate transfer and distribution of data from future NASA missions. During FY 1981, an x-band transponder will be developed to meet the communications requirements of the International Solar Polar spacecraft. In the NEEDS program during FY 1981, a prototype optical archival mass memory system with storage capacity of 10^{13} bits will be fabricated and tested. The design and fabrication of a data base management system will be completed in FY 1981.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft Systems Research and Technology.....	5,495	7,250	7,250	8,700

OBJECTIVES AND STATUS:

The objective of this program is to develop and demonstrate system-level technologies required by spacecraft for current and future space missions, The program extends the accomplishments of the research and technology programs in the fundamental discipline areas to integrated activities such that the transfer of a complete capability is possible; research and technology activities are conducted in areas where a multidisciplinary approach is essential to objective accomplishment. These activities share the common goal of eventual transfer and use of the technology in NASA developed spacecraft. This requires establishment of technical feasibility and acceptable levels of risk and cost.

The Large Space Systems Technology program is the principal element in the Spacecraft Systems Research and Technology area. The program has three major parts. The antenna activity has the objective of developing the technology for low-mass structures which deploy into 300-meter shaped surfaces. The design of two concepts will be completed in FY 1980 and the fabrication of critical test components initiated. Several surface control concepts are being studied and test hardware is being fabricated. The platform activity seeks to develop the fundamental data and analysis techniques required for large space systems. The design

of critical deployable platform elements will be completed and the fabrication of test articles is being initiated; the detailed design of a platform assembly device will be completed, and assembly scenarios for large platforms are under development. Support activities include: the development of an interactive analysis and design capability which permits structures, control, and thermal disciplines to be considered simultaneously; the activities necessary to develop and test concepts for the control of the position, attitude, and shape of the antenna and platform; and the provision and test of materials for both the antenna and platform concepts.

The space-storable, fluorine-hydrazine propulsion system is under development to provide the long-life, high performance system required by planned planetary missions. Technology readiness will be demonstrated by a system-level space simulated test in 1982,

Ground tests of the 8-cm ion auxiliary propulsion system hardware (to be flown on a USAF free-flying spacecraft) are being conducted to establish operating limitations, develop the flight operation test plan and provide a data base for analysis of the flight data,

The concept of utility-type distribution and management of electrical and thermal energy is being studied at an integrated system level. The effort builds on the discipline research and technology activities in power generation and storage and will seek to develop a system in the 100-kW region.

BASIS OF FY 1981 ESTIMATE:

In the large space systems technology program, deployment and shape control tests will be conducted on selected antenna designs using subscale models and large scale critical components. These tests will provide data on the ultimate performance of the full-scale systems. In the platform area, tests of critical deployable platform components will be conducted and the fabrication of full-scale deployable modules will be initiated. These modules will be used for subsequent system tests. A model of a platform assembly device will be fabricated and a test program conducted. In the support areas, attitude- and shape-control concepts will be defined and the development of simulation models will be initiated. In the material support area, vacuum and thermal cycling tests of candidate composite materials will be conducted.

For the fluorine-hydrazine propulsion system, the thrust chamber and subsystem components to be used for the system level test in 1982 will be delivered. Assembly of the test hardware will be initiated.

The flight operation test scenarios for the launch of the ion auxiliary propulsion system will be completed.

The utility distribution and management program plan will be developed. Emphasis will be on integrating the results of the discipline research and technology programs into a system-level capability. The results of the N 1980 thermal management study will be used to define subsequent research.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Transportation Systems Research and Technology.....	7,074	9,750	10,235	8,200

OBJECTIVES AND STATUS:

The objectives of this program are: to provide the data base reauired for design and development of advanced aerospace vehicles; to provide the technology necessary for selected improvements in the current Space Transportation System (STS); and to support as required the on-going development of the STS. These objectives are accomplished through testing in ground-based facilities and through in-flight research and technology demonstration using the current Orbiter as an entry research vehicle.

During FY 1980, aerodynamic tests in ground-based facilities in support of the baseline STS will be completed and tests of modified configurations are being initiated. These include an STS augmented with solid strap-on motors and configuration changes necessitated by the addition of instrumentation developed by this program.

In FY 1980, final preparations will be completed for the first in-flight research using the Orbiter vehicle. This includes the completion of the instrument development effort and the integration of the instruments into Orbiter 102. A flight data bank is being established so that the data acquired during the early Shuttle flights will be available for future research and technology efforts. Data from both the standard and special instrumentation will be included, Instrumentation developed in this program will be carried on all the early Shuttle missions.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $485 thousand reflects a realignment of effort and associated funding from the Spacecraft Systems Technology program element. This action followed an extensive review of the program plans involving the use of the Shuttle and Spacelab for technology experiments to determine how to most efficiently use a lower level of funding. It was decided that it would be most appropriate to accelerate experiments which will provide technological information concerning the operations of the Space Transportation System.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, ground facilities will be used to conduct aerodynamic tests of modifications to the basic Orbiter configuration. Included are changes which increase the performance or capabilities of the current STS, and changes necessary to accommodate instrumentation developed in this program. In addition, tests to

investigate specific areas in support of the first Orbiter flights will be conducted. Such tests will investigate specific problems, increase operating margins, and explore new operation scenarios.

Three instrumentation package experiments will provide the basic aerodynamic data necessary for the Orbiter to be used as a research vehicle. The aerodynamic coefficient package, which was integrated into Orbiter 102 for OFT-1, will provide data during early Orbiter flights, Both the low and high altitude research air data systems will undergo final system tests and be delivered for integration into Orbiter 102. The first flight of these packages will occur in late FY 1982.

Two instrumentation package experiments will examine aerodynamic heating uncertainties and thus the requirements of the thermal protection system and operating limitations. The windward instrumentation package which is mounted in the C-141 Kuiper Aircraft Laboratory will be used during early Orbiter flights. The leeside instrumentation package will undergo final system tests and will then be integrated into the tail pod on Orbiter 102. The first flight will occur in late 1982.

Two experiments to examine the characteristics of the current thermal protection system will be conducted on OFT-2 and will be used to obtain additional data on subsequent early Orbiter flights. The experiments will be serviced between flights and the data will be analyzed.

The first instrumentation package to measure the dynamic, acoustic, and thermal environment in the Orbiter cargo bay will be delivered for integration. Flight of this first in a series of phase 1 packages will occur on an early OFT flight. The second phase 1 package will be in fabrication and test in preparation for a FY 1982 delivery.

