NASA
National Aeronautics and
Space Administration

Budget Estimates

Fiscal Year 1992

Volume I

Agency Summary

Research and Development

Space Flight, Control and
Data Communications

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1992 ESTIMATES

VOLUME 1

TABLE OF CONTENTS

AGENCY SUMMARY

AGE Y SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1992 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration conducts space and aeronautical research, development and flight activities for peaceful purposes designed to maintain United States preeminence in aeronautics and space. The President, in the National Space Policy, has charged NASA to conduct a balanced program of manned and unmanned exploration and to begin the systematic development of technologies necessary to enable and support a range of future manned missions. These activities will support the long-range goal of expanding human presence and activity beyond Earth orbit into the solar system. He also declared a goal establishing the U.S. as the preeminent spacefaring nation and announced a national and international initiative to seek new solutions to environmental problems.

The NASA FY 1992 budget request of $15.7 billion supports the President's policy by providing the resources necessary for a vigorous national program ensuring leadership in critical areas of the space program as well as continued preeminence in aeronautics. This budget concentrates on:

- A vigorous Space Science and Applications program, with funding increased 21% over FY 1991, to expand our knowledge of the Earth, its environment, the solar system and the universe, and human habitation of space;

- Continuation of the spacecraft data distribution system, and instrument development for the Earth Observing System and the Earth Probes for the Mission to Planet Earth, to provide long-term data on changes in the global environment;

- Initiation of the development of a New Launch System, jointly managed by NASA and the DOD, to provide a range of cargo capabilities and to achieve significant improvement in operations costs, system resilience, and reliability;

- Augmented funding to focus on enabling propulsion materials development for high speed civil aircraft; provide the facilities, technology and expertise necessary for superiority in civil and military aviation;

- Providing safe and effective assured access to space using both the Space Shuttle and Expendable Launch Vehicles;

- Moving forward with a restructured Space Station development program;

- Completing the technology program requisite for transitioning to the experimental flight phase of the National Aerospace Plane;

- Developing the technology base necessary to support a balanced program of robotic missions and human exploration beyond Earth orbit;

- Augmented funding for NASA educational activities for enhancing educational opportunities at all levels in the areas of math and science;

- Providing opportunities for commercialization of space and for international cooperation in space.

The program elements outlined in this budget will provide a strengthened base for assuring and continuing the United States' role as leader in space and aeronautical research and development. Specific major areas of emphasis are:

<u>Space Science and Applications</u>

The FY 1992 budget provides for a carefully coordinated and logically phased set of research and development activities to:

- Advance our scientific knowledge of Earth and the global processes which shape our environment;
- Explore the solar system using automated spacecraft in conjunction with ground-based observations and research;
- Expand our comprehension of the universe beyond the solar system using the full range of capabilities from Explorer spacecraft to the "Great Observatories";
- Increase our knowledge in the life sciences on key issues ranging from human performance and, habitation in space to the basic life processes and the potential of life elsewhere in the universe;
- Understand and develop the potential benefits of the microgravity environment in materials sciences and other applications; and,
- Maintain U.S. leadership in the world communications satellite market.

The Space Science and Applications program is in the midst of an exciting age of exploration and discovery. In 1990, the Hubble Space Telescope (HST), the Galileo mission to Jupiter, and the Ulysses mission to study the Sun were launched. During 1991-1992, the Gamma Ray Observatory (GRO), the Extreme Ultraviolet Explorer (EWE), the Upper Atmospheric Research Satellite (UARS), the Advanced Communications Technology Satellite (ACTS), the Mars Observer, the TOPEX, and several important Spacelab missions supporting Earth science, microgravity research and life sciences are scheduled for launch. Development continues on the Global Geospace Science (GGS) missions, the CRAF/Cassini and the Advanced X-ray Astrophysics Facility (AXAF). Funding for the initiation of Lifesat, a recoverable biosatellite to define radiation protection requirements for long-term habitation of space, is included. Funding is also included for the continued operation and data analysis of previously launched satellites, as well as for preparation for servicing of the Hubble Space Telescope with advanced instrumentation and correction of the spherical aberration in the primary mirror. Preparation for utilization of the Space Station Freedom continues, emphasizing both microgravity and life science research. Several important international cooperative missions continue in development for launch in FY 1992 and beyond, while a vigorous, multidisciplinary program of basic and applied research will continue.

Mission To Planet Earth

The Earth Observing System (EOS) and Earth Probes program remain high NASA priorities. These two initiatives were approved by Congress for initiation in FY 1991 as the major NASA contribution to the U.S. Global Change Research Program. The EOS will provide simultaneous, comprehensive Earth coverage and the measurement and data system capabilities necessary for long-term answers to global change. Design and development activities for the EOS-A instrument complement and data distribution system are proceeding. The explorer-class Earth Probes missions will address specific, highly-focused Earth science investigations requiring unique orbits or special sensor environments. The program has been augmented to initiate the Tropical Rainfall Measurement Mission (TRMM), and to procure an additional Total Ozone Mapping Spectrometer (TOMS). Procurement activities are underway for the acquisition of data by the Ocean Color Mission. The feasibility will be explored of using remotely-piloted aircraft as a monitoring platform which could be used as a precursor or complement to space observations.

Space Transportation

The primary focus of the Shuttle program is to conduct the planned flights in a safe and reliable manner and use the Shuttle's capability in the most efficient and prudent way. The budget provides for conducting 8 flights in FY 1991, 9 flights in FY 1992 and reaching a steady-state flight rate of ten flights in FY 1994. First flight of the new orbiter, Endeavour, is planned for FY 1992. Design and development activities will continue in FY 1992 on the Advanced Solid Rocket Motor, which will improve the safety, reliability and performance of the Shuttle fleet. Fabrication and procurement of a set of replacement structural spares continues as well as improvements to the Shuttle to address obsolescence, improve mission effectiveness and extend the stay time in orbit.

Funding is included to initiate development of a New Launch System. The principle objectives of this program are: to develop a launch vehicle that provides a range of cargo capabilities, including heavy-lift, with the ability for man-rating for some applications; to provide for both a near-term capability that is evolutionary and a longer-term capability that incorporates new technology; and, achieve significant improvements in operations costs and operational resilience. NASA and DOD will jointly manage and fund this program.

Space Station

The Space Station Freedom remains a critical element in this nation's exploitation of space in the future. It will provide experience in long-term human operations in space critical to future manned space exploration, support scientific and technological investigations, and further the commercial utilization of space. It is an avenue of cooperation with our allies, demonstrating the peaceful uses of space for the benefit of all.

NASA is currently restructuring the Space Station program in response to Congressional direction. This effort, to achieve a more incremental approach within constrained near-term and outyear budget availability, is being conducted in close coordination with the international partners.

Commercial Activities

The FY 1992 budget continues NASA's commitment to encouraging a healthy and expansive commercial space industry. Funding is included to provide expanded opportunities for access to space for Centers for Commercial Development of Space (CCDS) payloads through sounding rockets, small orbital Expendable Launch Vehicles (ELVs) and the NASA lease of a Shuttle middeck commercial payload module. In FY 1991, procurement activities will be completed on the Commercial Experiment Transporter (COMET) ELV program, which will provide access to the long-duration exposure required for microgravity research by several CCDS-developed payloads.

There are a number of ways in which the private sector is being involved in developing the infrastructure for research and working in space. NASA continues to procure launch services from the private sector for a number of scientific satellite missions. Commercially-developed upper stages are being used where appropriate for planned missions. The Extended Duration pallet, to extend the Shuttle on-orbit stay time to 16 days, is being procured on a commercial basis. Through the Technology Utilization program, we enhance and accelerate the application and use of aeronautics and space technology by the public, private and academic sectors.

Aeronautics Research and Technolonv

The goal of the Aeronautics program is to provide a technology base to continue the U.S. preeminence in the field of aeronautics. This is accomplished by maintaining a broad-based research and technology program utilizing advanced facilities, laboratories, computers and technical staff, with extensive involvement of the U.S. university and industrial sectors. Funding is included to augment the enabling materials development activities for high-speed civil transport propulsion system components. The high speed research program will continue to address critical environmental compatibility issues and establishment of a foundation for subsequent decisions on future high-speed civil transport technology and development programs. Funding has also been included for NASA's full participation in the multi-agency Federal High Performance Computing and Communications (HPCC) program. NASA's activities are focused on enabling broad advances in aerospace vehicle design, space and Earth systems science, and space exploration programs. The approach leverages current NASA leadership, while broadly strengthening its capability for sustained high performance computing research.

Space Research and Technolonv

This program develops the technology base on which our current and future capabilities in space depend. The Civil Space Technology Initiative (CSTI), started in FY 1988, and the Exploration Technology program (formerly Pathfinder), started in FY 1989, are developing the advanced technology required for future missions. They will significantly enhance current capabilities in propulsion, power, and related systems to access and operate in space. Funding in CSTI for the science sensor focussed technology effort has been augmented. In Exploration Technology, research and technology development in nuclear propulsion, human support, and surface operations will be continued. Funding for NASA's participation in the interagency nuclear power program, SP-100, with the Departments of Energy and Defense is supported. To assure continuing development of robotics technology, the Flight Telerobotic Servicer (FTS) has been transferred to the Space Research and Technology budget.

Transatmospheric Research and Technology

The NASA efforts in the joint National Aerospace Plane (NASP) program with DOD are aimed at accelerating the development of critical technologies intended to enable a potential new class of vehicles capable of flight to orbit or hypersonic cruise. Work will continue on developing the technology base necessary for a decision, planned for FY 1993, on whether to proceed to Phase 3, the design, building and flight testing of the NASP experimental flight vehicle (X-30). In FY 1990, the primary contractors for NASP (airframe and engine companies) formed a single team. This has increased program effectiveness through technology exchanges, including valuable data bases and processes. In FY 1991, teaming will lead to the development of a single, new vehicle concept for the X-30.

Space and Ground Network. Communications and Data Systems

The FY 1992 budget provides vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. Work will continue on the replacement Tracking and Data Relay Satellite (TDRS) and on the second TDRSS Ground Terminal. These projects are vital to insuring continuity of space tracking, command, telemetry, and data communications capabilities required to support satellites in low Earth orbit. Procurement activities on the Advanced TDRSS will proceed.

Academic Programs

NASA's educational programs are designed to leverage NASA's unique position to capture and channel student interest in science, engineering, mathematics and technology, as well as enhance teacher knowledge and skills related to these subjects. Funding for these programs will continue to expand NASA's graduate and undergraduate student fellowships, faculty fellowships, research and training grants at the historically black colleges and universities as well as other minority universities, and the Space Grant College and Fellowship program.

Institutional Capability

The NASA institutional capability is the underpinning for the successful accomplishment of the nation's aeronautics and space programs. This capability is comprised of the people who plan, conduct and oversee the research, development and test activities of NASA, as well as the valuable and unique NASA facilities. During a recent comprehensive manpower review, it became evident that the agency would be better served if some functions performed by contractors were performed by civil servants. As a result of that review, NASA will convert approximately 1060 contractor positions to civil servants during the course of FY 1992 for an increase of 595 FTEs for the entire fiscal year. The Construction of Facilities program continues the multi-year effort to restore, modernize and maintain the aeronautical research and development facilities and continue to build the ASRM facility.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1992 BUDGET SUMMARY
(Millions of Dollars)

	Budeet Plan 1990	1991	1992
RESEARCH AND DEVELOPMENT	5.227.7	6.023.6	7.198.5
Space station	1,749.6	1,900.0	2,028.9
Space transportation capability development	558.1	602.5	879.8
Space science and applications	1,998.3	2,429.6	2,934.6
Technology utilization	23.7	24.4	32.0
Commercial use of space	32.8	61.6	118.0
Aeronautical research and technology	442.6	512.0	591.2
Transatmospheric research and technology	59.0	95.0	72.0
Space research and technology	284.1	290.4	421.8
Safety, reliability and quality assurance	22.6	33.0	33.6
Academic programs	37.5	55.1	64.6
Tracking and data advanced systems	19.4	20.0	22.0
SPACE FLIGHT. CONTROL AND DATA COMMUNICATIONS	4.624.9	5.124.4	5.608.3
Shuttle production and operational capability	1,194.9	1,276.4	1,288.9
Space transportation operations	2,492.7	2,790.0	3,023.6
Expendable launch vehicles	139.7	229.2	341.9
Space and ground networks, communications and data systems	797.5	828.8	953.9
CONSTRUCTION OF FACILITIES	411.0	497.9	480.3
RESEARCH AND PROGRAM MANAGEMENT	2.023.2	2.211.9	2.452.3
INSPECTOR GENERAL	8.5	10.5	14.6
TOTAL BUDGET SUMMARY	12.295.3	13.868.3	15.754.0
OUTLAYS	12.427.8	13.497.5	14.719.5

SPACE EXPLORATION INITIATIVE
SPECIAL ANALYSIS

This special analysis identifies those NASA programs in the FY 1992 Budget which support the long-term goal stated in the National Space Policy of "...Expanding human presence and activity beyond Earth orbit in the solar system...". The budget is based on a strategy of supporting activities focused on key, long-lead technologies that will be necessary for any future exploration endeavors. These technologies are: space surface nuclear power, space nuclear and conventional propulsion, and life sciences and life support technologies.

The technology strategy appears consistent with the evolving approach for space exploration under development by the Space Exploration Initiative Synthesis Group. In addition, the Synthesis Group will identify at least *two* fundamentally different exploration architectures in parallel with the technologies which can make exploration affordable. Only after the technology and architecture groundwork has been firmly laid, will the Administration propose specific new manned and unmanned exploration missions. This suite of exploration technologies will be expanded over time, consistent with the "go-as-you-pay" philosophy recommended by the Advisory Committee on the Future of the U.S. Space Program.

The following provides a summary of the activities supported by the FY 1992 funding request of $94.0 million for the Space Exploration Initiative:

1. Space Research and Technology

The Space Research and Technology program includes $52.0 million for the Exploration Technology Program, and $15.0 million for the Exploration Mission Studies.

The Exploration Technology Program includes space surface nuclear power, space nuclear and conventional propulsion, and life support technology development. For space surface nuclear power, the budget proposes to continue the joint NASA/DOD/DOE SP-100 program. The focus of 1992 efforts will be on design studies and technology efforts directed at lunar operations using the SP-100 for high power levels (tens to hundreds of kilowatts). Nuclear rocket propulsion appears to offer significant advantages over conventional chemical propulsion, including reduced trip times and reduced mass (thus lower cost). The human support effort will address the technology for improving astronaut productivity, maintenance, and health, with minimal or no dependence on resupply of expendables for life support.

The Exploration Mission Studies will develop the preliminary technical, scientific and programmatic data needed to enable future national decisions on the architecture, or approach, that will serve as the basis for implementation of the Space Exploration Initiative.

2. Space Science

Two elements of the Space Science program support the space exploration initiative: Space Physics Supporting Research and Technology (SR&T) and Life Sciences.

An augmentation of $2.0 million in Space Physics SR&T will support a new effort in radiation research to develop a means of predicting solar flares and cosmic ray fluctuations in order to prevent harmful radiation exposure during long-term manned missions.

The Life Sciences program will play a central role in the human exploration program. Beginning in FY 1992, Life Sciences Research and Analysis will be augmented by $10.0 million to conduct pre-definition and definition studies in areas focusing on participation in human and precursor Lunar-Mars missions. These areas include artificial gravity, planetary protection, advanced remote medical care, and human factors research. The fundamental objective is how to enable humans to operate effectively in space for long continuous periods of time. The FY 1992 budget also includes $15.0 million for the initiation of the Lifesat, a series of recoverable biosatellites to define the effects of space radiation and microgravity to enable development of protection requirements for long-term habitation of space.