Additional research areas identified as candidate orbiter experiments in FY 1980 will be investigated in FY 1981. This will include technical justification and definition of the experiments as well as feasibility studies to determine the compatibility of the instrumentation packages with the Orbiter.

All the data obtained by the basic Orbiter flight instrumentation, the OFT development flight instrumentation, and the special instrumentation developed in this program will continue to be cataloged and filed for research purposes. This data base will be used to support research activities which deal with generic vehicle technology or specific STS problems.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Dollars in Thousands)			
Space system studies	2,000	2,200	2,200	2,200	RD 10-17
Information systems technology	---	2,600	2,600	5,100	RD 10-18
Spacecraft systems technology	10,023	9,300	6,215	2,400	RD 10-19
Total	12.023	14.100	11.015	9.700	
Space System Studies	2,000	2,200	2,200	2,200	

OBJECTIVES AND STATUS:

The objectives of Space Systems Studies are 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. Studies will continue to examine the development of future program technology needs, to determine the subsequent detailed technology requirements, and to consider alternative solutions for satisfying needs and requirements.

During FY 1980, studies were redirected towards the identification of needs and opportunities for planning the technology programs of spacecraft, information, and transportation systems and for generating an expanded and validated Space Systems Technology Model.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 efforts will continue to study the technology for spacecraft, information, and transportation systems. Analyses will be conducted to catalogue and rank available, planned, and forecast technology from sources within and outside NASA. Continuing studies will rank technology options and develop strategies for the attainment of long-range goals through application to near-term missions. Special study emphasis will be given to key technology issues, such as automation, large space structures, spacecraft support services, reusable propulsion, end-to-end data management, and large power sources.

The Space Systems Technology Model will also continue to provide the basis for the forecast of mission requirements and of capabilities in technology disciplines.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Information Systems Technology.....	---	2,600	2,600	5,100

OBJECTIVES AND STATUS:

The objective of this effort is to integrate advanced electronic devices or system concepts developed in the Research and Technology Base with supporting technology to demonstrate and validate improved performance, increased reliability and reduced costs of space information systems.

In FY 3980, the Satellite Communications Technology program was initiated. The purpose of this activity is to provide, through research, design and experimental tests, the components and enabling technology needed to open new frequency bands and to support NASA satellite communications systems developments. Current focus is on the critical components, techniques, and subsystems which are required for the complete communications system, such as high power, efficient transmitters, beam-shaping antennas, frequency reuse conservation techniaues, multiple spot beams, on-board message switching, high frequency devices at Low cost, bandwidth-compression conservation techniques, low cost Earth terminals and intersatellite links. In FY 1980, work began on the basic research, advanced development, technology investigations, analyses, and experiments in high risk critical technology areas to determine viable concepts and approaches.

BASIS OF FY 1981 ESTIMATES:

Research and technology effort in the Satellite Communications Technology program will continue on solid state power amplifiers suitable for single or multidevice power amplifier circuits; advanced transponder concepts which incorporate multiplexers, filters, driver amplifiers, modulators, and demodulators; new tube amplifier fast wave devices for shorter wavelength and higher power applications; and new power processor devices for efficient energy transfer.

In FY 1981, system parameters will be established, and design specifications for the critical, high risk components, techniques and subsystems needed for satellite communications and distribution technologies for future NASA missions in the 1987-2000 timeframe will be developed. During FY 1981, work on multibeam antenna feeds and on-board switching systems will be initiated. Fabrication and tests will be completed on an experimental 20 gigahertz (GH_z) traveling wave tube. Work will begin on power-combining techniques and the fabrication and test of matrix switches.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Spacecraft Systems Technology.....	10,023	9,300	6,215	2,400
Space Transportation System Operations.....	(---)	(4,800)	(3,500)	(8,900)

OBJECTIVES AND STATUS:

The objective of this effort .is to provide the capability to extend research and technology programs into the environment of space using the Space Shuttle, the Spacelab, and free-flying vehicles. Research and technology programs are so extended when the unique space environment is 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 mission, and completion of a flight of an ion auxiliary propulsion system on a free-flying Air Force satellite.

The Spacelab experiments remaining in the program are assigned to early Spacelab missions. They are all being completed on schedules compatible with the integration requirements of their assigned missions.

The LDEF is complete and in storage. The experiments are in various stages of development, and fabrication, and some experiments have been placed in storage. Integration of the experiments with LDEF and the LDEF with the Shuttle are continuing.

The 8-cm ion auxiliary engine flight demonstration on the USAF P80-1 spacecraft will provide the in-space demonstration of technology readiness.

CHANGES FROM FY 1980 ESTIMATE:

The decrease of $3,085 thousand reflects three unrelated changes. The first was a reallocation of $485 thousand to the Transportation Systems Research and Technology program. This action followed an extensive review of the program plans involving the use of the Shuttle and Spacelab for technology experiments to determine how to most efficiently use a lower level of funding. It was decided to accelerate experiments which will provide technological information concerning the operations of the Space Transportation System. The second change reflects a portion of the Congressional appropriation reduction from the NASA Research and

Development request. The third change provided an additional $2 million to the Standard and Practices line item for a necessary study of the Shuttle verification/validation program. The budgetary impact on this program is minimal due to the slippage of the Shuttle launch schedule.

BASIS OF FY 1981 ESTIMATE:

In FY 1981, the Spacelab experiments assigned to missions will all be completed and, in most cases, delivered to integration sites. These experiments will either be integrated into flight packages or placed into storage to await future integration and flight.

Development will continue on unfinished LDEF experiments and, by the end of FY 1981, nearly all experiment development will be completed. In anticipation of the 1982 launch date, the LDEF will be removed from storage and prepared for shipping. Experiments will be retested and further prepared for integration; flight batteries and other life-limited components will be procured.

Flight hardware for the experimental test of the 8-cm ion engine auxiliary propulsion system will be delivered to the U.S. Air Force in FY 1980 in preparation for integration with the USAF P80-1 spacecraft.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

STANDARDS AND PRACTICES

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Standards and practices.....	9,000	3,000	5,000	2,100

OBJECTIVES AND STATUS:

The objectives of this activity are to improve overall NASA program practices, serve as a technical review resource within the Agency and reduce the costs of NASA projects by encouraging the use of space-qualified eouipment on multiple missions. Those objectives are accomplished through independent reviews of NASA programs, support to design effort, participation in flight readiness reviews, setting up of special task activities when critical problems occur, and by participation in interagency activities to insure adequate communications on special activities or problem areas.

All standard equipment developed under the Standards and Practices program will be completed in FY 1980. Eighteen regular standard equipment items have been qualified for use by NASA programs, six are in process of

qualification,, and a commercial source is being solicited for one propulsion item. Four ground support equipment items are in the inventory for use by NASA programs, two other items have been fabricated, and one is currently being fabricated.

A review of the standard equipment program determined that the cost savings were marginal because of a considerably lower rate of utilization of the equipment and more rapid changes in technology than originally planned. As a result, it was decided to phase out the standard equipment development program.

However, to insure that maximum advantage is taken of the presently flight-qualified equipment and of other hardware that is available within NASA and throughout the aerospace industry, a computer-based data bank is being developed which will list standard and available flight-qualified equipment. A pilot program is being conducted in FY 1980 to encourage users to consider these items before beginning independent designs.

Within the program practices activities, audit results of reliability, quality assurance, standard components, safety and environmental health programs are being compiled. This will establish a store of information on trends which indicate undesirable practices and which will provide guidelines for improving program and project management. These efforts will continue to enable the office to monitor the technical and programmatic execution of NASA programs and to take early corrective actions when indicated.

A recent special assignment, being directed by the Chief Engineer, is an independent review by a senior technical group from outside the Shuttle program of the flight readiness certification program for the first Space Transportation System flight (STS-1).

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase in funding for FY 1980 will provide the additional resources needed to conduct the independent review and assessment of the adequacy of the first Space Transportation System flight (STS-1) Verification/Certification Program.

This assessment has been divided into 13 main areas:

- o Propulsion
- o Integrated Vehicle Loads
- o Orbiter Loads
- o Aero and Thermal Analysis
- o Thermal Protection Systems
- o Flight Control Hydraulics System and Associated Electronics
- o Launch and Ascent Guidance, Navigation and Control

- o Entry and Landing Guidance, Navigation and Control
- o Landing/Deceleration System and Miscellaneous Critical Mechanisms
- o Environmental Control and Life Support System (ECLSS) and Crew Equipment
- o Separation Systems
- o Electrical Power Distribution and Control (EPD&C)
- o Ground Systems

A "cognizant engineer" has been assigned responsibility for each of the areas. Support will be provided by technical experts from within and outside NASA, and through contracts with organizations familiar with the technical areas under review. A preliminary analysis of the adequacy of the Verification/Certification Program for STS-1 is expected to be completed in mid-1980. Reviews of specific areas of concern will then be keyed to the Shuttle launch schedule.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 program shifts emphasis from development of standard equipment to encouraging greater utilization of already flight-qualified equipment. Continued efforts to improve program practices throughout the Agency and increased emphasis on efforts to evaluate and predict product quality, reliability and performance in expected radiation environments and mission life of spacecraft components and systems are also included.

In addition, systems level hardware and software product assurance reviews and analyses are added due to the increasing complexity of spacecraft components and systems. Similarly selected pilot demonstration efforts will be undertaken to build confidence in special systems configurations, such as very large-scale integrated circuits which present unique problems associated with testing and qualification for space use.

ENERGY
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

ENERGY TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Energy technology	5,000	3,000	3,000	4,000
Distribution of Program Amount by Installation:				
Johnson Space Center	650	---	---	150
Marshall Space Flight Center	1,205	850	1,000	1,250
Jet Propulsion Laboratory	1,160	1,050	1,000	1,750
Lewis Research Center	1,265	1,100	978	700
Headquarters	720	---	22	150
Total	5,000	3,000	3,000	4,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — ENERGY TECHNOLOGY

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of this program is to relate NASA's aeronautical and space technologies, engineering, scientific, and managerial expertise, and existing facilities capabilities to the research and development needs of the Department of Energy and other agencies. These activities contribute to the search for solutions to energy-related problems on Earth. The Energy Technology activity accomplishes the program objective through investigations of the potential application of NASA capabilities to energy-related problems. When these capabilities are shown to be sufficiently mature, plans are developed for reimbursable support from the appropriate agency. This process assures the development of plans that are not only technically sound, but which are properly related to the program needs of the user agency. The success of this approach is supported by the fact that in FY 1980, NASA's energy-related reimbursable work for the Department of Energy and other agencies is expected to total approximately $300 million, an increase of about thirty percent over FY 1979.

As a result of the independence attained through direct funding, NASA is now a major contributor in Wind Energy, Photovoltaic Energy Conversion, Solar Heating and Cooling, Advanced Ground Propulsion Systems, and Energy Storage. Significant progress has also been made toward defining the major technology problems bearing on the feasibility of using a Satellite Power System to convert sunlight to electric power for transmission to the Earth for utilization.

BASIS OF FY 1981 ESTIMATE:

During FY 1981, NASA will continue to focus on areas where NASA-developed expertise could be utilized. This will include investigations in: evaluation of Stirling engine concepts for power generation; new concepts for advancing coal conversion technology; opportunities for industrial energy conservation; small dispersed solar systems applications; the exploration of bio-energy as a promising source of nonfossil fuel energy; and an examination of the future technology needs of electric utility systems.

TRACKING AND
DATA ACQUISITION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1981 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
	(Thousands of Dollars)				
Operations	249,903	275,800	264,500	271,500	RD 12-3
Systems implementation	40,497	46,400	57,300	76,200	RD 12-12
Advanced systems	9,500	10,600	10,600	11,300	RD 12-21
Total	299,900	332,800	332,400	359,000	

Distribution of Program Amounts by Installation:

Goddard Space Flight Center	216,557	238,200	234,000	249,700
Jet Propulsion Laboratory	59,021	68,800	69,800	74,400
Wallops Flight Center	5,800	6,300	6,500	9,800
Dryden Flight Research Center	3,150	3,000	3,300	3,600
Headquarters	15,372	16,500	18,800	21,500
Total	299,900	332,800	332,400	359,000

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 and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for: sounding rockets, research aircraft, earth orbital and suborbital missions, for planetary spacecraft, and for deep space probes. It also includes the support of all phases of the Space Shuttle flight program, from the completed Approach and Landing Tests to the upcoming Orbital Flight Tests, and the Space Transportation System operational flights.

The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and earth applications data from onboard 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 and acquisition of biomedical data on their physical condition; (f) communication of information between the various ground facilities and central control centers; and (g) processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure the safety of the crew.