NATIONAL AERONATICS AND SPACE ADMINISTRATION
FISCAL YEAR 1992 ESTIMATES
SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Millions of Dollars)

	TOTAL	R & D	SFC&DC	CofF	R&PM	IG
Fiscal Year 1990						
Appropriation P.L. 101-144	12,377.2	5,306.9	4,543.1	500.0	2,018.5	8.7
Transfers among accounts		-18.0	70.0	-85.0	33.0	
Reduction pursuant to PL 101-239	-156.5	-61.2	-63.2	-4.0	-28.1	
Lapse of FY 1990 Unobligated Funds	-0.4				-0.2	-0.2
Transfer from FY 1987 funds	75.0		75.0			
Total Budget Plan	12,295.3	5,227.7	4,624.9	411.0	2,023.2	8.5
Fiscal Year 1991						
Appropriation P.L. 101-507	15,078.0	6,023.6	6,334.1	497.9	2,211.9	10.5
Portion applied to debt reduction	-1,209.7		-1,209.7			
Total Budget Plan	13,868.3	6,023.6	5,124.4	497.9	2,211.9	10.5
Fiscal Year 1992						
Appropriation Request/Budget Plan	15,754.0	7,198.5	5,608.3	480.3	2,452.3	14.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1992 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Thousands of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
Johnson Space Center	2,546,224	1,887,525	2,155,839	1,129,200	1,188,200	1,323,900	1,036,648	305,933	433,970	59.746	55,010	34.760	320,630	338,382	363,209
Kennedy Space Center	1,345,618	1,445,110	1,590,308	857,300	939,600	1,022,600	150,278	138,721	155.357	60,602	69,115	91,585	277,438	297.674	320,786
Marshall Space Flight Center .	2,937,409	2,837,790	3,123,522	1,677,138	1,924,100	1,911,700	960,375	580,175	851,030	30,629	47,604	37,344	269,267	285,911	323,448
Stennis Space Center.........	76,056	103,622	118,042	26,900	25,100	33,000	12,176	16,368	33.477	11,843	33,612	21,038	25,137	28,542	30,527
Goddard Space Flight Center ..	1,848,670	2,135,045	2,365,907	632,636	678,400	724,400	921,290	1,114,999	1,261,101	30,067	36,615	41,030	264,677	303,031	339,376
Jet Propulsion Laboratory	738,557	815,629	1,071,235	153,966	150,200	180,800	572.450	631,369	876,205	12,141	34,060	14,230	0	0	0
Ames Research Center	559,000	608,133	684,829	18,700	18,800	20,900	307.941	352,443	386,808	45,019	27,050	40,780	187.340	209,840	236,341
Langley Research Center	470.174	522,882	582,924	3,800	0	0	250,980	273,892	323,139	25,515	34,490	28,580	197,879	214,500	231,205
Lewis Research Center	794,098	652,897		56.400	117,700	224,400	497,888	259,505	348,062	33,804	42,990	19,940	206,006	232,702	256,501
Headquarters	864,550	842,823	1,019,051	60,707	82,300	166,573	517,669	450.1%	500,471	3,272	9,010	1,100	274.822	301,318	350,907
Undistributed Reduction.......	0	0	-5,700	0	0	0	0	0	0	0	0	-5,700	0	0	0
Space Sta Dist Under Review...	0	1,900,000	2,028,900	0	0	0	0	1,900,000	2,028,900	0	0	0	0	0	0
Undistributed Construction of Facilities:															
Various Locations	72,052	80,344	121,613	0	0	0	0	0	0	72,052	80,344	121,613	0	0	0
Facility Planning and Design	26,300	28,000	34,000	0	0	0	0	0	0	26,300	28,000	34,000	0	0	0
Total Budget Plan	12,286,708	13,857,800	15,739,373	4,624,827	5,124,400	5,608,273	5,227,695	6,023,600	7,198,500	410,990	497,900	480,300	2,023,196	2,211,900	2,452,300
Inspector General.............	8,523	10,500	14,600	---	---	---	---	---	---	---	---	---	---	---	---
Total Agency..................	12,295,231	13,868,300	15,753,973												

DISTRIBUTION OF FULL TIME EQUIVALENT WORKYEARS BY INSTALLATION

	1990 ACTUAL	1991 BUDQET ESTIMATE	1991 CURRENT ESTIMATE	1992 BUDGET ESTIMATE
JOHNSON SPACE CENTER....................	3,587	3,625	3,618	3,617
KENNEDY SPACE CENTER....................	2,425	2,549	2,510	2,509
MARSHALL SPACE FLIGHT CENTER.............	3,594	3,654	3,650	3,650
STENNIS SPACE CENTER....................	182	215	216	216
GODDARD SPACE FLIGHT CENTER..............	3,730	3,855	3,860	3,975
AMES RESEARCH CENTER....................	2,159	2,181	2,228	2,228
LANGLEY RESEARCH CENTER..................	2,887	2,932	2,923	2,923
LEWIS RESEARCH CENTER...................	2,715	2,809	2,798	2,792
HEADQUARTERS...........................	1,639	1,865	1,926	2,030
(SPACE STATION PROJECT OFFICE - LEVEL II)	(207)	(264)	(220)	(220)
SUBTOTAL, FULL-TIME PERMAMENT WORKYEARS	22,918	23,685	23,729	23,940
OTHER THAN FULL-TIME PERMAMENT WORKYEARS	767	781	297	291
SUBTOTAL, CEILING CONTROLLED FTE....	23,685	24,466	24,026	24,231
PROJECT CORE............................				595
GRAND TOTAL, CEILING CONTROLLED FTE.	23,685	24,466	24,026	24,826

MULTI-YEAR
BUDGET

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1992 MULTI-YEAR BUDGET ESTIMATES

The FY 1992 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The attached table contains the budget estimates for FY 1992, along with the Administration's projections for 1993 and 1994, which are consistent with the latest totals for Domestic Discretionary funding contained in the Omnibus Budget Reconciliation Act of 1990. The funding estimates for FY 1993 and 1994 should not be construed as the final budget estimates. The annual NASA budget formulation process undertakes a thorough review of the technical progress, current funding requirements, Congressional action, and current priorities for ongoing research together with research opportunities which often cannot be forecast two or three years in advance. These intensive reviews are conducted each year prior to final recommendations being included in the annual budget requests.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1992 MULTI-YEAR BUDGET ESTIMATES
IN MILLIONS OF REAL YEAR DOLLARS

FY 1992 PRESIDENT'S BUDGET

	1990 PAST YEAR	1991 CURRENT YEAR	1992 BUDGET YEAR	1993 ESTIMATE	1994 ESTIMATE
RESEARCH AND DEVELOPMENT	5227.7	6023.6	7198.5	8512.9	9477.6
SPACE STATION	1749.6	1900.0	2028.9	2426.0	2790.8
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	558.1	602.5	879.8	999.8	997.4
PHYSICS & ASTRONOMY	859.4	975.1	1140.6	1321.4	1308.5
LIFE SCIENCES	106.1	138.0	183.9	284.0	326.1
PLANETARY EXPLORATION	390.8	457.1	627.3	635.3	643.5
SPACE APPLICATIONS	642.0	859.4	982.8	1344.1	1827.2
SPACE SCIENCE AND APPLICATIONS	1998.3	2429.6	2934.6	3584.8	4105.3
TECHNOLOGY UTILIZATION	23.7	24.4	32.0	31.7	33.0
COMMERCIAL USE OF SPACE	32.8	61.6	118.0	144.2	137.4
COMMERCIAL PROGRAMS	56.5	86.0	150.0	175.9	170.4
AERONAUTICAL RESEARCH & TECHNOLOGY	442.6	512.0	591.2	670.5	716.0
TRANSATMOSPHERIC RESEARCH & TECHNOLOGY	59.0	95.0	72.0	120.0	145.0
SPACE RESEARCH & TECHNOLOGY	284.1	290.4	421.8	409.7	419.6
SAFETY. RELIABILITY & OUALITY ASSURANCE	22.6	33.0	33.6	32.5	34.0
ACADEMIC PROGRAMS	37.5	55.1	64.6	70.5	74.5
TRACKING AND DATA ADVANCED SYSTEMS	19.4	20.0	22.0	23.2	24.6
SPACE FLIGHT. CONTROL & DATA COMMUNICATIONS	4624.9	5124.4	5608.3	5683.8	5765.0
SHUTTLE PRODUCTION & OPERATIONAL CAPABILITY	1194.9	1276.4	1288.9	1277.0	1210.5
SPACE TRANSPORTATION OPERATIONS	2632.4	3019.2	3365.5	3340.8	3477.0
SPACE & GROUND NETWORK, COMM AND DATA SYSTEMS	797.5	828.8	953.9	1066.0	1077.5
CONSTRUCTION OF FACILITIES	411.0	497.9	480.3	469.8	541.6
RESEARCH AND PROGRAM MANAGEMENT	2023.2	2211.9	2452.3	2492.6	2495.4
INSPECTOR GENERAL	8.5	10.5	14.6	15.3	15.7
TOTAL NASA	12295.3	13868.3	15754.0	17174.4	18295.3

RESEARCH
AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

GENERAL STATEMENT

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

SPACE STATION: A program to develop a United States space station to continue the Nation's leadership in space and to provide for enhancement of science and applications programs and to further the commercial utilization of space while stimulating advanced technologies.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT: A program to provide for the development and use of capabilities related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts related to the development and flight certification of the jointly developed U.S./Italy Tethered Satellite System, development and operations of the Spacelab systems, the development and procurement of upper stages that place satellites in high altitude orbits, the engineering and technical base support at the manned NASA centers, payload operations and support equipment, national launch system studies and advanced development activities, and advanced programs study and evaluation efforts.

SPACE SCIENCE AND APPLICATIONS: A program using space systems, supported by ground-based and airborne observations: (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

TECHNOLOGY UTILIZATION: 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 program.

COMMERCIAL USE OF SPACE: A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

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

SAFETY, RELIABILITY, AND QUALITY ASSURANCE: A program to enhance the safety and technical execution of NASA programs.

ACADEMIC PROGRAMS: This program includes activities to support agency-wide university, minority university programs, and elementary and secondary school programs.

TRACKING AND DATA ADVANCED SYSTEM: This program includes activities to perform studies and provide for the development of systems and techniques leading to improve tracking and data program capabilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
FISCAL YEAR 1992 ESTIMATES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Millions of Dollars)		
SPACE STATION	1749.6	2451.0	1900.0	2028.9
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	558.1	773.4	602.5	879.8
SPACE SCIENCE AND APPLICATIONS	1998.3	2481.6	2429.6	2934.6
Physics and astronomy..................	859.4	985.0	975.1	1140.6
Life sciences.........................	106.1	163.0	138.0	183.9
Planetary exploration..................	390.8	485.2	457.1	627.3
Earth sciences........................	434.2	661.5	667.9	775.6
Materials processing...................	101.9	97.3	102.3	125.8
Communications........................	77.7	52.8	52.5	39.4
Information systems...................	28.2	36.8	36.7	42.0
CO[illegible]S	56.5	101.0	86.0	150.0
Technology utilization.................	23.7	24.4	24.4	32.0
Commercial use of space................	32.8	76.6	61.6	118.0
AERONAUTICS AND SPACE TECHNOLOGY	785.7	1163.9	897.4	1085.0
Aeronautical research and technology...	442.6	512.0	512.0	591.2
Transatmospheric research and technology	59.0	119.0	95.0	72.0
Space research and technology.........	284.1	532.9	290.4	421.8
SAFETY, RELIABILITY AND QUALITY ASSURANCE	22.6	33.0	33.0	33.6
ACADEMIC PROGRAMS	37.5	50.1	55.1	64.6
TRACKING AND DATA ADVANCED SYSTEMS	19.4	20.0	20.0	22.0
TOTAL	5227.7	7074.0	6023.6	7198.5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; 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; [$6,023,600,000] **$7,198,500,000, to remain** available until September 30, 1993, (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1991; additional authorizing legislation to be proposed.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

SABI SUMMARY

(In ; ; of dollars)

	Budget Plan FY 1990	FY 1991	FY 1992
Space station.......................... ..	203	391	151
Space transportation capability development..........................	92,042	82,158	189,838
Space science and applications..	457,184	351,094	415,808
Commercial programs.....................	3,662	3,700	3,700
Aeronautical research and technology.....	68,049	58,059	46,743
Transatmospheric research and technology.	2,625	3,040	3,650
Space research and technology............	22,975	22,146	18,360
Academic programs......................	453	385	385
Safety, reliability and quality assurance	820	850	920
Energy technolgy.......................	16,988	18,014	14,220
Total................................	665,001	539,837	613,775

NATIONAL AERONAUTICS *AND* SPACE ADHINSTRATION

FISCAL YEAR 1992 ESTIMATES

DISTRIBUTION OF RESEARCH *AND* DEVELOPMENT BUDGET PUN BY INSTALLATION *AND* FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Plight Center	Stennis Space Center	Coddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Station	1990	1,749,623	786,783	44,979	313,264	345	182,120	11,251	2,302	3,711	233,960	170.908
	1991	1,900,000	DISTRIBUTION UNDER REVIEW									
	1992	2,028,900	DISTRIBUTION UNDER REVIEW									
Space Trans Cap Dev	1990	558,142	162,700	85,500	290,000	6,000	7,200	300	---	500	300	5,642
	1991	602,500	190.400	119,200	252,600	9,100	13,200	600	---	1.300	1,900	16.200
	1992	879,800	248,600	127,600	418,200	24,000	14,400	400	---	1,100	29,200	15,300
Space Scf and Apps	1990	1,998,288	66,987	15.452	294,056	512	711,302	507.945	106,886	24,564	92,077	178.505
	1991	2,429,600	79,785	15,710	264,743	595	1,077,304	575,060	129,578	26,330	69,657	190.838
	1992	2,934,600	105.221	18,332	361,768	812	1,161,168	818,241	145,319	37,500	68,413	217.826
Physics and Astronomy	1990	659.434	14,011	11,291	247,925	---	495,313	23,294	15,221	200	---	52,119
	1991	975,100	15,800	10,300	215,400	---	623,100	16,000	20,300	---	---	74,200
	1992	1,140,600	17,206	10,300	301,600	---	686,900	30,800	9,100	---	500	84,200
Life Sciences	1990	106,051	42,033	4,161	---	40	338	1,038	44,014	378	---	14,049
	1991	138,000	54,579	5,410		55	442	1,352	57,146	497	---	18.529
	1992	183,960	76,038	8,032	---	02	655	2,008	71,499	738	---	24,848
Planetary Exploration	1990	390,848	9,300	---	100	---	11,900	300,623	15,000	25	-*-	47.900
	1991	457,100	8,000	---	200	---	17,300	371,200	13,500	---	---	46,900
	1992	627,300	9,400	---	200	---	18,200	535,700	14,100	---	---	49,700
Earth Science & Appr	1990	434,199	58	---	8,426	377	179,600	144,263	28,425	21,873	---	51,177
	1991	667,900	---	---	8,730	540	412,650	155,530	32,850	23,500	---	34,100
	1992	775,600	---		11,800	730	430,400	210,360	44,420	31,700	---	46,110
Materials Proc in Space	1990	101,887	1,525	---	37,607	---	75	28,081	14	2,088	27,771	4,726
	1991	102,300	1,326	---	37,413	---	80	22,890	---	2,333	31,057	7.201
	1992	125,800	2,583	---	44,668	---	85	20,276	---	4,982	41,963	3.243
Communications	1990	77,652	---	---	---	---	2,525	5,321	50	---	64,306	5.450

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1992 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Commercial Programs	1990	56,532	1,665	1,260	1,240	4,690	1,440	1,050	740	640	440	43,367
	1991	86,000	14,759	1,072	1,478	5,282	1,900	466	970	1,090	685	58,298
	1992	150,000	50,460	1,567	1,907	6,245	2,416	491	1,067	1,039	788	84,020
Technology Utilization	1990	23,700	415	510	340	940	940	1,050	340	640	440	18,085
	1991	24,400	4,240	482	433	577	850	466	545	740	530	15,537
	1992	32,000	2,550	477	497	645	1,016	491	517	789	598	24,420
Commercial Use Of Space	1990	32,832	1,250	750	900	3,750	500	---	400	---	---	25,282
	1991	61,600	10,519	590	1,045	4,705	1,050	---	425	350	155	42,761
	1992	118,000	47,910	1,090	1,410	5,600	1,400	---	550	250	190	59,600
Aero & Space Technology	1990	785,654	15,938	1,761	58,222	0	10.191	34,523	196,498	214,339	168,748	85,434
	1991	897,400	16,800	2,000	57,200	0	11,600	36,400	219,700	239,300	182,600	131,800
	1992	1,085,000	25,300	4,500	64,600	0	72,100	36,100	238,100	277,600	244,200	122,500
Aero Research & Tech	1990	442,598	85	112	912	---	544	725	165,702	156,651	106,695	11,172
	1991	512,000	---	---	---	---	800	1,000	188,600	180,300	128.900	12,400
	1992	591,200	---	---	---	---	500	700	199,500	206,600	170,500	13,400
Space Research & Tech	1990	284,029	15,853	1,649	57,260	---	9,647	33,798	26,735	50,305	50,875	37,907
	1991	290,400	16,800	2,000	57,200	---	10,800	35,400	27,600	53,900	50,100	36,600
	1992	421,800	25,300	4,500	64,600	---	71,600	35,400	34,200	63,500	68,400	54,300
Transatmos Res & Tech	1990	59,027	---	---	50	---	---	---	4,061	7,383	11,178	36,355
	1991	95,000	---	---	---	---	---	---	3,500	5,100	3,600	82,800
	1992	72,000	---	---	---	---	---	---	4,400	7,500	5,300	54,800

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1992 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Tracking & Data Acqui	1990	19,328	---	---	---	---	5,750	13,255	---	---	---	323
	1991	20,000	---	---	---	---	5,750	13,900	---	---	---	350
	1992	22,000	---	---	---	---	6,100	15,500	---	---	---	400
Academic Programs	1990	37,498	1,495	530	2,270	509	1,642	866	1,365	4,846	988	22,987
	1991	55,100	1,989	1,389	2,654	991	2,495	1,043	1,895	3,972	1,763	36,909
	1992	64,600	2,089	1,438	2,455	1,070	2,017	1,573	1,972	3,100	1,661	47,225
Safety,Reliability & QA	1990	22,630	1,080	796	1,321	120	1,645	3,260	150	2,380	1,375	10,503
	1991	33,000	2,200	1,350	1,500	400	2,750	3,900	300	1,900	2,900	15,800
	1992	33,600	2,300	1,700	2,100	550	2,900	3,900	350	2,800	3,800	13,200
TOTAL BUDGET PLAN	1990	5,227,695	1,036,648	150,278	960,375	12,176	921,290	572,450	307,941	250,980	497,888	517,669
	1991	6,023,600	305,933	138,721	580,175	16,368	1,114,999	631,369	352,443	273,892	259,505	450,195
	1992	7,198,500	433,970	155,337	851,030	33,477	1,261,101	876,205	386,808	323,139	348,062	500,471

NOTE: FY 1991 AND 1992 CENTER DISTRIBUTION DOES NOT REFLECT THE SPACE STATION FREEDOM
FUNDS SINCE THE DISTRIBUTION IS UNDER REVIEW

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF A FLIGHT — **SPACE STATION FREEDOM**

SUMMARY OF RESOURCES REOUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Development............................	1,661,223	2,299,800		
Flight telerobotic servicer..............	79,400	106,300	(UNDER REVIEW)	
Operations.............................	--	8,900		
Advanced programs......................	9.000	36.000		
Total................................	1.749.623	2.451.000	1.900.000	2028.900

pistribution of Proeram Amount bv Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center.....................	786,783	1,051,065		
Kennedy Space Center....................	44,979	87,027		
Marshall Space Flight Center.............	313,264	531,238		
Stennis Space Center....................	345	260		
Goddard Space Flight Center..............	182,120	140,529		
Jet Propulsion Laboratory................	11,251	9,200		
Ames Research Center....................	2,302	2,000		
Langley Research Center..................	3,711	3,020		
Lewis Research Center...................	233,960	369,484		
Headquarters...........................	170.908	257.177		
Total................................	1.749.623	2.451.004	1.900.000	2.028.900

The distribution by program element and by center for the FY 1991 current estimate and the FY 1992 budget estimate are under review, pending the preliminary results of the 90-day study to restructure the Space Station program, directed by the Conference Report accompanying the FY 1991 HUD-VA-Independent Agencies Appropriation Bill (P.L. 101-507). A 30-day extension has been requested with the completed analysis due in early March.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

OFFICE OF SPACE FLIGHT — SPACE STATION FREEDOM

OBJECTIVES AND JUSTIFICATION

Development of the permanently manned Space Station will add new momentum to the civil space program and is essential to preserving U.S. preeminence in spaced-based science, technology and manned space flight. The Space Station will uniquely enhance the U.S. space science programs, further the commercial utilization of space, and stimulate the development and application of advanced technologies of national importance. The Space Station Freedom (SSF) program gives NASA our first opportunity to gain direct experience in very long term human operations in space, and knowledge essential to future space exploration. It is also the centerpiece of cooperation with our international partners demonstrating the peaceful use of space for the benefit of all.