Tracking and acquisition of data from the space flight projects is accomplished by the use of a worldwide network of NASA ground stations. These 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 two types of facilities to meet the needs of the two classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports earth orbital missions and the Deep Space Network (DSN), which supports planetary and interplanetary flight missions.

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.

In future years the operation of the Tracking and Data Relay Satellite System (TDRSS) will be an important aspect of the NASA space program. This system will support all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA will obtain use of this system through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in FY 1982.

With the advent of TDRSS services several of the STDN tracking stations will be closed in 1982. Planning is also underway to consolidate the remaining core STDN stations with those of the DSN 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.

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new, and changing flight project requirements; and (c) the development of advanced tracking and data acquisition systems and the investigation of advanced tracking and data acquisition techniques.

CHANGES FROM FY 1980 BUDGET E:

The current estimate for FY 1980 is $400 thousand below the budget estimate. This reduction results from the Congressional general reduction in the FY 1980 NASA Research and Development appropriation request. The current estimates reflect adjustments between the operations and the systems implementation categories to consolidate funding for the more significant capabilities being implemented in the Space Tracking and Data Systems program. Explanations of these funding changes are provided under each individual program involved.

BASIS OF FUND REQUIREMENTS:

OPERATIONS

The FY 1981 funding requirements include a continuing support workload for an average of approximately 50 automated earth-orbiting and planetary missions. The operations funding also provides for the prelaunch support activity required for upcoming approved missions and for support to the Space Shuttle flights. The

increase in the FY 1981 funding request for Operations is due to two factors: (a) continuing cost escalation in all areas of Operations; and (2) support of the upcoming Shuttle Orbital Flight Test requiring additional wideband communications circuits to transmit the high volume of data between the Shuttle and the ground control facilities.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Spaceflight tracking and data network..	127,068	141,200	136,400	134,200	RD 12-4
Deep space network	51,032	55,600	49,500	54,500	RD 12-6
Aeronautics and sounding rocket support	4,516	4,800	5,300	5,500	RD 12-8
Communications	34,027	39,800	37,700	39,300	RD 12-9
Data processing	33,260	34,400	35,600	38,000	RD 12-10
Total	249,903	275,800	264,500	271,500	
Spaceflight Tracking and Data Network Operations	127,068	141,200	136,400	134,200	

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network (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's automated planetary missions, as well as spaceflight missions of other nations, commercial firms, the Department of Defense, 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 14 geographically dispered ground stations, 13 of which are located at remote sites and one at the Goddard Space Flight Center (GSFC), Greenbelt, Maryland. A network control center and mission control center complex are also located at the GSFC which has the field center management responsibility for the network.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew safety and other project related purposes. To meet the extremely precise tracking needs of NASA's Earth and Ocean Dynamics Programs, the network is supplemented by laser tracking systems capable of providing high precision ranging.

In addition to the operational facility at the GSFC, the 13 land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; Quito, Equador; Winkfield, England; and Madrid, Spain. A transportable station is located at NASA's Dryden Flight Research Center, California, for support of the Shuttle program. Smaller transportable stations will be located at New Smyrna Beach, Florida, and Tula Peak, New Mexico, for support of the early Shuttle missions. An engineering test and network system training facility at the GSFC is also maintained and operated as part of the STDN.

The STDN is currently providing support for an average of nearly 50 automated applications and space science spacecraft. Examples of significant missions being supported include the Landsat-2, and -3. three Applications Technology Satellites (ATS-1, -3 and -5); the Heat Capacity Mapping Mission; the Orbiting Astronomical Satellite-3; two High Energy Astronomy Observatories (HEAO-2 and -3); Atmosphere Explorer (AE-5); Nimbus-5, -6, and -7; the Magnetic Field Satellite (MAGSAT); the International Sun-Earth Explorers (ISEE-1, -2, and -3); and the International Ultraviolet Explorer.

Upcoming missions to be supported by the network include the Solar Maximum Mission, the Space Telescope, the Dynamics Explorer mission, the Gamma Ray Observatory, and the Space Shuttle Orbital Flight Tests. The overall spacecraft support workload of the STDN is projected to average approximately 40 spacecraft during 1981.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $4.8 million is a net reduction resulting primarily from the delay in the Shuttle orbital flight test schedule and the termination of ATS-6 support.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding requirements for the STDN operations provide for the maintenance and operation of the network and control center facilities, as well as the related logistics, network planning, scheduling, documentation, and computer programming costs associated with the around-the-clock operation of the network. The projected decrease from FY 1980 to FY 1981 is largely due to the planned phase down of very high frequency capabilities throughout the network and the transfer of budget responsibility for the laser and Smithsonian Astrophysical Observatory to the Office of Space and Terrestrial Applications.

The FY 1981 request includes funds for support of the Shuttle Orbital Flight Tests. Funds are also included in the request to provide a ground backup recording capability for Landsat-3 support in the event of failure of the on-board tape records. This capability will insure a continued flow of Landsat-3 data until Landsat-D can be launched.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Operations.....	51,032	55,600	49,500	54,500

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 the distant spacecraft are controlled and scientific data are acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems, software, 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 stations consist of one 64-meter and two 26-meter diameter antennas at each location, except at Goldstone where one of the 26-meter antennas has been expanded to 34 meters. Similar modifications are currently underway to provide the same configuration at the two overseas locations in 1980. The three locations are approximately 120 degrees apart in longitude and permit continuous viewing of the planetary spacecraft. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The JPL has field management responsibility for the network.

The current workload in the DSN consists of the seven on-going Pioneer spacecraft (Pioneer 6-11 and Pioneer-Venus), two Viking spacecraft (one orbiter and one lander), the two Helios missions, and the two Voyager spacecraft. Support of these missions will continue during FY 1981, except for the Viking orbiter.

The Pioneer 11 mission provided an excellent test of the DSN capabilities when the network successfully supported the Saturn Encounter navigation of the spacecraft outside and through the ring-plane and utilizing an arrayed antenna technique to provide increased sensitivity and good quality data for our first close view of Saturn 'and several of its moons.

Of the older Pioneer spacecraft, Pioneer 10 is over 2.9 billion kilometers from Earth and is proceeding on a path that will take it beyond the solar system. Pioneer 10 continues to be the most distant human made object communicated with and eaeh time data is received, a new communications record is established.