The SSF will be unique because it will provide the United States with a permanently manned presence in space, and will accommodate diverse capabilities. This new laboratory, a research center in space, will stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge. Perhaps the most significant feature of the Space Station, essential to its utility for science, commerce, and technology, is the presence of its crews. Men and women aboard the Space Station will be able to apply their resourcefulness and creativity to enhance operations and experimentation. The Space Station's microgravity environment and extended time in orbit will enable scientists to make new discoveries in such areas as in materials research and life sciences.

The SSF will be a multipurpose, international facility. In 1984, President Reagan invited the full participation of other nations. During the ensuing definition phase, Canada, member countries of the European Space Agency (ESA), and Japan worked closely with the United States to define their participation. These parallel definition and preliminary design studies have resulted in the identification of the Space Station elements to be developed by our partners. Negotiations with these international partners for the development phase of the program were completed in the fall of 1988. Agreements have been signed with the Canadian government for the development of a mobile servicing system and with the member countries of ESA for the inclusion of a pressurized attached module, a man-tended free flyer, and a polar platform. An agreement has also been signed with the Japanese government for the development of an attached laboratory module. In accordance with the terms of the agreements, the United States and the international partners will share the total available resources and the costs for its operation.

The basic configuration of the Space Station and its supporting elements is a result of a lengthy and iterative process involving NASA centers, U.S. industry, our international partners, and the national and international science communities. Although the configuration is being reviewed as part of the current restructuring study, the starting baseline is comprised of a single horizontal boom structure with up to 75KW of photovoltaic power, U.S. laboratory and habitation modules, resource nodes, two international laboratory modules (one European and one Japanese), and a Canadian mobile servicing capability. These elements comprise the manned base, and provide accommodations for science and application payloads. However, the funding constraints specified for the study result in severe reductions to the funding profile planned for all years. The content of the pre-study baseline will have to be rephased and reduced, and development and assembly schedules will be adjusted accordingly. Management and funding of the U.S. Polar Platform have been transferred to the Office of Space Science and Applications, consistent with previous planning.

The Conference Report accompanying the FY 1991 HUD-VA-Independent Agencies Appropriation Bill (P.L. 101-507) directed NASA to revise the Space Station Freedom design and assembly sequence and make its recommendations within 90 days of the enactment of P. L. 101-507. The Act was signed November 5, 1990. NASA is undertaking this study with the objective of developing a plan within the specified constraints, while providing capabilities acceptable to domestic users, our international partners, Congress and the Administration. The specific goal is to restructure the Space Station program to require slower annual funding growth than previously planned, to simplify both development and operations, and to maintain capabilities for early utilization. The study will not be completed within the 90 days, and an extension has been requested to early March 1991. A recent significant accomplishment of the Space Station Freedom program was the conduct and completion of the Integrated Systems Preliminary Design Review in December, 1990. Since one objective in the restructuring activity is to efficiently use existing designs to the extent possible, the completion of the Preliminary Design Review (PDR) also served as a significant step in the restructuring activity. We continue to make other substantial progress in our restructure efforts. We have been working closely with the Space Station Freedom contractors and our international partners to simplify the Station design and implementation schedule to reflect the Committees' expectation of a more incremental approach.

In addition to the development of the manned base, the Space Station program has included development of a Flight Telerobotic Servicer (FTS). The limited role of the FTS within the constraints of the restructured Space Station program has impelled transfer of the project outside the Space Station program. A revised project with modified objectives will be managed by the automation and robotics organization of the Office of Aeronautics, Exploration, and Technology.

One design objective of the Space Station is to enable hardware and software to evolve in response to increased user demands and the need for augmented operational capabilities. The achievement of this objective is dependent on the results of the research, studies, and advanced technical developments funded within advanced programs. These activities are important for the long-term cost-effective utilization of

Space Station Freedom and the preparation for future manned exploration. Due to the reduction in overall Space Station Freedom resources, advanced programs activities and funding are currently under review.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Congress reduced the FY 1991 funding requested for the Space Station by $551.0 million. The current study to restructure the program is not yet complete, and an extension is anticipated. Because of this extension and the magnitude of the reductions necessary in funding plans for not only FY 1991, but also for FY 1992 and subsequent years, the definition of requirements is not yet sufficient to develop more detailed estimates. The reduction has necessitated deferral of operations funding requirements in FY 1991, a change from the $8.9 million requested in the budget. Detailed estimates and decisions on funding levels for development, FTS, and advanced programs have not yet been made.

BASIS OF FY 1992 ESTIMATE

As stated previously, the timing of the restructuring study and the magnitude of the reductions to the funding profile have delayed development of detailed cost estimates and decisions on relative program priorities. A decision has been made to fund a modified FTS program under the Office of Aeronautics, Exploration and Technology commencing in FY 1992.

SPACE
TRANSPORTATION
CAPABILITY
DEVELOPMENT

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

[redacted] **SPACE TRANSPORTATION CAPABILITY DEVELOPMENT**

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spacelab................................	93.700	130.700	129,300	150,200	RD 2-4
Upper stages............................	79.700	91,300	82,200	108,500	RD 2-7
Engineering and technical base...........	181.600	218,500	208,500	235,200	RD 2-9
Payload operations and support equipment.	65.461	122,500	101,500	144,500	RD 2-12
Advanced programs.......................	34.700.	53,200	35,200	53,800	RD 2-14
New launch system.......................	--	53,900	23.900	175,000	RD 2-18
Tethered satellite system................	27.300	17,900	21,900	12,600	RD 2-20
Orbital maneuvering vehicle..............	75.681	85.400	--	--	RD 2-21
Total................................	558.142	773.400	602.500	879.800	

Distribution of Program Amounts By Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center....................	162.700	243.100	190.400	248,600
Kennedy Space Center....................	85.500	117,200	117,200	127,800
Marshall Space Flight Center.............	290.000	312,000	252,600	418,200
Stennis Space Center....................	6,000	6,100	9.100	24,800
Goddard Space Flight Center..............	7,200	9.800	13,200	14,400
Jet Propulsion Laboratory................	300	500	600	400
Langley Research Center..................	500	1.400	1,300	1,100
Lewis Research Center...................	300	6,500	1,900	29,200
Headquarters............................	5.642	76.800	16.200	15.300
Total................................	558.142	773.400	602.500	879.800

PROGRAM OBJECTIVES AND JUSTIFICATION

The principal areas of activity in Space Transportation Capability Development include the operation of the Spacelab Systems with some continuing development activities; procurement of Upper Stages required to place satellites in high altitude orbits; the Engineering and Technical Base support at the manned space flight centers; Payload Operations and Support Equipment for accommodating NASA payloads; Advanced Programs study and evaluation efforts; Advanced Transportation Technology efforts including definition and preliminary development of a new launch vehicle capability and improved propulsion technology; and the design and development of the United States/Italian Tethered Satellite System.

Spacelab and the Spacelab carrier systems were developed jointly by NASA and the European Space Agency (ESA). The Spacelab is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter cargo bay. The Spacelab carrier systems include pallets which provide payload mounting and support services (pointing, computer control, data processing, power, cooling, etc.). The Spacelab and carrier systems development program continues with a recertification program to insure flight safety, the procurement of flight hardware to support the flight program, and necessary modifications including replacing the onboard computer system, verification of the cross-bay Hitchhiker and Spacelab Pallet System (SPS), an Igloo pallet system, and upgrading obsolete Spacelab hardware to current technology.

Upper Stages are required to deploy payloads to orbits and trajectories not attainable by the Shuttle or expendable launch vehicles alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, and a solid rocket motor integrity program to improve the technical understanding and the engineering capability for solid motors.

The Engineering and Technical Base provides a core level research and development capability for the engineering, scientific, technical and Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA) support required by a wide variety of NASA programs at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC). Additional requirements above the core level of capability are funded by the benefiting programs.

The Payload Operations and Support Equipment program develops and places into operational status the ground and flight systems necessary to support the NASA STS payloads during prelaunch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program area are the STS optional services for NASA payloads, integration activities for the Shuttle and Space Station (including development of a mating capability), and multimission payload support equipment.

Advanced Programs conducts concept feasibility studies, selected system definitions and preliminary design (Phase B) studies, and undertakes related high leverage advanced development to provide the technical and programmatic data to identify evolving space transportation and system requirements and to evaluate new technology capabilities. Complementary objectives are to assimilate generic technology and advanced planning activities, and to provide an advanced planning programmatic link between the Office of Space Flight and other NASA program offices. Activity is focused on three major areas--advanced transportation, advanced operations support, and advanced space systems. Concept definition and key advanced development are under way and planned in these areas to assess performance, reliability and operational efficiency improvements, and to reduce future program risks and development costs through the effective use of new technology.

The New Launch System activity includes the initiation of a program to develop a new heavy lift launch vehicle as well as continuing Shuttle-C definition studies in 1991.

The Tethered Satellite System (TSS), a joint Italian/United States development effort, will provide a new reusable facility for conducting space experiments and unique tethered applications in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

BASIS OF FY 1992 FUNDING REQUIREMENT

SPACELAB

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Development	20,300	11,400	22,600	30,000
Operations	73.400	119.300	106.700	120.200
Total	93,700	130,700	129,300	150,200

OBJECTIVES AND STATUS

The Spacelab is a versatile facility designed for installation in the cargo bay of the orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. The reusable Spacelab system enhances the advancement of scientific research by serving as both an observatory and laboratory in space. Ten European nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. ESA designed, developed, produced, and delivered the first Spacelab hardware consisting of: a pressurized module and unpressurized pallet segments, an igloo which is used with pallets to supply equipment, computers and services essential to the experiments, an instrument pointing subsystem (IPS), and much of the ground support equipment and software for both flight and ground operations.

NASA procured an additional set of Spacelab hardware from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement. The remaining development activities include additional hardware to complete the Spacelab carrier system, ground support equipment, hardware modifications, hardware acquisition, system recertification, and qualification and procurement of reliable and high capacity AP-101SL computers. Support software and procedures development, testing, and training activities not provided by ESA, which are required for the Spacelab, are also included in NASA's funding. Additional Spacelab hardware, including the initial lay-in of spare hardware, is being procured from European and U.S. sources.

NASA has developed two principal versions of the Spacelab Pallet System (SPS). One will support missions requiring the igloo and pallet in a mixed cargo configuration like the Astro mission; the other version, the Enhanced Multiplexer/demultiplexer Pallet (EMP), will support missions that do not require use of the igloo such as the Materials and Structural Technology Experiment (MAST), the Space Technology Experiment Platform (STEP) and the Tethered Satellite System. In addition, the development of the Hitchhiker system is nearly complete. The Hitchhiker (MSFC design) will fly its verification flight as Space Test Program Experiment (STP-1) in FY 1991.

The Spacelab operations budget includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining engineering.

ASTRO-1, supported by an Igloo Pallet and Instrument Pointing System, was launched on a successful ultraviolet astronomy mission in December 1990. It was the first Spacelab mission to fly since Challenger. Two additional missions will fly Spacelab carriers in FY 1991, one a Module (Life Sciences investigations) mission and one supported by a Hitchhiker (several DOD experiments). Spacelab carriers will support eight missions in FY 1992. Three Spacelab module missions (microgravity materials science and life science investigations) and two Spacelab pallet missions (solar, atmospheric, and plasma physics and tethered spacecraft investigations) are planned with smaller Spacelab carriers such as Hitchhikers (x-ray radiation from space investigations), Getaway Special, and Mission Peculiar Experiment Support Structures (materials processing, and EVA, strut handling techniques in support of Space Station Freedom investigations) supporting other missions. Nine missions will also be supported in FY 1993 including two Spacelab module missions (materials processing and life sciences) and two Spacelab pallet (thermal energy management process investigations in support of Space Station Freedom and solar atmospheric, and plasma physics investigations) missions.

In addition to the support of these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1992 and FY 1993 as will operation of the depot maintenance program.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The $1.4 million decrease results from the rephasing of operations manpower based on the latest manifest partially offset by necessary increases in development to replace obsolete and failing equipment.

BASIS OF FY 1992 ESTIMATE

The FY 1992 request reflects the increase in the scheduling and frequency of Spacelab missions which were delayed by the Challenger accident and several Shuttle launch delays. Funding provides for the integration and payload processing of three to four major and three to four secondary missions per year.

The FY 1992 development funds are required to continue procurement of additional computers and experiment hardware and to upgrade or replace obsolete hardware in order to support an accelerated and active Spacelab traffic flow. The Spacelab flight hardware recertification, development of the Hitchhiker programs, and the Enhanced Multiplexer Pallet system (EMP) will be completed early in 1991.

The FY 1992 operations funds are required to support increased payload operations activities and to continue payload integration support, mission independent training, and logistics support. This support includes analytical integration, configuration management, hardware integration and software development and integration. Spacelab operations also provides for replenishment spares, the operation of the depots for both U.S. and European hardware and software, and sustaining engineering of all hardware and software. Funding is also included for the Getaway Special (GAS) program.

Included in the FY 1992 operations support of the Spacelab carrier missions is funding required for a number of major and minor missions. The NASA major missions requiring mission integration and payload processing in FY 1992 include the International Microgravity Laboratory-1 (IML-1), the U.S. Microgravity Laboratory-1 (USML-1), the Tethered Satellite System, a U.S. Microgravity Payload, and the Atmospheric Laboratory for Applications and Science (ATLAS-1). In addition, the Space and Life Sciences-2 (SLS-2) and ATLAS-2 mission, a Shuttle Radiator Assembly Demonstration (SRAD), and the second US Microgravity Payload (USMP-2) are planned for flight in FY 1993.

In addition to NASA missions, the Spacelab program will also support two (2) reimbursable missions: the Japanese SL-J module mission which is scheduled for FY 1992 and the German D-2 module mission which is scheduled for FY 1993. Appropriated funding is combined with reimbursable funding to support the total Spacelab operations requirements.

BASIS OF FY 1992 FUNDING REOUIREMENT

UPPER STAGES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Development	400	--	--	--
Procurement and operations	79.300	91.300	82.200	108.500
Total	79.700	91.300	82.200	108.500

OBJECTIVES AND STATUS

The Upper Stages are required to deploy payloads to orbits not attainable by the Shuttle or a core stage expendable launch vehicle (ELV) alone. The Inertial Upper Stage (IUS), the commercially developed Transfer Orbit Stage (TOS), and the Centaur upper stage are currently available for use.

The IUS was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The IUS has been launched from the Shuttle, the Titan 34-D and Titan IV Expendable Launch Vehicles. Six IUS vehicles have been contracted for launch of the Tracking and Data Relay Satellite System (TDRSS) spacecraft. The first three were funded through the TDRSS contract while the remaining three are funded under this budget element. The TDRS-E and TDRS-F are planned for launch on the Shuttle. The TDRS-G is now planned for launch on a competitively procured expendable launch vehicle. Three planetary missions, Magellan, Galileo and Ulysses, were previously launched with IUS upper stages.

TOS is a three-axis stabilized perigee stage that is being developed commercially by the Orbital Sciences Corporation for use with the Space Shuttle and the Titan 111. It will have the capability to place 6,000 to 13,000 pounds into geosynchronous transfer orbit. A TOS/Titan III and a TOS/Shuttle upper stage are being procured for the Mars Observer and the Advanced Communications Technology Satellite (ACTS) missions to be launched in FY 1992.

The Solid Propulsion Integrity Program (SPIP) objective is to establish the necessary engineering capability for improving the success rate of U.S.-built solid rocket motors. The program has made excellent progress in determining root causes and solutions to persistent problems plaguing motor nozzles and bondlines. The program is successfully moving the Nation's industry toward solid motors that have an improved basis in science and engineering. The program results are being used across the Nation's solid rocket motor community, including the Redesigned Solid Rocket Motor, the Advanced Solid Rocket Motor, and DOD solid motor programs.

The Centaur upper stage is being developed under the DOD Titan IV contract, which will provide capability beyond the Titan IV core stage performance. The Centaur will be required to support the launch of the Cassini and the Comet Asteroid Flyby (CRAF) missions.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Funding for Upper Stages is reduced $9.1 million due to revised DOD estimates on the Centaur and deletion of an IUS modification kit for the TDRS-F, currently baselined as a Shuttle flight.

BASIS OF FY 1992 ESTIMATE

Procurement and operations funding is required to continue production of major components and subsystems to support launch and flight operations of Upper Stages on both the Shuttle and ELV's for NASA missions. These missions include Shuttle IUS's for TDRS-E&F and completion of the Transfer Orbit Stage (TOS) for the Advanced Communications Technology Satellite (ACTS). Upper stages are also procured for the Expendable Launch Vehicle missions including an IUS for TDRS-G, a TOS stage for Mars Observer on a Titan III, and a Centaur stage for the Cassini mission on a Titan IV. Procurement of a Centaur for the CRAF mission has been delayed pending a decision on its launch date. The Solid Propulsion Integrity program is also continued.

BASIS OF FY 1992 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Research and test support	117,700	148,500	137,200	148,700
Data systems and flight support	17,400	18,400	17,900	23,800
Operations support	33,800	34,600	37,700	46,700
Launch systems support	12,700	17,000	15,700	16,000
Total	181,600	218,500	208,500	235,200

OBJECTIVES AND STATUS

The Engineering and Technical Base (ETB) provides the core capability required to sustain an engineering and development base for various NASA activities at the Office of Space Flight centers. Additional requirements above the core level are funded by the benefiting programs, such as the Space Shuttle or the Space Station. The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories and at the White Sands Test Facility. Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) areas are also supported by the ETB core. The core level for the central computer complex is established as a two-shift operation. At KSC, the core level provides for research and development of technology to enhance launch site hardware, ground processing, support services, and SRM&QA. The ETB funds at MSFC provide for multi-program support activities, including technical labs and facilities, SRM&QA, computational and communications services, and at SSC for facilities operations.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The total funding for the ETB has decreased $10.0 million in FY 1991 from the requested level as the result of general Congressional reductions. This will limit engineering and SRM&QA manpower growth at JSC, KSC and MSFC to the end of the FY 1990 level and defer planned equipment purchases at JSC and MSFC. The limits on engineering manpower at JSC and MSFC will constrain the support available to continuing programs.

BASIS OF FY 1992 ESTIMATE

The requested funding for ETB in FY 1992 provides for an increase of supp rt for basic research and development facilities and services at the centers to meet critical requirements for support to Shuttle, Space Station and other space transportation activities which have expanded their requirements significantly over the past several years. Areas that will be increased include the core capability for SRM&QA requirements, maintaining the capabilities of engineering labs and engineering support services with state-of-the-art equipment, and providing full manpower coverage to the single shift in the engineering labs.

In research and test support, funding is required to support computational capabilities at MSFC for engineering and science projects through the use of a Class VI computer system. This capability is required for the solution of more complex main engine three-dimensional dynamics modeling problems and for complex structural analyses. At JSC, the requested funding will provide for a five-day, one-shift operation for the engineering and development laboratories, such as the Electronic Systems Test Laboratory, the Thermo-chemical area, and SRM&QA activities, as well as a full up operation of a Class VI computer system. The computer will be used to obtain numerical solutions of very large sector materials for the aerodynamics, thermodynamics, and structural mechanics analysis associated with developing and operating manned and robotic space systems.

The FY 1992 request is consistent with achieving increases in engineering support at JSC and MSFC necessary to support new facilities in robotics, avionics, and computer aided design. The increase in FY 1992 also continues the program to replace obsolete multipurpose laboratory equipment which had been slowed in prior years.

Data systems and flight support will continue to provide a core level of support based on a five-day, two-shift operation of the central computer complex at JSC. Any additional requirements are the responsibility of the benefiting program. Increases in FY 1992 over FY 1991 are needed to initiate the information technology labs at JSC.

Operations support funding will continue to provide for the maintenance of multi-program research and development facilities and equipment, chemical cleaning, engineering design, technical analysis, component fabrication, and logistics support. Examples of specific services to be provided in FY 1992 include: (1) operation and maintenance of specialized electrical and cryogenic systems; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house hardware; (3) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for the support and surveillance of tests; (4) mission imaging services, including audiovisual mission support; (5) fabrication of models, breadboards, and selected items of flight hardware; and (6) technical documentation services. In FY 1992, increases are required at MSFC for ADP equipment, software, and programming support to accommodate additional users, data storage requirements, improve response time to users, and to implement a local area network. Increases at White Sands are needed to support environmental compliance activity.

In launch systems support, funding provides for the core capability for the engineering, scientific, and technical support for research and development activities at KSC. Specifically, the funds provide for multi-program support activities, including technical labs and facilities, and other engineering support services.

BASIS OF FY 1992 FUNDING REQUIREMENT

PAYLOAD OPERATIONS AND RT EQUIPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Payload operations......................	46,961	94,200	77,000	119,400
Payload support equipment................	18.500	28.300	24.500	25.100
Total................................	65.461	122.500	101.500	144.500

OBJECTIVES AND STATUS

The objectives of the Payload Operations and Support Equipment budget are to provide payload services which are required beyond the standard Shuttle services for NASA missions, and to provide multimission support equipment in support of all payload operations. Payload operations provide unique hardware, analyses, and launch site support services for NASA missions. A significant part of the total funding directly supports integration activities for the Space Station and Space Shuttle which include development of a mating system between the orbiter and the Space Station. The payload support equipment budget funds the development and acquisition of multimission reusable ground support equipment required for a wide range of payloads. This includes test equipment required to checkout payload-to-orbiter interfaces at KSC, mixed cargo hardware such as standard cable harnesses, and displays and controls related to payload bay operations.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Payload Operations and support equipment funding has decreased $21.0 million from the budget estimate as the result of general Congressional reductions. This will limit payload optional services which can be accommodated due to manifest adjustments. In addition, Space Station integration activities including the development of a mating system will be delayed.

BASIS OF FY 1992 ESTIMATE

Payload operations funding is required to support payload services for currently scheduled NASA launches including Space Station integration activities. Space Station integration funding is required to support technial integration to assure compatibility between Shuttle capabilities and Space Station requirements. There is a significant increase from FY 1991 due to initiating hardware development for the orbiter-to-station mating system as well as requirements for spacesuits, payload retention hardware, EVA activity, and other support hardware. Major payloads receiving support during this year include Upper Atmosphere Research Satellite (UARS), International Microgravity Laboratory (IML-1), Tethered Satellite System (TSS-1), European Retrievable Carrier (EURECA 1L), Intelsat Reboost, Advanced Communications Technology Satellite (ACTS), Canadian Experiment (CANEX-2), Diffuse X-ray Spectrometer (DXS), Atmospheric Laboratory for Applications and Science (ATLAS-1); and United States Microgravity Lab (USML-1). Funding is required to initiate technical integration and operations activities to assure compatibility between Shuttle capabilities and Space Station transportation requirements. A mating system for the orbiter is being developed as part of this activity.

Payload support equipment estimates reflect the requirement to modify and upgrade selected payload integration facilities for safer, more efficient operations. FY 1992 funding for multimission payload support equipment is required for development testing and delivery of payload common communication equipment (PCCE) to accommodate required payload data transmission, and initial spares provisioning for Cargo Integration Test Equipment (CITE) and PCCE. Also included is funding for the Payload Data Management System (PDMS) which is a physically and functionally integrated network of computer and software systems that provide data processing support to NASA and user communities in support of Shuttle payloads, including Space Station Freedom. Funds for fiber optic cabling and an upgraded operational intercom system in the industrial area at KSC are included in this budget to provide increased reliability and quality of data transmission among cargo facilities. Multimission payload support equipment funding also includes orbiter/payload interface hardware for groups of payloads, cargo bay cabling, modified aft flight deck panels, and associated display and controls.

BASIS OF FY 1992 FUNDING REQUIREMENT

ADVANCED PROGRAMS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced transportation..................	21,500	26,900	11,600	26,600
Advanced operations.....................	6,300	12,300	11,600	12,500
Advanced space systems..................	6.900	14.000	12.000	14.700
Total................................	34.700	53.200	35.200	$3.800

OBJECTIVES AND STATUS

The principal objectives of Advanced Programs are to conduct definition studies and selected advanced development to support potential new development programs, system improvements and expanded capabilities for space transportation systems. The definition studies include concept definitions, selected system definition and preliminary design studies, and key advanced development addressing requirements for increased reliability, cost effectiveness, and capability of space flight systems. Information from these studies will support decisions on the best alternatives for developing capabilities required to support future mission options. High leverage advanced development efforts will be conducted to reduce future program development risks and costs through the effective application of new technology. A complementary objective is to provide an advanced planning programmatic link between the Office of Space Flight and other NASA program offices.

The Advanced Program effort is focused on three major areas--advanced transportation, advanced operations, and advanced space systems. Advanced transportation activities include systems analysis and concept definition of launch vehicles as well as some advanced development activities to demonstrate promising technologies, Definition studies will be initiated on concepts for a new personnel launch system, systems for unmanned vehicles to deliver cargo to the Space Station, Shuttle evolution options, and advanced fully reusable manned vehicles. The advanced development activity will address such high payoff areas as Electrical Actuators, Advanced Guidance, Navigation & Control (AGN&C), and aluminum lithium fabrication techniques.

The Advanced Operations Program continues the pursuit of its goal of improving the ground and mission operations efficiency of the Space Shuttle through the introduction of advanced technologies into the operations environment. During FY 1990, the program transitioned several of its development projects to operations, including an automated computer network status and health monitoring system in the Shuttle Mission Control Center, a computer maintenance expert system at the Kennedy Space Center (KSC), a noise filtering headset for use by suited workers during hazardous Shuttle ground processing, and a spectral/video analyzer for use in detecting anomalies during Shuttle main engine testing at the Stennis Space Center (SSC). The advanced operations program also funded the Mission Operations Efficiency Study at the Johnson Space Center (JSC) which analyzed the complete mission operation process at the Center and recommended modifications to organizational roles, interfaces and procedures to improve operations efficiency through the reduction of responsibility overlap, product duplication and non-value-additive functions. FY 1991 will see additional development projects integrated into Shuttle operations, including a complete Launch Processing System operations analysis and remote maintenance expert system in the Shuttle Launch Control Center, a new system to detect leaks during engine testing at SSC, and improved methods of inspecting Shuttle radiators and thermal protection tiles during postflight processing at KSC.

The Advanced Space Systems program includes concept definition, advanced hardware development, or flight experiments in the following areas: flight demonstrations, orbital debris, satellite servicing, and tether applications. The flight demonstrations are directed at supporting the objectives of the Office of Space Flight as well as training young NASA engineers and managers with "hands-on" flight hardware experience. In October 1990, a Voice Control System for the Shuttle closed circuit television system was successfully demonstrated on STS-41. The orbital debris program is directed at understanding the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability. In FY 1990, a program was initiated which will result in measurement of the orbital debris environment using groundbased radar. At the conclusion of the first phase of this program, the uncertainty in our estimates of the orbital debris environment is expected to be reduced from 300 percent to 35 percent. The satellite servicing program is directed at developing satellite servicing tools and techniques in support of ongoing or planned NASA space programs. A power ratchet tool, developed for the Hubble Space Telescope Mission, was flown on the 1990 mission. Had another solution not been successful, this power tool would have been utilized in the event an EVA was required to fully deploy the telescope solar array. Transportation-related tether applications studies continue to define and implement flight experiments and demonstrations including orbital altitude changes without the use of propellants and tether-initiated recovery systems for the immediate or emergency return of small payloads from space. A flight deployer was delivered for testing in FY 1990 of a Small Expendable Deployer System. This system will enable the demonstration of a tether-initiated deployment on an expendable rocket as a secondary payload scheduled for flight in FY 1992.

CHANGES FROM FY 1991 BUDGET ESTIM

The current estimate reflects a net reduction of $18.0 million consistent with Congressional direction. This reduction was accommodated primarily through deferral of the Assured Crew Return Vehicle (ACRV) Phase B study and other program realignments.

BASIS FOR FY 1992 ESTIMATE

In FY 1992, major program emphasis will continue to be placed on concept definition, system definition, and advanced development for advanced space transportation, advanced operations support systems, and advanced space systems.

Funding for studies and technology efforts in the advanced transportation area is bring augmented to reflect an increased priority on activities related to advanced launch systems. This priority is consistent with key recommendations of the Advisory Committee on the Future of the U.S. Space Program. Manned vehicle activities will include studies for near-term concepts to complement the Shuttle in providing assured manned access to Earth orbit and longer-term concepts of advanced space systems to ultimately replace the Shuttle. Work will continue on concepts for a personnel launch system (PLS), which might be used with the proposed new unmanned launch system. Analysis of lift-to-drag characteristics and other design considerations will continue so that concept definitions can be finalized. The Precision Recovery System demonstrations will be expanded to assess applications for potential payloads which could have mid-term life duration in space, for return of expensive ELV components and possible other concepts of the PLS. In the area of unmanned launch systems, concepts, for payload delivery to the Space Station will be assessed, including studies of potential requirements for rendezvous and docking operations. Advanced development activities will be continued in the areas of Advanced Guidance, Navigation and Control (AGN&C), Electrical Actuators (EAs), health monitoring system level checkout/built-in test equipment (BITE) for on pad launch conditions and post flight subsystem status data readings, and expanding advanced structure and material fabrication/ manufacturing techniques. A joint effort will be conducted with the Office of Aeronautics, Exploration and Technology (OAET) to assess alternative propulsion system concepts for low cost boosters, system simplifications and pressurization systems. Also, studies will be initiated leading to the development of automated rendezvous and docking capability with focus towards the definition of a flight demonstration utilizing two unmanned vehicles.

Advanced operations efforts will continue to emphasize the identification and demonstration of technologies to improve efficiency, flexibility and reliability of current and future space transportation systems. Included in advanced operations is the selective application of expert systems, robotics, automation, and other technologies to labor-intensive and hazardous operations. Launch processing systems, mission control applications, flight planning, training, simulation and other environments will be targeted to demonstrate emerging technologies for improving ground and flight operations.

The advanced space systems area will define and develop manned and unmanned servicing concepts. Emphasis will be placed on the evolution towards a supervised autonomous satellite servicing capability. Systems, tools, and techniques will be defined to refuel, repair, and retrieve satellites on a routine basis. Flight experiments to demonstrate enabling technology will be performed. Detailed engineering studies will continue to focus on promising concepts of transportation-related tether applications. Critical enabling tether-related technology will be demonstrated utilizing small in-space flight experiments. Orbital debris activities will be focused on establishing measures for mitigation of debris growth trends; increasing spacecraft protection techniques and reducing debris hazards; and measuring and understanding the current and projected LEO debris environment for debris greater than 1 centimeter in diameter.

Increases in FY 1992 over FY 1991 funding levels are due to augmenting the advanced transportation studies to support increased emphasis on the new launch system.

BASIS FOR FY 1992 FUNDING REQUIREMENT

NEW LAUNCH SYSTEM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
New launch system (joint program)........	--	--	--	175,000
Advanced launch system (civil)...........	--	3,900	--	--
Advanced launch system (joint program)...	--	40,000	13,400	--
Heavy lift/Shuttle-C....................	(10,500)	10,000	10,500	--
Total................................	(10,500)	53,900	23,900	175,000

ECT AND STATUS

The objective of this national program is to develop a new unmanned (but man-rateable) launch system to support both civil and defense applications. Developing a new launch system to provide the U.S. with a flexible heavy lift capacity was a key recommendation of the Advisory Committee on the Future of the U.S. Space Program. In addition to taking operational pressure off the Shuttle and other existing launch systems for cargo missions, this program will offer new capabilities for launching a variety of spacecraft. The Space Station program, in particular, may benefit from reduced dependence on the Shuttle. If combined with a manned vehicle, some variation of the new system could eventually provide an alternative to the Shuttle for ferrying astronauts to and from space. In the longer term, derivatives of the new launch system will be required to support lunar and planetary exploration missions of the future. The program will be jointly managed by the NASA and DOD, with an equal share in common program costs. A review of potential development strategies has been initiated, with the selection of a national strategy planned to be completed by mid-1991.

While some aspects of this effort are still being defined, a strong emphasis is placed on reducing the high operational cost and complexity of launching paylaods into space. To provide an operational capability earlier than would otherwise be possible, it is likely that the initial capability will use some elements derived from existing launch vehicle programs as well as some new elements to be developed. Over the long term, it is envisioned that new technology and other improvements will be introduced to improve capabilities and reduce operational costs.

The new launch system program will replace two separate efforts described in the FY 1991 budget submission, the Advanced Launch System (ALS) and Shuttle-C. In FY 1991, there were significant reductions in both the NASA and DOD budget requests for the development of the liquid engine (the Space Transportation Main Engine (STME)), including construction of the turbopump test facility at the Stennis Space Center. Other elements of the advanced development program are being continued at a maintenance level. Limited vehicle design activity is also being continued to insure the technologies are being developed consistent with realistic vehicle requirements. The STME project is preparing for the release of the RFP for a prototype program to build and test high fidelity engines to verify design concepts. The STME is expected to be a key building block in the new launch system program. Concepts for the new program are being prepared to address vehicle concepts, technology evolution plans, facility plans, estimates of costs, and schedules. Initial results will be reviewed by the National Space Council in the spring 1991.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current budget reflects the Congressional reduction of $30.0 million. Consistent with that direction, $10.5 million is provided for Shuttle-C activities. The remaining $13.4 million will support advanced development activities, with emphasis placed on the liquid engine effort and the engine Component Test Facility at the Stennis Space Center.