The Pioneer 11 spacecraft, some 1.5 billion kilometers from Earth, is being tracked as it proceeds on a path taking it out of the solar system. The Pioneer 6-9 spacecraft are provided support during solar conjunctions. The two Helios missions are continuing their orbit about the Sun as they gather data on the solar plasma. The two Viking spacecraft continue to gather science data from Mars.

To take advantage of a rare alignment of the outer planets Jupiter, Saturn, and Uranus, Voyagers 1 and 2 were launched in 1977. Preparations are underway in the DSN to provide coverage of the Voyagers' encounters with Saturn in November 1980, and August 1981. As is typical of planetary missions, the two Voyager spacecraft will require support for several years during their flight to Saturn and Uranus.

The DSN 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, black holes, and other interstellar phenomena.

In addition to the Voyager missions, the upcoming DSN workload also includes preparation for support of the International Solar Polar and Galileo missions. These support preparations require thorough and complex testing, training, engineering and software effort, and compound the difficulty of overall support planning and execution since such preparations must be carried out at the same time that the network is supporting the extensive and continuous on-going workload described above.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The net decrease of $6.1 million is due to the transfer of funding for Jet Propulsion Laboratory engineering effort associated with specific projects from the operations budget to the systems implementation budget. This transfer provides for improved management visibility by budgeting for specific projects in one program area. A portion of the transfer for engineering effort was offset by increased cost escalation, particularly for operations at the Madrid station.

BASIS OF FY 1981 ESTIMATE:

The DSN operations funds provide for the maintenance and operations of the network facilities, control center, and the support and engineering effort associated with the operation of the network. The funds requested for FY 1981 are based upon the on-going workload, including the Voyager missions, the Pioneer 6-11 missions, the Pioneer-Venus extended mission, and the Viking Lander extended mission.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Operations..	4,516	4,800	5,300	5,500

OBJECTIVES AND STATUS:

Instrumentation systems are maintained and operated for the sounding rocket, balloon, small satellite, and aeronautical programs conducted by the Wallops Flight Center (WFC) and the aeronautical flight research programs of the Dryden Flight Research Center (DFRC). These instrumentation systems include general purpose tracking, telemetry, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket Program continues to be very active, with over 300 launches last year, ranging from the smaller meteorological rockets to the larger Scout rockets. The majority of these sounding rocket launches are conducted at the WFC. This workload is expected to remain at approximately the same level in FY 1981. In addition to the continuing sounding rocket, balloon, and aeronautical program activities, the WFC will provide specialized tracking, evaluation, and calibration services for the launch phases of the Shuttle orbital flight tests.

The Dryden Flight Research Center (DFRC) operates the Aerodynamics Test Range facilities. These facilities are composed of precision radar tracking, telemetry, and communications equipment, which are used to monitor and control high performance aircraft research and development programs of both NASA and the Air Force. Various aircraft research and technology projects are supported by the Aerodynamics Test Range. Aircraft flown in these flights include the F-111, F-104, F-15, F-8, F-14, and remotely piloted vehicles, including Highly Maneuverable Aircraft Technology (HiMAT). Tracking and data acquisition support of the Shuttle orbital flight tests is planned at the DFRC for FY 1980 and 1981.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $500 thousand in the FY 1980 level provides for operational communications in support of the tilt rotor program and Shuttle at the Dryden Flight Research Center and to provide rehabilitation of heavy mechanical subsystems for the radar and antenna pedestals at Wallops Flight Center.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding requirements support the sounding rocket launches and the Aerodynamics Test Range activities. The reauest also includes funding to support the initial Shuttle orbital flight test landings at the Dryden Flight Research Center.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Communications Operations.....	34,027	39,800	37,700	39,300

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM) interconnects by means of leased voice and data circuits the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the 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.

To an increasing extent, the NASA flight projects are requiring the transfer of vast amounts of data between the mission control centers and the tracking sites because of the increased need for real time control of the spacecraft and on-board experiments. In addition, there is a requirement to provide increasing amounts of experiment data more quickly to the users for analysis.

In order to meet high data transfer rate requirements, NASA is increasing its utilization of digital techniques in providing communications support, The availability of this technology allows for a greater amount of data to be sent over conventional communication circuits. Also, circuits capable of transferring data at increasingly higher rates are becoming available from the common carriers at reasonable costs. Consequently, the techninues of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center has become economically attractive. This approach, referred to in the communications field as a "bent pipe" mode, simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations. As a result, the trend toward the direct transfer of data from the spacecraft to the control center via high data rate communications links is expected to continue.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The decrease of $2.1 million in the FY 1980 funding level resulted from two factors: (1) the delay in the Shuttle orbital flight test schedule which, in turn, allowed for a delay in ordering up the wideband and video communications circuits required for Shuttle support; and (2) lower than originally estimated prices for some overseas wideband circuits.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding requirements for communications operations will provide for the circuits and services required to operate. and maintain the NASCOM. International communications satellites will permit the extension of additional digital wideband services to all overseas tracking stations. These services will provide for the near real-time transfer of data for all on-going flight programs.

The major reason for the increased requirements in FY 1981 is due to the support requirements for the Shuttle flights. This project requires a full year of wideband communications circuits throughout virtually the entire network of stations. Wideband service will also be initiated to support the Tracking and Data Relay Satellite System (TDRSS) facility testing phase.

The operation of the switching centers and technical control facilities is a continuing function assuring high reliability and efficiency in the use of the various types of communications services available to NASCOM from the common carriers.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Data Processing Operations	33,260	34,400	35,600	38,000

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a useable 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 large and complex Solar/Astronomical Observatories and the Landsat satellites.

Tracking data are 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 from each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data are the primary product of the spacecraft missions and it is through reductions and analyses of these data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, 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.

In addition to the tracking and positional data processing described above, there is also a great deal of data processing required on the information received from the on-board experiments. Two facilities, the Image Data Processing Facility (LDPF) and the Telemetry On-Line Processing System (TELOPS) have been established at the Goddard Space Flight Center to process different types of experimental data.

The IDPF, initially established to handle imagery data of the Earth Resources Technology satellite (Landsat-1), now supports the second and third Landsat spacecraft. These spacecraft are supported with a new all-digital system using computer compatible tapes which, when completely operational, will reduce the time required to provide data to users. The operational requirement for this facility is expected to continue through the next several years for support of the currently operational and/or approved programs, including Nimbus 7, Synchronous Meteorological satellites, Heat Capacity Mapping Mission, and the upcoming Solar Maximum Mission.