B

The FY 1992 funds will be used to proceed with the initial stages of development of the new launch system. Program planning for FY 1992 has not yet been completed, but it is likely that the focus of FY 1992 activities will be on initiating development of the STME prototype engine, conducting definition and design studies of vehicle components and elements, and assessing requirements and design options for supporting launch facilities. Technologies and operational approaches that can reduce per-flight costs and increase system robustness will be pursued.

BASIS FOR FY 1992 FUNDING REQUIREMENT

THERED SA SYSTEM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Tethered satellite system................	27,300	17,900	21,900	12,600

OBJECTIVES AND STATUS

The development of a Tethered Satellite System (TSS) will provide a new reusable space facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. A number of significant scientific and engineering objectives can be uniquely undertaken with a TSS facility such as the observation of important atmospheric processes occurring within the lower thermosphere, new observations of crustal geomagnetic phenomena, and entirely new electrodynamic experiments interacting with the space plasma. This effort is underway as a cooperative development program with the Italian government.

The United States is responsible for overall program management, overall systems engineering and integration, orbiter integration, ground and flight operations, development of the deployment mechanism and provision of the non-European instruments (OSSA funded). The U.S. effort was initiated in 1984. The Italians are responsible for the design and development of the satellite and the European instruments being flown on the joint missions. They initiated their development efforts in 1984.

CHANGES FROM FY 1991 BUDGET ESTIMATES

The $4.0 million increase is driven by necessary testing of the mechanisms used to provide control during deployment and retrieval, continue systems and experiments integration effort, and adjustments due to the 9 month launch delay from May 1991 to February 1992.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding will complete the TSS flight planning and integration activities and accomplish flight operations activities. Integration of the Italian-provided satellite and the deployer-mounted science instruments at KSC will continue through early FY 1992 in preparation for the planned engineering verification flight in mid-FY 1992.

BASIS OF FY 1992 FUNDING REQUIREMENT

ORBITAL MANEUVERING VEHICLE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Orbital maneuvering vehicle..............	75,681	85,400	--	--

OBJECTIVES AND STATUS

A decision was made to terminate the Orbital Maneuvering Vehicle (OMV) program in June 1990.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Consistent with Congressional direction, no FY 1991 funding is provided. Negotiation of termination requirements have not yet been completed.

SPACE SCIENCE
AND APPLICATIONS

P

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1992 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS

	Budeet Plan				
		1991		1992	
	1990 Actual	Budget Estimate	Current Estimate	Budget Estimate	Page Number
		(Thousands of Dollars)			
Physics and astronomy..................	859,434	985,000	975,100	1,140,600	RD 3-1
Life sciences.....	106,051	163,000	138,000	183,900	RD 4-1
Planetary exploration..................	390,848	485,200	457,100	627,300	RD 5-1
Earth science......	434,199	661,500	667,900	775,600	RD 6-1
Materials processing in space....	101,887	97,300	102,300	125,800	RD 7-1
Communications....	77,652	52,800	52,500	39,400	RD 8-1
Information systems...................	28.217	36.800	36.700	42.000	RD 9-1
Total...............................	1.998.288	2.481.600	2.429.600	2.934.600	

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPWENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Hubble space telescope development.......	81,800	--	--	--	
Gamma ray observatory development........	41,200	--	22,000	--	RD 3-6
Global geospace science..................	57,600	98,500	96,600	65,300	RD 3-8
Advanced x-ray astrophysics facility development (AXAF)....................	44,000	113,000	101,200	211,000	RD 3-10
Payload and instrument development.......	93,038	97,200	94,600	115,900	RD 3-12
Shuttle/Spacelab payload mission management and integration.............	75,104	89,100	88,800	88,000	RD 3-14
Space station integrated planning and attached payloads.....................	4,975	15,000	3,000	--	RD 3-16
Explorer development....................	88,352	100,800	99,800	107,900	RD 3-17
Mission operations and data analysis.....	215,723	293,900	313,300	388,400	RD 3-20
Research and analysis...................	104,942	122,500	100,800	103,100	RD 3-23
Suborbital program.....................	52,700	55,000	55,000	61,000	RD 3-25
Total................................	859,434	985,000	975,100	1,140,600	

RESEARCH AND DEVELOPWENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY

SUMMARY OF RESOURCES REQ

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center....................	14,071	17,210	15,800	17,200
Kennedy Space Center....................	11,291	10,344	10,300	10,300
Marshall Space Flight Center............	247,925	272,374	215,400	301,600
Goddard Space Flight Center.............	495,313	559,240	623,100	686,900
Jet Propulsion Laboratory...............	23,294	30,777	16,000	30,800
Ames Research Center....................	15,221	9,305	20,300	9,100
Langley Research Center.................	200	--	--	--
Lewis Research Center...................	--	450	--	500
Headquarters............................	52,119	85,300	74,200	84,200
Total................................	859,434	985,000	975,100	1,140,600

OFFICE OF SPACE SCIENCE AND APPLICATIONS PHYSICS AND ASTRONOMY

OBJECTIVES AND JUSTIFICATION

The objectives of the Physics and Astronomy program are to increase our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. Objects studied by the astrophysics program include distant galaxies and galactic clusters, as well as stars and other structures in nearby galaxies and the interstellar medium in our galaxy. Unusual and exotic phenomena -- such as quasars, neutron stars, pulsars and black holes -- are of particular interest to the astrophysics program, and are the target of many ground-based and space-based research programs. In the space physics program, intensive study of our own sun, with its multitude of time-varying phenomena, provides key answers to a vast range of questions requiring comprehensive research into solar-terrestrial processes and the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere.

The objectives of the Physics and Astronomy program are accomplished with a mixture of large complex free-flying space missions, less complex Explorer spacecraft, Shuttle/Spacelab flights and suborbital missions. Space-based research allows observations in the infrared and the ultraviolet wavelengths which cannot be conducted on the ground due to the obscuring effects of the atmosphere. Also, observations in the visible light region are vastly improved when conducted above the atmosphere. The entire program rests on a solid basis of supporting research and technology, data analysis, and theory.

Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful. Recently, these include the Cosmic Background Explorer (COBE, 1989), the Roentgen Satellite (ROSAT, 1990), the Combined Release and Radiation Effects Satellite (CRRES, 1990), the Hubble Space Telescope (HST, 1990), and the ASTRO-1 (1990).

The HST provides an international spaceborne astronomical observatory capable of measuring objects appreciably fainter and more distant than those accessible from the ground, since it is above the turbulent and absorbent atmosphere. Currently, the Hubble Space Telescope can resolve spatial features by a factor of ten better than ground-based optical telescopes, for objects as dim as the 24th magnitude. Full capability to observe objects from 25th to the 28th magnitude, originally planned for Hubble, will be restored by the 1993 servicing mission. This increased capability will allow us to address basic questions concerning the origin, evolution, and disposition of galaxies, quasars, clusters, and stars, thus allowing us to increase significantly our understanding of both the early and present universe--its beginning and end.

The Gamma Ray Observatory (GRO) mission will be launched by the Space Shuttle in FY 1991. This mission will measure gamma rays, which are produced by the most energetic and exotic fundamental physical processes occurring in nature. Instruments on this mission will provide unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts.

The Global Geospace Science (GGS) program is a complementary science mission to the Collaborative Solar-Terrestrial Research (COSTR) project and establishes the U.S. as a leader in solar-terrestrial physics research. These projects, collectively referred to as the International Solar-Terrestrial Physics (ISTP) program, are being conducted in cooperation with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The GGS will make the first coordinated geospace measurements in the key plasma source and storage regions, with emphasis on the cause-effect relationships of energy flow.

The Advanced X-ray Astrophysics Facility (AXAF) was approved as a FY 1989 new start for the x-ray telescope assembly and high resolution mirror assembly. The start of spacecraft initial design is planned for FY 1992. The AXAF will be a major national observatory for x-ray astronomy. The 1.2 meter-class grazing incidence telescope will provide a factor of 100 increase in sensitivity, a factor of 10 increase in angular resolution and double the energy coverage provided by the Einstein observatory (HEAO-2). It will provide new observations and insights in studies of stellar structure and evolution, large-scale galactic phenomena, active galaxies, clusters of galaxies and cosmology. It will restore U.S. leadership in a field pioneered by U.S. astronomers.

Shuttle/Spacelab and attached payload mission management activities will continue with increasing emphasis on major life sciences and microgravity research missions such as the series of Spacelab-Life Sciences (SLS), International Microgravity Laboratory (IML) and the United States Microgravity Laboratory (USML) missions. Other missions scheduled include the Atmospheric Laboratory for Applications and Science (ATLAS) series, the United States Microgravity Payload (USMP) series, the Space Radar Laboratory (SRL) series, and a variety of other Shuttle and middeck experiments.

The Cosmic Background Explorer (COBE), a major Explorer mission, was successfully launched in November 1989. Another major Explorer mission currently under development is the Extreme Ultraviolet Explorer (EWE), scheduled for launch in 1991. A third mission, the X-ray Timing Explorer (XTE), is in development. In addition, a U.S. instrument was developed for inclusion on the Roentgen Satellite (ROSAT), built by the Federal Republic of Germany and launched in June 1990. A Cosmic Ray Isotope Experiment (CRIE) has been developed along with a DOD experiment, for flight aboard the Combined Release and Radiation Effects Satellite (CRRES), a collaborative mission with the DOD launched in 1990. We are developing an instrument for flight on the Japanese Solar-A mission (previously called the High Energy Solar Physics Mission, HESP). Solar-A will be launched in FY 1991 to study the Sun during the upcoming solar maximum. Finally, the Explorer program supports U.S. participation in the Japanese Astro-D Spectroscopic X-ray Observatory Mission, to be launched in 1993.

Payload and instrument development activities provide the data necessary to conduct basic research projects and to provide correlative and development feasibility information for major free-flying spacecraft. Instrument development activities include Shuttle payloads such as the Tethered Satellite System (TSS). Also included are Space Plasma Physics flight of opportunity instruments such as those for the Japanese Geotail spacecraft and the European Solar and Heliospheric Observatory (SOHO) and Cluster spacecraft under the COSTR program.

During the past several years, suborbital observation from balloons, sounding rockets, and high-flying aircraft took on increased significance. This enhanced effort will continue to provide observations and instrument development opportunities for research groups. Furthermore, increased emphasis will also continue in the research and analysis (R&A) and the mission operations and data analysis (MO&DA) areas in order to maintain a vital research base in Physics and Astronomy. This research base continues to support advanced technology development activities on the Orbiting Solar Laboratory (OSL) and the Space Infrared Telescope Facility (SIRTF).

BASIS OF FY 1992 FUNDING REQUIREMENT

GAMMA RAY OBSERVATORY DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spacecraft.............................	35,600	--	17,500	--
Experiments and ground operations........	5.600	--	4.500	--
Total................................	41.200	--	22.000	--
Mission operations and data analysis.....	(4,000)	(29,000)	(18,200)	(30,000)
Space transportation system operations...	(10,400)	(--)	(28,400)	--

OBJECTIVES AND STATUS

The Gamma Ray Observatory (GRO) will study the highest energy electromagnetic radiation emitted from sources in the cosmos. This spectral region represents one of the last frontiers in astronomy to be studied at high sensitivity. Because of their extreme energy, gamma-rays are produced by the most energetic and intriguing phenomena occurring in the universe: phenomena occurring in the central energy source region of quasars, in supernovae, near black holes, and on the surface of neutron stars. Gamma-rays provide the unique direct signature of all nuclear processes which occur in astrophysics: the synthesis of elements, cosmic rays interacting in the interstellar medium, and transformations involving the fundamental particles of physics. The GRO will provide new information on phenomena ranging from the enigmatic, and yet unidentified, cosmic gamma-ray bursts, to the diffuse gamma-ray sky background, whose origin must have cosmological significance.

Due to the low flux of cosmic gamma-rays, their penetrating nature, and the high background produced by cosmic-ray interactions, detailed observations require large instruments to be flown in space for extended periods of time. The four complementary instruments selected for the GRO represent a quantum jump in sensitivity, spectral range, and spectral, spatial, and temporal resolution over any previous missions or instruments in these energy ranges. The GRO, scheduled for launch on the Space Shuttle in 1991, is designed to be pointed at fixed directions in space for hours or weeks to obtain the long exposures required.

In FY 1990, GRO was transported by aircraft to the Kennedy Space Center where it currently awaits its scheduled launch. On-orbit checkout will complete GRO development activities.

CHANGES FROM FY 1991 BUDGET ESTIMATE

FY 1991 funding for GRO development is increased by $22.0 million and GRO mission operations and data analysis (MO&DA) is reduced by $10.8 million to reflect the launch delay from November 1990 to April 1991.

GLOBAL GEOSPACE SCIENCE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Global geospace science..................	57,600	98,500	96,600	65,300
Mission operations and data analysis.....	--	--	--	(1,500)
Launch vehicles.........................	(16,000)	(60,600)	(54,500)	(36,400)

OBJECTIVES AND STATUS

Global Geospace Science (GGS) will be part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the Sun and the Earth.

GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program which provides instruments and launch support to gain science return in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The scientific value of this effort will be greatly enhanced by the addition of the two GGS spacecraft. The combined program will include five spacecraft missions: *two* U.S. spacecraft, Wind and Polar; two ESA spacecraft, SOHO and Cluster; and one ISAS spacecraft, Geotail.

The GGS mission will measure and model the effects of the Sun on the Earth's space system to enhance our understanding of the processes and flow of energy and matter in the solar energy chain from outer geospace to atmospheric deposition. The GGS will also enhance our ability to assess the importance of variations in atmospheric energy deposition from the geospace system to the terrestrial environment. The GGS consists of two fully-instrumented U.S. spacecraft, Wind and Polar, making simultaneous measurements in key geospace regions. The GGS provides the first coordinated geospace measurements in key plasma source and storage regions, multi-spectral global auroral imaging, and multi-point study of magnetospheric response to solar wind. Wind and Polar are both planned for launch in FY 1993 on Delta ELVs.

All commitments by the foreign governments are in place and development activities are continuing. Spacecraft contract award was completed in FY 1989, as was final confirmation and initiation of instrument development activity. The GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The GGS FY 1991 budget has been reduced by $1.9 million as part of the Congressionally-directed general reduction. The reduction is possible due to the negotiated phasing of the spacecraft contractor's funding requirements, and will not impact the Wind and Polar launch dates.

BASIS OF FY 1992 ESTIMATE

FY 1992 funds are required to continue development of GGS spacecraft, instruments and ground system. Funding will allow continuation of these development efforts in order to take advantage of simultaneous measurements provided by the COSTR program and other solar-terrestrial research efforts. Integration of both the Wind and Polar spacecraft will occur during FY 1991. Instrument deliveries, integration and testing will occur in FY 1992, in preparation for launch of Wind and Polar in FY 1993.

BASIS OF FY 1992 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY DEVELOPWENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Mirror development......................	40,900	94,500	95,100	188,700
Experiments.............................	3.100	18.500	6.100	22.300
Total.................................	44.000	113.000	101.200	211.000
Mission operations and data analysis.....	(1,000)	(4,000)	(2,800)	(7,800)
AXAF advanced technology development.....	(10,100)	(34,000)	(20,700)	(--)

OBJECTIVES AND STATUS

The Advanced X-ray Astrophysics Facility (AXAF) is the next major advance in x-ray astronomy and is the third of the four "Great Observatories." The AXAF will provide new observations and insights into studies of stellar structures and evolution, large-scale galactic phenomena, active galaxies, clusters of galaxies, and cosmology. The 1.2 meter grazing incidence telescope will provide a factor of 100 increase in sensitivity, a factor of ten increase in angular resolution, double the energy coverage which was provided by the Einstein Observatory (HEAO-2), and will address fundamental questions of modern astrophysics. Timely development of the AXAF program is required in order to fly in concert with the Hubble Space Telescope, now observing the universe in visible and ultraviolet radiation, and the Gamma Ray Observatory, which will conduct observations in the gamma ray spectrum. The scientific return of these Great Observatories will be enhanced enormously if flown together to observe the whole range of phenomena in the cosmos, from the most tranquil to the most violent, and provide a complete physical picture of the most engimatic objects in the universe.

The AXAF will be a long-lived observatory designed for on-orbit instrument replacement and servicing. With the Shuttle, the U.S. will have the unique capability to maintain this telescope in orbit.

In FY 1990, AXAF development activities commenced on the High Resolution Mirror Assembly/X-ray Telescope Assembly (HRMA/XTA), with a particular focus on development of the flight mirrors at Hughes-Danbury Optical Systems (HDOS) in Danbury, Connecticut. Per Congressional agreement, AXAF instrument and observatory definition activities were funded under research and analysis.

In FY 1991, development will be completed on the largest and most challenging set of parabolic/hyperbolic mirrors (P-1/H-1). This set of mirrors will be tested optically in June 1991, and x-ray testing will begin at the x-ray calibration facility at the Marshall Space Flight Center (MSFC) in August 1991.

CHANGES FROM FY 1991 BUDGET ESTIMATE

In order to offset the Congressional general reduction, the AXAF development and mission operations and data analysis budgets were reduced $13.0 million in FY 1991. The AXAF advanced technology development was reduced $13.3 million (within Physics and Astronomy Research and Analysis). The total reduction to *AXAF* of $26.3 million will cause deferral of instrument and spacecraft development. The program is being replanned consistent with these and out-year reductions to a revised launch date in early 1998.

BASIS OF FY 1992 ESTIMATE

In FY 1992, mirror development activities will continue on the mirror assembly at Eastman-Kodak in Rochester, New York. Production of the flight mirrors will continue at HDOS. Spacecraft definition activities at TRW and MSFC will begin in preparation for the AXAF System Requirements Review (SRR) scheduled for later in the year. Instrument requirements reviews will be completed and progress will be made toward preliminary design reviews for the instruments in early FY 1993. Modifications to the x-ray calibration facility at MSFC to enable testing of the entire HRMA will be initiated.

BASIS OF FY 1992 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Collaborative solar terrestrial research.	53,900	61,800	60,200	64,700
Tether satellite systems.................	6,800	3,400	4,000	1,600
Shuttle test of relativity experiment....	21,655	26,000	23,400	29,400
Astrophysics payloads...................	7,283	3,800	3,800	18,700
Space physics payloads..................	3,400	2,200	3,200	1,500
Total................................	93,038	97,200	94,600	115,900

OBJECTIVES AND STATUS

Instrument development activities support a wide range of instrumentation - from early test, checkout and design of instruments for long-duration free-flying missions to international flights of opportunity.

The Collaborative Solar Terrestrial Research Program (COSTR) will provide state-of-the-art instrumentation for flight opportunities on international spacecraft. Instruments under development will provide a U.S. contribution to an international thrust in space physics research in the 1989-1995 timeframe, principally, the European Solar Terrestrial Science Programme (STSP) and the Japanese Geotail Mission.

The Tethered Satellite System (TSS), scheduled for launch in early 1992, will provide a facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The objective of the TSS mission (TSS-1) is to verify the controlled deployment, retrieval and on-station stabilization of a satellite tethered from the orbiter, and to carry out an electrodynamics experiment using a conducting tether extended 20 km above the orbiter. The TSS-1 is an international cooperative project with the Italian government. The U.S. is responsible for overall project management, system integration, developing the tether deployment and retrieval system, developing and integrating U.S.-provided instruments, and flight on the Space Shuttle. Italy is developing the satellite and is responsible for development and integration of Italian-provided instruments.

Astrophysics and space physics payloads include a number of instruments designed for flight on the Space Shuttle and ELV's. Emphasis will be on instrument development for study of the complex relationships of solar irradiance and the near-Earth plasma environment (Atmospheric Laboratory for Applications and Science - ATLAS missions), as well as for study of the ultraviolet and x-ray universe.

The Shuttle Test of Relativity Experiment (STORE) flight of the Gravity Probe-B instrument involves the development of a multigyroscope experimentation package to fly as an attached payload on a Shuttle flight planned for 1994, as an integral part of the study of relativity.

CHANGES FROM 1991 BUDGET ESTI IE

Tether Satellite System and Space Physics Payloads have increased due to launch delays and associated cost growth on the TSS-1 and ATLAS-1 missions. The COSTR program has been reduced to cover these increases.

The Shuttle Test of Relativity Experiment has been reduced in accordance with Congressional direction. Potential impacts affecting the launch readiness date are being assessed.

BASIS OF FY 1992 ESTIMATE

In FY 1992, the COSTR program will continue development of U.S.-provided instruments for the ISAS/NASA Geotail mission which will explore the Earth's magnetosphere and deep geotail region. Geotail launch is scheduled for July 1992. NASA will also be developing instruments and providing mission support equipment for the ESA/NASA Cluster and SOHO missions, which will provide unique capabilities for measuring solar oscillations and solar corona. Funding is also required to support instruments and core equipment development and integration on TSS-1. Funding for the Shuttle Test of Relativity flight of the Gravity Probe-B instrument will continue. Funding will support data analysis from the Astro mission, as well as development of instruments and data analysis activities post-launch for the ATLAS and DXS missions. Funding will also be applied to the U.S.-provided instruments on the international/cooperative efforts consistent with current agreements.

BASIS OF FY 1992 FUNDING REOUIREMENT

SHUTTLE/SPACELAB/PAYLOAD MISSION MANAGEMENT AND INTEGRATION

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Shuttle/Spacelab payload mission management and integration............	75,104	89,100	88,800	88,000

OBJECTIVES AND STATUS

The primary objective of the Spacelab payload mission management program is to manage the mission planning, integration, and execution of all NASA Spacelab and attached Shuttle payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; and data dissemination to experimenters.

Mission management activities for Physics and Astronomy missions include the recently-completed Astro and the upcoming Diffuse X-ray Spectrometer (DXS) mission. The Astro mission flew aboard Shuttle in December 1990; DXS is currently planned for flight in 1992. Mission management activities are ongoing for several other space science and applications missions, such as the Atmospheric Laboratory for Applications and Science (ATLAS). The first of this series is planned for flight in 1992. The mission will incorporate a large number of instruments designed to study the complex relationships of solar irradiance, atmospheric composition and changes, and the near-Earth plasma environment. Other missions include several flights of an imaging radar (SIR-C) beginning in 1993; a series of Spacelab Life Sciences (SLS) missions, the first scheduled for launch in mid-1991; a joint microgravity mission with the Japanese (SL-J); a series of cooperative International Microgravity Laboratories (IML's); a series of U.S. Microgravity Payloads (USMP's) and U.S. Microgravity Laboratories (USML's); and flight of the Canadian Waves in Space Plasma (WISP) instrument on the Spartan carrier. Mission management activities also support other (NASA) payloads, for example, the Lidar In-space Technology Experiment (LITE) which will demonstrate technology and measurement techniques with high potential for use in studies of the Earth's atmosphere. Several Shuttle middeck experiments are also supported.

CHANGES FROM FY 1991 BUDGET ESTIMATE

A minor reduction was made as a result of the Congressionally-directed general reduction.

BASIS OF FY 1992 ESTIMATE

Mission management activities will continue in FY 1992 as Spacelab missions become more frequent. Integration, testing, and evaluation will continue for major Shuttle/Spacelab missions including the United States Microgravity Laboratory (USML-1), the International Microgravity Laboratory (IML-1), the first of the ATLAS (ATLAS-1) series, and a joint microgravity mission with Japan (SL-J). Preparation for FY 1993 missions will proceed including flights of the ongoing series of United States Microgravity Payloads (USMP), the second flight in the ATIAS (ATLAS-2) and Spacelab Life Science series (SLS-2), and a joint life sciences mission with Germany (SL-D2).

BASIS OF FY 1992 FUNDING REQUIREMENT

SPACE STATION INTEGRATION PLANNING AND ATTACHED PAYLOADS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space station integration planning and attached payload definition............	4,975	15,000	3,000	--

OBJECTIVES AND STATUS

The primary aim of the Space Station integration planning and attached payload definition program is to perform the necessary planning and definition of payloads for the space science and applications use of Space Station Freedom (SSF). This includes the initial definition of the attached payloads, selected in FY 1989 through a competitive Announcement of Opportunity for early deployment on the Space Station. The program also involves definition of integration and operations requirements to guide the planned development of Space Station and science support capabilities.

In FY 1991, studies continue to define the end-to-end science operations requirement for the Space Station era (i.e., the cycle from identification of an experiment, through operations to dissemination, analysis and archiving of data). Studies also continue to determine the best use of Space Station resources (such as power, crew time, volume, data handling capabilities) for science requirements.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease is due to the Congressionally-directed reduction of $12.0 million. This reduction will necessitate deferrals of preliminary science integration and utilization studies, deferral of attached payload Phase B definition studies, and elimination of funding for attached payload concept studies.

BASIS OF FY 1992 ESTIMATE

With the deferral of the attached payloads program under the revised Space Station program, the space science and applications activity planned for SSF consists of life sciences and microgravity hardware and experimentation, along with the ongoing integration/science operations/user accommodation efforts. Accordingly, the continuing Space Station utilization activity has been transferred to the Materials Processing program within the Space Applications budget line item.

BASIS OF FY 1992 FUNDING REOUIREMENT

EXPLORER DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Cosmic background explorer...............	3,100	--	--	--
Extreme ultraviolet explorer.............	11,400	10,900	10,300	4,400
Explorer platform.......................	34,900	16,500	25,000	6,900
X-ray timing explorer....................	7,600	23,900	15,700	37,400
Roentgen satellite experiments...........	2,000	--	--	--
Combined release and radiation effects satellite experiments..................	2,200	--	--	--
Small explorers.........................	14,600	29,100	27,900	34,800
Other explorers.........................	12.553,	20.400	20.900	24.400
Total................................	88.352	100.800	99.800	107.900

OBJECTIVES AND STATUS

Investigations selected for these projects are usually of an exploratory or survey nature, or have specific objectives not requiring the capabilities of a major observatory. Past Explorers have discovered radiation trapped within the Earth's magnetic field, investigated the solar wind and its interaction with the Earth, studied upper atmosphere dynamics and chemistry, mapped our galaxy in radio waves and gamma-rays, and determined properties of the interstellar medium through ultraviolet observations. Recent Explorers have performed active plasma experiments on the magnetosphere, made in situ measurements of the comet Giacobini-Zinner, and completed the first high sensitivity, all-sky survey in the infrared, discovering over 300,000 sources.

The Cosmic Background Explorer (COBE) was launched in November 1989 and is currently studying the properties of the cosmic microwave background. This is important for understanding the early universe and cosmology. In FY 1990, COBE completed a successful, all-sky survey of the infrared and microwave background radiation of the universe between the wavelengths of one micrometer and 9.6 millimeters. Explorers under development will survey the sky in the extreme ultraviolet for the first time, and measure time variable phenomena in x-ray sources. The Explorer program also provides a means of developing instruments for "payload-of-opportunity" missions, such as those involving other Federal agencies or international collaboration.

The Roentgen Satellite (ROSAT), a U.S.-German cooperative mission, was launched by the U.S. in June 1990. ROSAT will conduct the first detailed all-sky x-ray survey and provide in-depth studies on selected objects. The Combined Release and Radiation Effects Satellite (CRRES), a joint NASA/DOD mission, was launched on an Atlas-Centaur vehicle to a geosynchronous transfer orbit in FY 1990. The CRRES mission released trace chemicals, whose transport in the magnetosphere can be observed from ground and airborne-based instruments.

In FY 1986, a new cooperative mission called Solar-A was initiated with the Japanese. Solar-A will be launched in FY 1991 to study the sun during the upcoming solar maximum. The U.S. has selected an instrument for this spacecraft which will relate energetic solar phenomena and dynamic coronal structures observed in hard and soft x-rays to the topology of evolving solar magnetic fields. This will allow the first simultaneous observations of these phenomena from space.

In FY 1991, development continues on the Extreme Ultraviolet Explorer (EWE). The EWE, scheduled for launch on a Delta ELV in 1991, will carryout the first all-sky survey in the extreme ultraviolet spectrum; the first deep survey of a section of the ecliptic plane in the extreme ultraviolet; and systematic spectroscopy of sources discovered in the all-sky survey to identify the emission physics.

Development activities will also continue in FY 1991 on the X-ray Timing Explorer (XTE). This payload will replace EWE on the Explorer Platform during a Shuttle mission planned for 1995. The XTE-unique aspects of Explorer Platform development are currently under definition and are being funded within the Explorer Platform budget.

In addition to the traditional Delta-class explorers, the Explorer program has begun development of "small class" explorers (SMEX). While subject to more stringent constraints than Delta-class missions (weight, telemetry, power, etc.), it is anticipated that a significant number of scientifically exciting missions can utilize this capability and be developed on a short timescale. Fifty-one proposals were received in response to the Small Explorer Announcement of Opportunity (AO). Following peer review, three payloads were selected for development in Spring 1989. The first of these three missions, the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), is scheduled for launch on a Scout-class launch vehicle in 1992. The two subsequent missions, the Fast Auroral Snapshot Explorer (FAST) and the Submillimeter Wave Astronomy Satellite (SWAS), are to be launched by the end of 1995.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Total Explorer funding has been reduced by $1.0 million as part of the Congressional general reduction. Funding for the Explorer Platform has been increased to reflect the additional manpower levels required to support a 1991 launch. This has been offset by reductions to EWE, XTE, and the Small Explorers, thus requiring some minor delays in previously planned launch dates for EWE and XTE. The Other Explorer line is increased to fund international missions of opportunity not previously funded in the Explorer program.

BASIS OF FY 1992 ESTIMATE

Funding for EWE and Explorer Platform will support a late 1991 launch. The XTE will continue development activities toward its 1995 launch. The XTE-unique definition work will continue for the Explorer Platform. The Small Explorer (SMEX) program will be well underway as the first mission, SAMPEX, completes final integration and test activities in preparation for a launch in mid-1992. The FAST and SWAS will continue development in preparation for launches in 1994 and 1995. Two new explorers - the Advanced Composition Explorer (ACE) and the Far Ultraviolet Spectroscopic Explorer (FUSE) - will begin development activities in FY 1992.

BASIS OF FY 1992 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Hubble space telescope operations and servicing	139,050	159,700	186,000	209,200
Hubble space telescope data analysis	13,300	32,200	35,900	36,000
Astrophysics mission operations and data analysis	42,273	81,100	70,500	98,300
Space physics mission operations and data analysis	21,100	20,900	20,900	44,900
Total	215,723	293,900	313,300	388,400

OBJECTIVES AND STATUS

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

Space Physics research activities rely on data received from the Interplanetary Monitoring Platform (IMP), and the Dynamics Explorer which are still operational, the Active Magnetospheric Particle Trace Explorer (AMPTE), which ceased to operate in 1989, and the International Sun-Earth Explorers (ISEE-162) which reentered in October 1987. The IMP continues to provide the only available source of solar wind input measurements to the Earth. The ISEE-3 spacecraft, renamed the International Cometary Explorer (ICE), provided complementary solar wind measurements upstream of Comet Halley in 1986. The Space Physics MO&DA program also supports data analysis for the highly-successful Solar Maximum Mission (SMM), and the Combined Release and Radiation Effects Satellite (CRRES), launched in July 1990.

The Hubble Space Telescope (HST) is designed to operate for fifteen years, requiring on-orbit maintenance of the spacecraft and on-orbit changeout of the scientific instruments. The first planned servicing mission, scheduled for 1993, will put into place optical corrections to accommodate the spherical aberration of the primary mirror. The capabilities lost due to spherical aberration--narrow field spectroscopy and observation of 25th to 28th magnitude objects--will be restored. The HST is used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations are carried out through an independent HST Science Institute. The Institute operates under a long-term contract with NASA. While NASA retains operational responsibility for the observatory, the Institute implements NASA policies in the area of planning, management, and scheduling of the scientific operations of the HST.

Initiation of the definition and implementation of a unified data system for physics and astronomy has begun, which will ensure the fullest access and exploitation of the various mission data sets, with emphasis on the wealth of data to be returned by the Great Observatories. An initial definition process involving extensive inputs from the astrophysics community has now been completed, and FY 1991 funding will continue progress on the principal elements of this system.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The GRO operations was reduced by $10.8 million to reflect the launch slip to April 1991. The HST operations and servicing was increased by $26.3 million and HST data analysis was increased by $3.7 million consistent with the increased estimates for activities during the HST operational era, as well as the planned servicing mission in 1993. A reduction in astrophysics operations is the result of the Congressional general reduction, together with the above increases results in an overall increase of $19.4 million.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding level is required to support mission operations and data analysis for ongoing missions including COBE, HST, GRO, ROSAT, and EWE. Servicing mission activities on HST will continue, including development and test of optical corrections for replacement instruments, and preparations for the first planned servicing mission in 1993. Second-generation HST instruments will continue development for future on-orbit replacement, as will a continuing line of spare subsystems to ensure operational efficiency throughout its planned 15-year lifetime.

Mission operations, data analysis, and guest investigator programs will continue for the Combined Release and Radiation Effects Satellite (CRRES), the Interplanetary Monitoring Platform (IMP), and the International Ultraviolet Explorer (IUE). Mission operations for the Dynamics Explorer (DE) and the International Cometary Explorer (ICE) will cease operation in FY 1991, but data analysis will continue. The High Energy Astronomical Observatories (HEAO 1-3), Magnetospheric Particle Trace Explorer (AMPTE), and the Infrared Astronomy Satellite (IRAS) data analysis will also continue. These programs have produced valuable data sets which are used by a wide segment of the science community. Space Physics MO&DA also reflects transfer of responsibility and funding for the Ulysses and Voyager spacecraft from the Planetary MO&DA program beginning in 1992.

BASIS OF FY 1992 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology.......	94,842	88,500	80,100	103,100
Advanced technology development..........	10,100	34,000	20,700	--
Total................................	104,942	122,500	100,800	103,100

OBJECTIVES AND STATUS

This program provides for the preliminary studies required to define missions and/or payload requirements, as well as providing a research and technology base necessary to define, plan and support flight projects.

The objectives of supporting research and technology (SR&T) are to: (1) optimize the return expected from future missions through scientific problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships; and, (5) continue the acquisition, analysis and evaluation of data from laboratories, balloons, rocket and spacecraft activities.

Research is supported in the disciplines of astronomy, astrophysics, gravitational physics, plasma, cosmic ray and solar physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter, and cosmic rays. Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. Theory activities are related to all the physics and astronomy disciplines and are critical to the correlation of available information. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced x-ray, ultraviolet, and infrared astronomy imaging devices under this program may enable spacecraft to carry instruments for astronomical observations which have increased orders of magnitude in sensitivity and improved resolution over currently available detectors.

One major thrust of the space physics program is directed at studies of the near-Earth geospace environment, from the flow of the solar wind past the magnetosphere, to variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest for basic plasma physics but there are also many practical ramifications, such as ionospheric influences on communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

FY 1991 activities continue definition studies of the Stratospheric Observatory for Infrared Astronomy (SOFIA), Orbiting Solar Laboratory (OSL), and Space Infrared Telescope Facility (SIRTF).

The advanced technological development (ATD) activities support detailed planning and definition of potential new physics and astronomy missions. The ATD activities assure that future 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. Current activities are concentrated on AXAF observatory definition which should be completed by the end of FY 1991.