The Telemetry Processing Facility which handles the conventional, nonimagery data was reconfigured in FY 1978 as the Telemetry On-Line Processing System. 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 digital form from the tracking stations via NASCOM communication lines and is able to store up to six months of telemetry data on-line, thus, eliminating most of the tape and tape handling operations within the old processing facility.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $1.2 million in the FY 1980 funding level resulted from greater that expected costs associated with bringing the new all-digital IDPF into full operation and the implementation of a domsat terminal for rapid handling of Landsat data.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 budget requirements include funds to operate the IDPF and the TELOPS to process data from currently orbiting satellites, as well as data from the satellites scheduled to be launched during the period. The scientific reauirements for the acquisition and processing of data from the older satellites are under continuing review and support for older missions is terminated or curtailed as mission objectives are achieved or when the experiment data is no longer useful or cost effective to acquire and process,

Software procurement activities have been initiated for support of upcoming space science and applications spacecraft such as the Space Telescope and Dynamics Explorer, as well as Spacelab. The activities cover spacecraft orbit and attitude control and related data processing requirements which require additional funding for FY 1981. Software effort is also required to develop the necessary programs to accommodate the Tracking and Data Relay Satellite System/free-flyer mode of operation.

BASIS OF FUND REQUIREMENTS:

SYSTEMS IMPLEMENTATION

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the aggregate support needs of the many and varied space missions, and to provide augmentation to this capability, as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation.

The system 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 provisioning of large module spares, and the acceptance testing, integration and checkout of equipment.

FY 1981 funding is needed to maintain the required level of 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 1981 funds are also required to continue the implementation of new capabilities for upcoming missions, including the International Solar Polar Mission, Galileo, Space Telescope, Gamma Ray Observatory, Shuttle, and Spacelab programs.

Funds are also included to initiate long lead time items for the consolidation of the remaining STDN core stations with the DSN stations. The consolidated network, under the management of the Jet Propulsion Laboratory, is keyed to the mid-1980's.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate	Page No.
		(Thousands of Dollars)			
Spaceflight tracking and data network	14,085	17,000	17,000	22,600	RD 12-13
Deep space network	10,115	15,100	22,400	23,100	RD 12-15
Aeronautics and sounding rocket support	4,052	3,700	4,000	7,100	RD 12-17
Communications	4,815	3,700	4,400	5,600	RD 12-18
Data processing	7,430	6,900	9,500	17,800	RD 12-19
Total	40.497	46.400	57.300	76.200	
Spaceflight Tracking and Data Network Systems Implementation	14,085	17,000	17,000	22,600	

OBJECTIVES AND STATUS:

The Spaceflight Tracking and Data Network Systems Implementation program encompasses the procurement and implementation of systems and services necessary to sustain an effective capability for reliable support of ongoing scientific and applications satellite missions, to provide the network and control center capabilities required for efficient control, tracking, command, and data acquisition support of all NASA earth orbital missions, and to meet 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, and command. Among these are the International Sun-Earth Explorers (ISEE-1, -2, and -3), the High Energy Astronomy Observatories (HEAO-2, and -3), Landsat-2 and -3, the Magnetic Field Satellite (MAGSAT), the Stratospheric Aerosol and Gas Experiment, Nimbus-5, -6, and -7, and the Laser Geodynamic Satellite (LAGEOS). Network and control center systems are in the final stages of implementation for upcoming new missions such as the Space Shuttle Orbital Flight Tests and Solar Maximum Mission. Plans and procurements are also underway to meet support requirements for future missions such as the Space Shuttle operational flights, Spacelab, Landsat-D, and the Space Telescope.

BASIS OF FY 1981 ESTIMATE:

Eouipment modifications are required in the network and control centers in FY 1981 to maintain the required level of proficiency for support of a diverse and demanding workload and to assure the reliability of the network systems, Accordingly, funds are required for replacement of worn out systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational

control of the network. The funds requested also provide for procurement of subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

The operational flights of the Space Transportation System (STS) will employ the Tracking and Data Relay Satellite System (TDRSS) for orbital tracking and command and for data, television, and voice communications. A comprehensive capability for prelaunch testing and launch support of Shuttle and for compatibility testing of Shuttle and STS payloads with TDRSS is being installed at the Merritt Island, Florida, network station, Funds are requested in FY 1981 to complete the Merritt Island station TDRSS compatibility test capability and to complete the STS and STS payload telemetry and command monitoring systems at the TDRSS ground station at White Sands, New Mexico. Funds are also included for the continued implementation of mobile compatibility test vans to be used for prelaunch free-flyer spacecraft/TDRSS compatibility testing.

In addition, funds are requested to procure a spare transponder to ensure continuous operation of the TDRSS bilateration tracking systems. The bilateration tracking system is required to obtain precise position information on the TDRSS Precise position of the TDRSS spacecraft is necessary in order to calculate precise orbits of the spacecraft being tracked by TDRSS.

In FY 1981, effort will continue on the design and implementation of a new control center for the Space Telescope. This work will be conducted in concert with the development of the Science Institute (funded by the Office of Space Science) to minimize the design cost for both hardware and software systems as well as to facilitate testing and other operations.

In FY **1981,** a new transportable station will be implemented at a foreign site to provide coverage to the Landsat-D spacecraft during those periods when the spacecraft is not in view of the TDRSS.

To efficiently and effectively meet the mission control workload in the 1980's, a new approach to control center design has been initiated. This approach involves techniques for rapid configuration of control center equipment to meet the requirements of a particular mission. The overall objective of the new design is to permit the sharing of resources to improve equipment utilization and to decrease the number of software and operations personnel, In FY **1981,** the necessary complement of computers will be purchased and the integration of a "cluster" of control centers undertaken.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Systems Implementation	10,115	15,100	22,400	23,100

OBJECTIVES AND STATUS:

The Deep Space Network is responsible for recovering science data from and providing the capability for remote operation of planetary and interplanetary spacecraft. In addition, after the Tracking and Data Relay Satellite System (TDRSS) becomes operational, the Deep Space Network will support highly elliptical earth orbital missions. The systems and facilities required to accomplish this are highly specialized and include Deep Space stations with their large aperture antennas (up to 64-meter diameter), ultrasensitive receivers, and high power transmitters. Advanced data handling systems are also required both at the stations and in the network control center.