CHANGES FROM FY 1991 GET ESTIMATE

Research and analysis activities has been reduced by $21.7 million, resulting from Congressionally-directed decreases to the mission studies for OSL and SIRTF, as well as a significant reduction for AXAF advanced technology development, resulting from the Congressional general reduction. As previously noted, the AXAF reduction, in combination with a corresponding decrease in development, has delayed the planned launch date to early 1998.

BASIS OF FY 1992 ESTIMATE

During FY 1992, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for viable physics and astronomy and space physics programs. FY 1992 funding will support continued studies on potential future missions, including OSL and SIRTF.

BASIS OF FY 1992 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Sounding rockets........................	30,100	31,300	31,300	34,300
Airborne science and applications........	10,700	11,500	11,500	12,000
Balloon program.........................	11,900	12,200	12,200	14,700
Total.................................	52,700	55,000	55,000	61,000

OBJECTIVES AND STATUS

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis.

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects. Additionally, the sounding rocket program provides several Space Science and Applications programs with the means for flight testing instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. Approximately forty rockets are scheduled for launch in FY 1992.

Support for Spartan missions aboard the Shuttle is also included--Spartan 201 and WISP. Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to measure the intensity and scattering properties of solar light. Spartan 201 is planned for Shuttle launch in 1993. Spartan has also been selected as the carrier for the Canadian WISP experiment, following cancellation of the Orbital Maneuvering Vehicle program. The WISP/Spartan is planned for launch in 1995. Research with instrumented jet aircraft has been an integral part of the NASA physics and astronomy program since 1965. For astronomy research, the airborne science and applications program operates the Kuiper Airborne Observatory (KAO). This full-scale manned facility consists of a C-141 aircraft equipped with a 91-centimeter infrared telescope. The C-141's ability to fly for several hours at altitudes approaching 13 kilometers, provides a cloud-free site for astronomical observations above most of the infrared-absorbing water vapor in the Earth's atmosphere. This has been essential in expanding astronomical observations into the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1990, the C-141 conducted one major campaign in the Southern Hemisphere (seven weeks) to continue studies of the Supernova SN1987A and observations of the galactic center. The KAO is currently the only facility in the world that can conduct these observations in the far infrared and submillimeter wavelengths. The KAO also conducted one deployment to Hawaii. Planetary observations in the infrared (Mars, Pluto, Jupiter) also continue to provide important scientific return.

The Balloon program provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere. Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In many instances, it is necessary, because of size, weight, cost, or lack of other opportunities, to fly primary scientific experiments on balloons. In addition to the level-of-effort science observations program, significant emphasis has been and will be placed on development of a balloon capable of lifting more than 3,500 pounds, and to support missions lasting several days.

The Balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, as well as for maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas, and remote launch sites. Funding for the experiments flown on balloons is provided from other research and technology programs supporting the various scientific disciplines.

BASIS OF FY 1992 ESTIMATE

FY 1992 funds will provide for continuation of the sounding rocket, Spartan, and balloon programs including management and operation of the NSBF. This funding is also required to continue definition and development activities for balloon improvement and long-duration balloon flights. In FY 1992, the Airborne Science and Applications funding will be used to continue flights of the KAO.

LIFE SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS | LIFE SCIENCES

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget	Page Number
		(Thousands of Dollars)			
Human space flight and systems engineering..........................	40,678	71,000	58,300	58,600	RD 4-4
Space biological sciences................	21,067	32,000	22,800	31,100	RD 4-4
Radiation biology initiative/lifesat.....	(1,600)	(2,000)	(2,000)	15,000	RD 4-7
Search for extraterrestrial intelligence.	4,000	12,100	12,100	14,500	RD 4-9
Research and analysis...................	40,306	47,900	44,800	64,700	RD 4-10
Total................................	106,051	163,000	138,000	183,900	

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget
Johnson Space Center....................	42,033	67,400	54,579	76,038
Kennedy Space Center...	4,161	6,300	5,410	8,032
Marshall Space Flight Center.............	--	125	--	--
Goddard Space Flight Center.............	338	400	442	655
Jet Propulsion Laboratory................	1,038	1,900	1,352	2,008
Ames Research Center....................	44,014	61,000	57,146	71,499
Lewis Research Center....................	--	150	--	--
Langley Research Center....	378	700	497	738
Stennis Space Center....................	40	25	55	82
Headquarters...........................	14,049	25,000	18,519	24,848
Total................................	106,051	163,000	138,000	183,900

OBJECTIVES AND JUSTIFICATION

The two major goals of the Space Life Sciences program are to develop medical and biological systems which enable human habitation in space, and to advance knowledge about life processes in the universe. Results from the research program are applied to: the immediate needs of maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; the development of environmental health requirements for space flight, and the design of controlled and bioregenerative life support systems; understanding the origin, evolution and distribution of life in the universe; and, understanding the biosphere of the planet Earth.

Continuing support of the Space Life Sciences program is essential to: understand the basic biological mechanisms of response to the forces of gravity; evolve the critical technologies necessary to enable long-term piloted space flight; and, develop the capability to sustain a permanent manned presence in space. The research program studies fundamental biological processes through both ground-based and space research efforts which are mutually supportive and integrated.

The Space Life Sciences Research and Analysis program includes five major elements: (1) space medicine, which provides for the physical and environmental health of space crews by seeking to understand and prevent adverse environmental and/or physiological changes which occur in space flight and upon return to Earth; (2) space biology, a multidisciplinary basic research program that studies the fundamental mechanisms of gravitational interaction with all orders of plants and animals in flight and ground experiments; (3) controlled ecological life support systems, a program of research and critical technology development for life support systems necessary to maintain life in space autonomously for long periods of time; (4) exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and, (5) biospheric research, which explores the interaction between life on Earth and its physical and chemical environment.

The Space Life Sciences Flight program, consisting of research in human space flight and systems engineering and space biological sciences, provides scientific and engineering support to select, define, develop and conduct relevant in-space medical and biological experiments related to the microgravity environment. The flight program is actively preparing experiments for launch on Spacelab missions in 1991 and 1992. Definition activities are underway to develop payloads for later Spacelab missions and Space Station utilization. Experiments are currently conducted on the Shuttle and Spacelab, and are being prepared for transition to Space Station Freedom. An active international cooperative program with the European Space Agency (ESA), the Centre National d'Etudes Spatiales (CNES), Deutsche Forschungsund

Versuchsanetalt fur Luft-und Raumfahrt (DFVLR), Canadian Space Agency (CSA), the National Space Development Agency of Japan (NASDA), and the Soviet Union, pursues investigations of common interest. A vigorous joint program with the Soviet Union is aimed at solving biomedical problems associated with long-duration missions. This research is being accomplished utilizing the MIR Space Station in addition to ground-based research.

BASIS OF FY 1992 FUNDING REQUIREMENT

SPACE LIFE SCIENCES FLIGHT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Human space flight and systems engineering...........................	40,678	71,000	58,300	58,600
Space biological sciences..........	21,067	32,000	22,800	31,100
Total................................	61,745	103,000	81,100	89,700

OBJECTIVES AND STATUS

The objective of the Space Life Sciences flight program is to develop payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation to the space environment, including weightlessness. The program includes selection, definition, in-flight operation, data analysis and reporting on medical and biological investigations involving humans, animals and plants. Human space flight and systems engineering activities advance NASA's ability to extend the duration, enhance the performance, and improve the safety of human space flight. Past experience indicates that humans clearly undergo physiological changes during weightlessness. Many of the observed changes are physiologically significant, yet are not well understood. Shuttle/Spacelab and Space Station Freedom are suitable platforms for gaining a greater understanding of the basic mechanisms underlying these changes. Space biological sciences flight activities use the space environment, especially weightlessness, to further basic understanding of fundamental biological processes. Such flight experiments lead to a better understanding of gravitational adaptation, enhance our basic science knowledge, make it possible to improve life in space and on Earth, and increase the confidence with which we can estimate the physiological consequences of more sustained weightless exposure and design corresponding countermeasures.

FY 1991 activities include the final preparation and flight of approved experiments on the first dedicated Life Science mission (Spacelab Life Sciences-1 (SLS-1)) which is scheduled to be launched in May 1991 and will concentrate on studies of human and animal biomedical responses, with emphasis on cardiovascular, bone metabolism and vestibular functions. SLS-1 will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences, and it will involve highly skilled scientists as payload specialists, thus permitting the use of numerous experimental techniques and procedures never before utilized in space. Many of the experiments and associated flight hardware flown on earlier Shuttle flights will support and enhance preparations for SLS-1 and subsequent missions. Life Sciences experiments will also be conducted on upcoming Shuttle flights including the International Microgravity Lab-1 (IML-1), and cooperative missions with Japan (Spacelab-J) and Germany (Spacelab D-2).

In FY 1991, under the Human Space Flight and Systems Engineering program, efforts will continue in a major new area of research--ensuring Shuttle crew performance in orbit and upon landing on extended duration orbiter missions. The Extended Duration Orbiter Medical Program (EDOMP) involves investigations on Spacelab and Shuttle Middeck experiments with the operational goal of enabling long-duration missions in time for the U.S. Microgravity Lab-1 (USML-1) mission in 1992. Preparation for the Space Station will commence with investigation planning, technology assessment for flight equipment, and critical technology and hardware development.

CHANGES FROM THE FY 1991 BUDGET ESTIMATE

The reduction in the flight program is the result of Congressional direction, and has significantly curtailed efforts to develop payloads for Space Station Freedom. Hardware designed for the Space Station, including the Life Sciences Centrifuge, the Space Biology Initiative, and the Biomedical Monitoring and Countermeasures (BMAC) program will be delayed. In addition, the progress of Spacelab hardware upgrades and replacements has been slowed, and resources are being directed to maintain flight experiments on near-term Shuttle and Spacelab missions.

BASIS OF FY 1992 ESTIMATE

Preparations are underway to support several Shuttle Spacelab missions in FY 1992. Among these are IML-1, of which approximately 50 percent of the payload relates to space life sciences. The focus of U.S. activity on IML-1 includes studies of plants, neurovestibular change, human performance, radiation and cellular differentiation. The first Extended Duration (13-day) Shuttle flight is currently planned for USML-1, planned for 1992. At that time, approximately 100 Designated Science Objective experiments will have been conducted on preceding missions to determine acceptable parameters for maintaining crew health and safety on USML-1 and future extended missions. In FY 1992, development of upgraded and replacement Life Sciences Laboratory Equipment (LSLE) for Space Shuttle use will accelerate as many items of existing hardware, some in use since the early 1980's, are phased out.

Efforts will continue on definition and development of new experiments (selected through the Announcement of Opportunity (AO) process) and hardware that will be flown on several future Spacelab/Shuttle missions in FY 1992 and beyond - i.e., Shuttle mid-decks, the Japanese SL-J mission, the second dedicated life sciences mission (SLS-2), the German D-2 mission, IML-2 and SLS-3. Collaboration with the Soviet Union on its COSMOS biosatellite program will continue with joint research on COSMOS flights in 1991 and 1992.

In FY 1992, under the Space Biological Sciences program, detailed definition and development will continue on an integrated Centrifuge facility for Space Station Freedom. By providing continuous on-board 1-G control that can separate influences of weightlessness from other effects of space flight, this facility will support a broad spectrum of life sciences research using small animals and plants. The Centrifuge will allow scientists to test the response of living organisms to operational forces at various stages of adaptation to weightlessness. This facility represents a marked enhancement of basic research capability to the Life Sciences program, and has been a top priority recommendation of the National Academy of Sciences for several years.

Activity will continue in the Space Biology Initiative program to determine how biological research will be accommodated on the Space Station, as well as to define instrument and facility requirements. Studies will identify unique scientific and hardware transition requirements from continuing Spacelab flights to Space Station operations. In addition, technology assessment, advanced technology development, hardware design and development, and experiment definition and planning will be conducted.

BASIS OF FY 1992 FUNDING REQUIREMENT

RAD

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Radiation biology initiative/lifesat.....	(1,600)	(2,000)	(2,000)	15,000

OBJECTIVES AND STATUS

The Radiation Biology Initiative (RBI) will address several aspects of the effects of space radiation on living things, and provide a scientific basis for the protection of humans engaged in long-duration stays in space, including missions to the moon and Mars. Through both ground and space-based experiments, researchers will develop methods to characterize space radiation fields that present hazards outside the Earth's protective magnetosphere. These fields include Solar Particle Events and highly charged, energetic nuclei (HZE) constituting galactic cosmic rays (GCR). Experimental data on the biological effects of these fields will be used to establish protocols for dosage limits and aid in the development of shielding material and spacecraft design.

Ground-based simulation of space radiation is fundamental to assessing the risk posed by HZE particles. The RBI plans to utilize existing Department of Energy (DOE) laboratories for this purpose. The Brookhaven National Laboratory in New York can provide the kind of facility needed for this critical component of RBI research. Discussions with DOE in FY 1991 will lead to a joint plan for NASA use of the Brookhaven beam accelerator.

Mission studies continue in FY 1991 on Lifesat, the reusable reentry satellite for radiation and biology research, which represents the space-based component of RBI. Obtaining space validation of ground-derived data will enhance RBI research and introduce the critical factor of microgravity as it correlates to radiation effects. Lifesat will contain living specimens including cell and tissue cultures, lower animals, and plants. Designed for launch on a Delta II rocket, the biosatellite will reach high inclination orbits beyond the range of the Shuttle or Space Station where cosmic radiation is a factor, and remain in space for up to 60 days.

BASIS OF FY 1992 ESTIMATES

In FY 1992, the RBI will enter a new phase of development, as activity at Brookhaven is expected to commence and a Phase C/D New Start occurs for the Lifesat spacecraft. Beginning in FY 1992, this activity is separately identified in the Life Sciences budget. The RBI research at Brookhaven will employ a separate "beam line" built off of the main accelerator booster ring. By exposing a multitude of samples to particle impacts, predictive models can be developed to guide objectives for space-based experiments. Four launches of the polar-orbiting Lifesat spacecraft are planned, with the first in FY 1996. The second and third launches will consist of two identical spacecraft positioned at different orbits or orientations. Funds requested in FY 1992 will support spacecraft contract award in the spring of 1992 followed by initial design and early development activities. At Brookhaven, configuration of the facility and associated hardware will continue, as will science definition activity.

BASIS OF FY 1992 FUNDING REQUIREMENT

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Search for extraterrestrial intelligence..........................	4,000	12,100	12,100	14,500

OBJECTIVES AND STATUS

The Search for Extraterrestrial Intelligence (SETI) microwave observing project will continue development of advanced signal detection and processing systems in FY 1991. Employing NASA's existing radio astronomy facilities as well as Deep Space Network (DSN) antennas to analyze microwave signals in space for evidence of advanced life elsewhere in the galaxy, SETI promises to be one of the most unique exploration missions ever undertaken. SETI will be divided between a targeted search in regions of the galaxy with high probability Earth-type systems, and a general survey of the entire sky for non-naturally occurring signals believed to be of intelligent origin.

BASIS OF THE FY 1992 ESTIMATE

The SEI microwave observing project is planned to begin operation in October 1992 to coincide with the five-hundredth anniversary of Columbus' arrival in the New World. The primary activity in the project during FY 1992 will be to continue system build and test in preparation for initial full systems deployment. The Sky Survey prototype will begin field test and integration to the DSN 34 meter antenna at Goldstone, California. Concurrently, the development of the Sky Survey operational system will be at its peak activity to enable full deployment and completion of the observational phase by the year 2000. The first of the Targeted Search systems will be completed, integrated, and tested in FY 1992. Field testing and later integration into the Arecibo telescope in Puerto Rico will take place. The purchase and assembly of the remaining systems will be started, and planning will be continued for their deployment to the dedicated site at Greenbank, West Virginia and other observing sites worldwide. Other activities will include the development of the operational planning for both the Sky Survey and the Targeted Search under the direction of the Investigators Working Group selected in FY 1991, the final increment of funding to the National Science Foundation (NSF) for the upgrade of the Arecibo telescope, and continuation of educational activities with NSF under the auspices of the International Space Year.

RESEARCH AND ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space life sciences research and analysis	40,306	47,900	44,800	64,700

OBJECTIVES AND STATUS

The research and analysis activity supports Space Life Sciences program goals of advancing knowledge in all areas of space life sciences and developing medical and biological systems which enable human habitation in space. The program is composed of five elements: (1) space medicine; (2) space biology; (3) controlled ecological life support systems research; (4) exobiology; and, (5) biospheric research.

The Space Medicine program is responsible for assuring the physical welfare, performance and adequate treatment of in-flight illness or injuries of spaceflight crews. Such conditions as space motion sickness, spatial disorientation, fluid shifts and endocrine changes, can decrease performance and cardiovascular tolerance and possibly aggravate latent disease. These conditions must be carefully evaluated to determine preventative measures. To this end, careful medical selection,, periodic evaluation of health status, and in-flight monitoring of the adaptation to space and success of physiological countermeasures must be continually undertaken. Long-term monitoring of space flight crews will be performed in a standardized fashion in order to identify risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. Biomedical research investigates the fundamental physiological basis for problems encountered in manned spaceflight. Research areas include clinical medicine; neuroscience; cardiopulmonary, musculoskeletal, and regulatory physiology; cell and developmental biology; behavior, performance and human factors; and radiation and environmental factors.

The Space Biology program explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigate fundamental biological questions. Specific objectives are to perform the basic science research required to identify and investigate the role of gravity in plant and animal behavior, morphology, development and physiology; the mechanisms of gravity sensing and the transmission of this information within both plants and animals; the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the physiology of organisms; the uses of gravity to study the normal nature and properties of living organisms; and, the effects of microgravity on plant and animal growth, long-term survival and reproduction in space.