The Deep Space Network Systems Implementation funding provides for the engineering and procurement of the systems and related services to be used in this network to assure that its capabilities keep pace with ongoing and upcoming approved planetary mission support requirements. It provides for the initiation of consolidation of the Deep Space and collocated near Earth stations into a single highly automated network that will provide enhanced capability while reducing overall maintenance and operations costs. Included is the replacement of obsolete equipment in order to improve the performance, reliability, and maintainability of the network. Overall, the equipment and techniques funded under this program are major contributors to: improvements in spacecraft navigation accuracy; the successful conduct of increasingly complex experiments; and the ability to receive increasing amounts of scientific information from planetary spacecraft at ever increasing distances from Earth. The need for dedicated network support during many time-critical mission events combined with the increasing communication distances and the demand for greater ground navigation precision, requires a continuing effort to extend network capabilities, performance, and reliability while at the same time reducing maintenance and operations costs.

Major efforts planned during FY 1981 include the start of a multiyear modification program to consolidate the Deep Space and collocated near Earth stations into a single network while providing support for the two Voyager Saturn encounters and implementation of a new high accuracy navigation technique.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

An increase of **$7.3** million from the FY 1980 budget estimate resulted from the transfer of funding for the Jet Propulsion Laboratory engineering effort required for specific projects from the operations budget to the systems implementation budget. The purpose of this transfer is to consolidate the total funding requirements of specific projects in the systems implementation budget. This will provide for improved management visibility,

BASIS OF FY 1981 BUDGET:

Funding for FY 1981 provides for completion of a number of modifications and improvements required for the support of the second Voyager Saturn encounter. These include an operational digitally controlled uplink oscillator necessitated by an anomaly in the Voyager 2 onboard receiving system. It also provides for modifications to improve the sensitivity of the receiving antennas to increase the amount of scientific imagery data that can be returned during the Saturn encounter phase.

Implementation of an operational Very Long Baseline Interferometry (VLBI) tracking capability will also continue. This capability is necessary to meet current and future navigation requirements at the outer planets, particularly during periods when the spacecraft, in the vicinity of the planets, are viewed in the center of the plane of the ecliptic. An order of magnitude improvement in navigation accuracy is necessary in order for the spacecraft to achieve close satellite flybys and to provide the precision for gravity assist maneuvers as the spacecraft journey to subseouent planetary encounters. Missions requiring this accuracy level are Voyager at the Saturn and Uranus encounters and Galileo at the Mars and Jupiter encounters.

A phased consolidation of the Deep Space and collocated near Earth stations will begin in FY 1981 based on intensive system engineering design activities underway in FY 1980. Centralization of signal processing at each of the three Deep Space complexes (California, Spain, and Australia) by implementing data distribution equipment will reduce the amount of signal processing equipment per complex. This, together with ongoing modifications and replacement of obsolete data processing computers, will reduce the operations and maintenance costs. At the same time these modifications will increase network performance and flexibility by providing the capability to effectively array two or more antennas to increase sensitivity. Further reductions in maintenance and operations costs will be provided by automating much of the antenna front-end including the microwave and receiver equipment.

It is also planned to convert the 26-meter and 9-meter antennas to allow added reception at the X-band frequencies now being used by more recent and approved new spacecraft, while at the same time providing a greater potential for antenna arraying. The entire consolidation effort of antenna conversion, equipment automation, signal distribution and centralized processing is carefully sequenced to ensure that the network is capable of supporting current and planned future flight missions without interruption.

Concurrent with these important engineering changes, FY 1981 funds will also be required to maintain the high level of reliability for support of the time critical maneuvers and planetary encounters. This will be accomplished through a continuing program of spares provisioning, major equipment refurbishment, and minor eouipment and facility modification and maintenance to assure interface compatibility of existing equipment with the new system configurations being implemented in the network.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Systems Implementation	4,052	3,700	4,000	7,100

OBJECTIVES AND STATUS:

The aeronautics, balloon, and sounding rocket programs are supported at the Wallops Flight Center in Virginia, and the Dryden Flight Research Center in California.

The aeronautics program at Wallops supports: (1) the investigation of major and minor airframe changes on stall, spin and recovery characteristics of light general aviation aircraft; (2) the development of advanced guidance and control concepts in general aviation aircraft; (3) the investigation of agricultural aircraft aerodynamics namely the effects on wake modifications, towing and cruise performance; (4) the development and demonstration of advanced airborne system concepts and problems such as noise, congestion, and adverse weather delays.

The sounding rocket programs supported by Wallops consist of payloads which range in weight from 12 to 1,200 pounds and are launched to altitudes from 70 to 700 km. They support atmospheric physics, plasma physics, solar physics and astronomy. Of considerable importance is the Environmental Observation Program which measures atmosphere dynamics parameters (temperature, winds, pressure, density) and selected constituents (ozone, nitric oxide and water vapor) within the field of view of earth observation satellites for intercomparison purposes. Wallops also hosts the international intercomparison project for the World Meteorological Organization is support of the Global Ozone Research and Monitoring Project.

Wallops provides fixed and mobile ground support equipment for instrumentation support to these programs. To maintain this equipment, spare and replacement parts must be acquired, as well as some nonrecoverable flight hardware such as on-board antennas and transponders. To meet specific test requirements, modifications and augmentations of selected telemetry, communications, tracking, command, and data handling systems are required. In addition, the mobile equipment must be periodically refurbished and modified to meet remote

site reouirements such as the ongoing meteorological program in cooperation with several nations, including Argentina, Brazil, and Spain.

The aeronautical research technology programs supported by the Dryden Flight Research Center (DFRC) consist of high altitude and terminal area tests involving high performance aircraft such as the F-111, F-14, F-15, F-104, F-8, remote piloted vehicles including Highly Maneuverable Aircraft Technology (HiMAT) and other aircraft and helicopters, Dryden Flight Research Center was the site for the Approach and Landing Tests for the Shuttle Orbiter in 1977 and will support the Orbital Flight Tests beginning in 1980. Ground support equipment, located at the Dryden Flight Research Center, including the high precision radar, the telemetry data handling, and the associated timing, communications, and command systems, is maintained and modified to meet the changing requirements of the approved flight projects.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $300 thousand will provide for increased costs associated with upgrading of radar systems.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 funding requirements will provide the sustaining equipment and modifications to support the sounding rocket and aeronautics programs described above. In addition, it will provide funding for an impact prediction system for more reliable and downrange safety related support to the sounding rocket program. The present system is approximately 15 years old with the attendant problems of procuring spare parts, increased maintenance, and decreasing reliability.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
	(Thousands of Dollars)			
Communications Systems Implementation.....	4,815	3,700	4,400	5,600

OBJECTIVES-AND STATUS:

The objective of the Communications System Implementation program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to 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 together such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in the NASCOM are the implementation of a control and status system that can remotely control the configuration of the TDRSS multiplexing system at White Sands and the implementation of a 50 megabits per second transmission capability connecting the White Sands, Johnson Space Center and Goddard Space Flight Center for support of Spacelab missions and Landsat-D.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $700 thousand in the FY 1980 funding level resulted from greater than expected cost for the status and control system for the TDRSS multiplexer and the 50 megabits per second transmission capability for support of Spacelab and Landsat-D.

BASIS OF N 1981 ESTIMATE:

The FY 1981 funding requirements will provide the sustaining equipment and modifications to support the NASCOM Network and to continue effort on the automation of communications from the TDRSS ground station. Included also are the equipment and ground terminal to relay Landsat-D data in near real-time from the Indian Ocean area.

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Data Processing Systems Implementation.....	7,430	6,900	9,500	17,800

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 (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements these computer complexes, utilizing sophisticated software programs, determine spacecraft attitude and orbit, generate commands to the spacecraft and provide the status of onboard subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Several significant activities in this program are underway at GSFC. The Telemetry On-Line Processing System (TELOPS), which became operational during 1978, is now routinely supporting a number of spacecraft, including the recently launched HEAO-3. The Image Processing Facility has been modified and is generating products for Landsat, Heat Capacity Mapping Mission, and Nimbus-7. Procurement is proceeding for a computer

replacement that will provide an improved central point for handling tracking data reception from the STDN. A centralized tracking data base is a continuing reauirement for performing orbit computations. Implementation continues for a new system to process data from the numerous and varied experiments which comprise the payloads of early Spacelab missions.

CHANGES FROM FY 1980 BUDGET ESTIMATE:

The increase of $2.6 million in the FY 1980 funding level results from provision of redundant capability for critical parts of the Spacelab data processing system at the Goddard Space Flight Center to insure a reliable data processing capability.

BASIS OF FY 1981 ESTIMATE:

The FY 1981 budget request will provide continued funding for sequential 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 onboard computers, and flight maneuver control. This computer complex is approximately 15 years old. Not only are hardware and software maintenance becoming more difficult and expensive, but the now frequent system outages are becoming a real threat to transmission of vital spacecraft commands. Further, system architecture requires greater software development to adapt to new missions. Funds are also necessary to augment and complete certain system procurements, including the Interim Spacelab Data Processing System and the Flight Maneuver Operations Control (FMOC) backup system. The Interim Spacelab Data Processing copability will be derived by augmenting and sharing the existing facility that currently processes free-flyer data. In particular, the old 1108 computers will be replaced with faster, more reliable systems, providing additional capacity that can be used for Spacelab missions as well as generally upgrading system performance for support of the free flyers.

There is also a continuing requirement to procure and maintain adequate supplies 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 FUND REQUIREMENTS:

ADVANCED SYSTEMS

	1979 Actual	1980 Budget Estimate	1980 Current Estimate	1981 Budget Estimate
		(Thousands of Dollars)		
Advanced Systems.	9,500	10,600	10,600	11,300

OBJECTIVES AND STATUS:

The Advanced Systems Program conducts studies and develops tracking and data acquisition systems and techniaues required (1) to obtain new and improved capabilities for the networks and data facilities to meet the'needs of approved missions and near term new starts, and (2) to improve the cost-effectiveness and optimize the reliability of the overall tracking and data acquisition support for the total mix of space flight missions. This includes investigations of required tracking and data acquisition support for upcoming missions and also flight/ground systems trade-off studies to determine, for example, which has the lowest lifecycle costs for operational support planning of future space missions.

BASIS OF FY 1981 ESTIMATE:

The Advanced Systems Program will continue to produce improvements in the techniques and the systems required for tracking and data acquisition. The capability of the Deep Space Network to track and accurately guide planetary spacecraft to their reauired planetary "window" or position relative to the target planet has improved by a factor of 10 every five years since 1964. The Galileo mission to Jupiter in 1984 requires continuation of this trend and new tracking technology is being developed for Galileo navigation during its Mars flyby.

The capability of the Deep Space Network to acquire telemetry data from planetary missions has also improved greatly. For example, it has improved over a million-fold since the Mariner IV in 1964 to the current receiving capability for Voyager, which is 115 kilobits per second from Jupiter nearly a billion kilometers away. Developments are now aimed at adding another factor of four improvement over the current Deep Space Network data acquisition capability to permit a corresponding increase in the scientific scope and value of future planetary missions.

The Earth satellite network in combination with the data handling and control facilities has increased its total data flow in support of all Earth orbital missions. From a workload level of approximately 200 million bits on a typical day in 1964 its capability is 1,000 times that amount today. To do this, major changes in techniques were necessary for mission control, digital data handling and image processing. New technology is

now underway for use during the upcoming **TDRSS** era when an additionai factor of 10 in workload level will be reached, Here the prime objective is to seek significant improvements in overall support cost-effectiveness mainly for earth observational missions and Shuttle space operations. Studies are also being initiated co define the technology needs for a next generation TDRSS as experience is gained with the current generation of TDRSS.

Techniques for highly accurate measurement by the networks of parameters related to the space-time environment also play a vital role in support of NASA missions and experiments. The Advanced Systems program has of necessity remained at the forefront of this technology which includes, for example, laser ranging, frequency standards, worldwide time synchronization and baseline length measurement. Laser ranging systems used to support the **TAGEOS** satellite and to make geodetic measurements are now accurate to within 10 centimeters. Fieldworthy atomic frequency standards are being improved in accuracy by an order of magnitude every two years. These standards are probably the most accurate direct measuring instruments made by man, and they ultimately determine and limit our ability to track and navigate spacecraft and conduct experiments in areas such as gravitational physics and relativity. Vital also is our ability to synchronize two or more of these standards, currently to within one microsecond, and to measure baseline length to an accuracy of centimeters on a worldwide basis. To obtain greater accuracy required for each of the measurement techniques is an objective of the Advanced Systems Program.