The Controlled Ecological Life Support Systems program seeks to provide air, water and food to support life through bioregenerative closed systems which receive only energy from the external environment. Development of such systems is a critical path element for long-duration manned spaceflight and eventual lunar colonization.

The Exobiology program is directed toward understanding the origin and evolution of life, and life-related molecules, on Earth and throughout the universe. Research seeks to trace the pathways leading from the origin of the universe through the major epochs in the evolution of living systems. Research encompasses the cosmic evolution of the biogenic compounds, prebiotic evolution, early evolution of life, and evolution of advanced life. Emphasis is placed on understanding these processes in the context of the planetary and astrophysical environments in which they occurred. Flight experiments in Earth orbit and on planetary missions are important program elements. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on Earth as related to early chemical and biological evolution.

The Biospheric Research program explores the interaction between global biological and planetary processes to develop an understanding of global biogeochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes in global dynamics. Biospheric modeling efforts integrate biological data with atmospheric, climate, oceanic, terrestrial, and biogeochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

In FY 1991, the first three NASA Specialized Centers of Research and Training (NSCORT) will be established at universities to support long-term, broad-based interdisciplinary research on selected high priority research topics. The NSCORT program, which is modeled on the highly successful National Institutes of Health program, will help increase science results by concentrating resources, facilities and personnel on focused research problems. NSCORT will conduct research in the following science programs: biomedical science, operational medicine, space biology, exobiology, biospherics, and controlled ecological life support systems. Ultimately the NSCORT program will expand to a total of 10 participating institutions.

CHANGES FROM THE FY 1991 BUDGET ESTIMATE

The FY 1991 program has been reduced by $3.1 million as part of the overall $25.0 million, Congressionally-directed decrease to life sciences. As a result, support for principal investigations has been slightly reduced and other research delayed to FY 1992.

BASIS OF THE FY 1992 ESTIMATE

The Space Medicine program will resume collecting information on occupational exposure in microgravity on each Shuttle flight and conduct in-flight clinical testing of countermeasures, especially in the area of vestibular dysfunction, cardiovascular deconditioning and muscular atrophy. Understanding the dynamics of physiological adaptation to physical forces and being able to measure stress on the human body is crucial to the design of countermeasures to maintain astronaut health and productivity. Research in the fields of psychology and the ergonomics of man/machine interfaces will also be supported. These areas are important to improving the performance and efficiency of flight crews. Research in radiation biology will continue to aim at precisely measuring dosages and the effects of cosmic and solar radiation, with the goal of determining the optimum radiation shielding required for humans in space.

The Space Biology program will concentrate ground research on developing working models of functioning gravity-sensing neural (information) networks to understand neurosensory processing in microgravity; understanding the physiological side effects of centrifugation in preparation for use of the Shuttle/Space Station centrifuge as a research tool; and identifying the cellular events of the gravity perception mechanism in plants.

The Controlled Ecological Life Support Systems program will continue to investigate basic biological processes and physical methods to control the interior environment of manned spacecraft. In developing such a life support system, the near-term emphasis will be on system definition and development of design concepts and critical technologies for flight, and supporting research in the areas of controlled-environment plant production, waste processing and human nutrition.

The Exobiology program will emphasize the development of new flight experiment concepts to investigate models of early Solar System evolution and mechanisms for the synthesis of biologically significant molecules in space.

The Biospheric Research program will place emphasis on improving estimation techniques for determining the structural state of the terrestrial biomass by combining ground-based measurements at tropical, temperate, and wetland sites with remote sensing data and biogeochemical modeling of the interactions of ecosystems on a global scale. Information gathered through remote sensing will also be used to help nations prepare for outbreaks of vector-borne disease (malaria) by allowing predictive modeling of the occurrence of the disease vector (mosquitoes).

Additional NSCORT selections are also expected in FY 1992.

Beginning in FY 1992, with a $10.0 million augmentation, the Life Sciences program will conduct Pre-phase A and Phase A studies in areas focusing on participation in human and precursor Lunar-Mars missions. These areas include artificial gravity, planetary protection, advanced remote medical care, and human factors research. Trade-off studies of physiological effects of microgravity and engineering options for artificial gravity systems will be a significant component of this activity. Planetary protection efforts will include development of contamination protection criteria. Advanced medical care for the Lunar and Martian environments will evolve from systems in use on Shuttle and Space Station. Emphasis will be on remote telemedicine techniques and computer-aided diagnostic capabilities. These studies are endorsed by the NASA Life Sciences Advisory Committees as necessary objectives for safe human space exploration, and will be paced to meet science targets consistent with robotic mission and technology development milestones.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL **YEAR** 1992 **ESTIMATES**

BUDGET SUMMARY

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

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Galileo development.....................	17,127	--	--	--	
Magellan.................................	--	--	--	--	
Ulysses..................................	14,252	3,300	3,034	--	RD 5-4
Mars observer............................	98,922	68,900	78,528	54,400	RD 5-6
Mars balloon relay.......................	4,400	2,000	1,497	1,200	RD 5-6
Comet rendezvous asteroid flyby/cassini..	29,519	148,000	145,000	328,000	RD 5-8
Mission operations and data analysis.....	155,956	173,500	161,175	150,500	RD 5-10
Research and analysis....................	70,672	89,500	67,866	93,200	RD 5-12
Total..................................	390,848	485,200	457,100	627,300	

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center.............	9,300	9,400	8,000	9,400
Marshall Space Flight Center.............	100	160	200	200
Goddard Space Flight Center.......,.....	17,900	18,200	17,300	18,200
Jet Propulsion Laboratory...............	300,623	393,440	371,200	535,700
Ames Research Center.	15,000	14,200	13,500	14,100
Langley Research Center.,......	25	--	--	--
Headquarters.............................	47,904	49,800	46,900	49,700
Total..................................	390,848	485,200	457,100	627,300

OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to better understand the Earth through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful based on a strategy that places a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the smaller bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental characterization of the bodies, and then proceed to levels of more detailed study.

With the Magellan mapping of the Venusian terrain, the reconnaissance phase of inner planetary exploration which began in the 1960's will be virtually complete. In addition to Magellan, the Pioneer Venus mission continues to carry the study of the Earth's nearest neighbor and closest planetary analog beyond the reconnaissance stage to the point where we have now obtained a basic characterization of Venus' thick, massive atmosphere, as well as fundamental data about the formation of the planet. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of meteorites and the lunar rock samples returned by Apollo continue to be highly productive, producing new insights into the early history of the inner solar system and thus leading to revision of our theoretical concepts.

The exploration of the giant outer planets began more recently. The Pioneer-10 and -11 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and -2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980, with Voyager-2 following in August 1981. The Voyager data on these planets, their satellites, and their rings have revolutionized our concepts about the formation and evolution of the solar system. Voyager-2 encountered Uranus in January 1986 and provided our first look at this giant outer planet. Its trajectory carried it to an encounter with Neptune in August 1989 and provided spectacular images of this mysterious planet and its satellites. In February 1990, Voyager-1 took the first snapshot ever of our solar system. As the Pioneer-10 and 11 and Voyager-1 and -2 spacecraft trajectories take them outside our solar system, they continue to return scientific data about the system's outer region.

Magellan, which was launched in May 1989, arrived at Venus in August 1990 and began providing global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a synthetic aperture radar to penetrate the planet's opaque atmosphere, Magellan provides a resolution sufficient to identify small-scale topographical features which address fundamental questions about the origin and evolution of the planet. Magellan is also obtaining altimetry and gravity data to accurately determine the planet's gravity field as well as internal stresses and density variations so that the evolutionary history of Venus can be compared with that of the Earth.

Galileo was launched by the Shuttle/IUS in October 1989. Achieving its first gravity assist by Venus in February 1990, the spacecraft flew by Earth in December 1990, where it played back images taken of Venus and of the Earth/Moon system. The comprehensive science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the preceding Voyager and Pioneer missions. During twenty-two months of operation in the Jovian system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analyses, while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

Ulysses, which was launched in October 1990 by the Shuttle/IUS/Payload Assist Module (PAM-s), is a joint NASA/European Space Agency (ESA) activity. The mission carries a package of experiments to investigate the sun at high solar latitudes that cannot be studied from the Earth's orbit.

Mars Observer (MO) will build upon the earlier discoveries of Mars by Mariner 9 and Viking and will emphasize the geologic and climatic evolution of this complex planet. The mission will utilize a modified Earth-orbiting spacecraft, thereby benefiting from the previously developed technology. This mission was recently augmented to accommodate the Mars Balloon Relay (MBR) experiment. The French-supplied hardware will be incorporated into the existing payload and will allow Mars Observer to act as a data relay station for data returned from the balloon stations of the U.S.S.R. 1994 Mars mission. Mars Observer will be launched in 1992, using a Titan III launch vehicle with a Transfer Orbit Stage (TOS) upper stage.

In FY 1991, development will continue on the Comet Rendezvous Asteroid Flyby (CRAF) and Cassini (the Saturn Orbiter/Titan Probe) missions. Both missions will provide new understanding into the origin of the solar system which may provide new clues to the origin of life as well.

Mission operations and data analysis activities continue to support the Voyager, Pioneer, Galileo and Magellan missions as well as the recently-launched Ulysses spacecraft. Planetary flight support activities also continue to provide ongoing design, development and maintenance of ground support hardware and software for mission control, telemetry and command functions for all planetary spacecraft.

The Research and Analysis program continues to define the scientific priorities for future missions as well as maximizing the exploitation of existing data sets.

BASIS OF FY 1992 FUNDING REQUIREMENT

ULYSSES DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	5,530	--	--	--
Experiments	3,500	1,000	867	--
Ground operations	5,222	2,300	2,167	--
Total	14,252	3,300	3,034	--
Space transportation systems operations	(11,600)	--	(29,200)	(--)
Upper stage	(12,500)	(14,400)	(5,400)	(--)
Mission operations and data analysis	--	(8,900)	(8,400)	(10,000)

OBJECTIVES AND STATUS

Ulysses was launched in October 1990 using the Space Shuttle and IUS/PAM-S launch stages. Ulysses is a joint mission of NASA and the European Space Agency (ESA). The ESA provided the spacecraft and some scientific instrumentation. The U.S. provided the remaining scientific instrumentation, the launch vehicle and support, tracking support, and the Radioisotope Thermoelectric Generator (RTG). The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. The mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, to provide a better understanding of solar activity on the Earth's weather and climate.

Ulysses was restructured in FY 1981 from a two-spacecraft mission--one provided by the United States and one provided by ESA--to a single ESA spacecraft mission. However, the United States' participation in the program remains substantial. NASA is responsible for five of the nine principal investigator instruments, and three of the four European investigations have U.S. co-investigators. Operational responsibilities for Ulysses will be transferred to the Space Physics division in FY 1992.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current estimate reflects a $0.3 million reduction to provide funding to sustain the necessary workforce level for maintenance of the 1992 launch of Mars Observer.

BASIS OF FY 1992 ESTIMATE

Ulysses mission operations and data analysis (MO&DA) funding is budgeted under Physics and Astronomy (Space Physics) MO&DA.

BASIS OF FY 1992 FUNDING REQUIREMENT

MARS OBSERVER DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spacecraft..............................	59,522	31,200	34,409	23,936
Experiments.............................	30,900	28,400	31,609	21,760
Ground operations......................	8,504	9,300	12,510	8,704
Total................................	98,922	68,900	78,528	54,400
Mars balloon relay experiment...........	4,400	2,000	1,497	1,200
Launch vehicle..........................	(39,900)	(98,000)	(98,000)	(44,200)
Upper stage.............................	(27,300)	(23,300)	(15,400)	(11,800)

OBJECTIVES AND STATUS

The Mars Observer mission is the first of the planetary observer missions. The planetary observer approach, which was recommended by NASA's Solar System Exploration Committee, starts with a well defined and focused set of science objectives and uses Earth-orbital spacecraft and instruments with previous spaceflight heritage. The objectives of the Mars Observer mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and observe their interaction with the Martian environment during all four seasons of the Martian year.

Mars Observer will be launched in September 1992 on a Titan III with a Transfer Orbit Stage (TOS). The spacecraft will be inserted into a near-polar Martian orbit in 1993, from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of approximately one Martian year, which is nearly two Earth-years.

FY 1991 activities include for completion of fabrication of the instrument hardware and continuation of system design of the overall mission. Fabrication activities on the spacecraft, instruments and ground systems will be largely completed and system integration and test will be initiated. Funding will also provide for integration of the Mars Balloon Relay (MBR) hardware into the spacecraft at the spacecraft contractor's facility.

The MBR experiment will be incorporated into the Mars Observer mission and will permit a significant increase in the amount of data returned from the balloon stations of the U.S.S.R. 1994 Mars mission. The MBR data will be routed through the Mars Observer Camera data stream for transmission to Earth. Receiver and antenna hardware provided by France (CNES) will be accommodated on the Mars Observer spacecraft for MBR operations to be initiated at the conclusion of the Mars Observer nominal mission in 1995.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Mars Observer funding has been increased by $9.6 million to support ongoing hardware and software developments necessary to maintain the September 1992 launch readiness date. The MBR funds were reduced by $0.5 million to partially offset the increased funds for MO development. Remaining funds were obtained from other flight programs (e.g., Voyager, Pioneer, Ulysses) as well as research and analysis.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding will support the completion of spacecraft and instrument integration and test activities. Final fabrication of the spacecraft, instruments and ground system and their transportation to Kennedy Space Center will also be completed in preparation for the September 1992 launch.

BASIS OF FY 1992 FUNDING REQUIREMENT

COMET RENDEZVOUS ASTEROID FLYBY/CASSINI DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	19,400	94,300	93,300	209,920
Experiments	8,100	47,800	46,800	104,960
Ground operations	2,019	5,900	4,900	13,120
Total	29,519	148,000	145,000	328,000
Launch vehicle	(1,300)	(9,200)	(8,700)	(68,200)
Upper stage	(--)	(6,300)	(1,400)	(28,900)

OBJECTIVES AND STATUS

During the 1970's, our Nation established scientific and technological leadership in exploration of the outer solar system. The Comet Rendezvous Asteriod Flyby (CRAF)/Cassini program will extend our leadership in important ways during this critical period in solar system science. The CRAF will fly closely past an asteroid and rendezvous with a comet for intensive study. Cassini will fly past an asteroid enroute to Saturn where it will begin four years of study of the Saturnian system. After achieving orbit around Saturn, Cassini will eject a probe to pass down through the atmosphere of Saturn's moon Titan, measure atmospheric composition, and gain the first images of Titan's surface. The orbiting spacecraft will use radar to map most of Titan's surface.

The CRAF/Cassini program, building upon the discoveries made through the Pioneer and Voyager spacecraft, will provide unprecedented information on the evolution of our solar system and will help determine if the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. The CRAF/Cassini targets (comet, Titan, Saturn system) have a common origin in the outer solar system. The icy conditions on all the small bodies preserve a record of different stages and processes occurring during solar system formation and evolution. CRAF will provide the first long-term study of a comet, and the nature and behavior of its ejected gases. It will provide the ability to assess organic molecules present at the beginning of the solar system and their potential contributions to the origin of life. Cassini will provide intensive, long-term observation of Saturn's atmosphere, rings, magnetic field, and moons. The Cassini probe will enable direct physical and chemical analysis of Titan's methane-rich, nitrogen atmosphere which is a possible model for the pre-biotic stage of Earth's atmosphere. Through the joint study of origins with CRAF and early processes with Cassini, the program will improve our understanding of the early evolutionary process of our solar system.

Both missions will use virtually identical Mariner Hark II spacecraft with common design, fabrication, test, and integration team elements. Science instruments for CRAF have been tentatively selected. Cassini instruments were selected for definition in November 1990. Confirmation of CRAF instruments is planned for April 1991, and Cassini instruments will be confirmed in October 1991.

The CRAF/Cassini program has strong components of international cooperation. The Federal Republic of Germany has agreed to provide part of the propulsion system and one science instrument for CRAF. The European Space Agency (ESA) has selected the Cassini probe as its major new science program for 1990 at an estimated total cost of $200 million. In addition, ESA member states will contribute approximately $75 million worth of science instruments and scientist participation.

The mission plan for CRAF/Cassini is under review at this time. The baseline plan is for a CRAF launch in August 1995 to the comet Kopff, with a Cassini launch to Saturn in April 1996. Since funding for a CRAF launch vehicle has been deferred, new mission trajectories have been identified which will provide several launch opportunities per year for the CRAF mission. Current plans are to adhere as closely as possible to the original launch date in order to ensure launch readiness at the first possible opportunity. The agency is currently addressing the availability of a launch vehicle to incorporate into the revised CRAF mission plan.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current estimate reflects a $3.0 million Congressional reduction. This will be accommodated by delaying some procurements until early 1992.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding will continue design and development activities of the CRAF and Cassini spacecraft in accordance with the aforementioned launch schedule. A selection of the tentative science instrument payload for the CRAF mission has been made and development will proceed in FY 1992 upon confirmation of the payload in the Spring of 1991. The selected Cassini instruments will also initiate development activities following payload confirmation.

MISSION OPERATIONS AND \T ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Galileo operations......................	37,315	44,200	49,120	57,700
Magellan operations.....................	41,207	32,700	32,700	29,200
Ulysses operations......................	--	8,900	8,346	--
Mars observer enhancement................	--	15,000	--	--
Pioneer programs........................	9,406	10,300	9,560	10,900
Voyager/Neptune data analysis............	8,834	5,300	3,400	5,700
Voyager interstellar mission....	16,658	14,300	14,385	--
Planetary flight support.................	42,536	42,800	43,664	47,000
Total................................	155,956	173,500	161,175	150,500

OBJECTIVES AND STATUS

The objectives of the mission operations and data analysis program are in-flight operation of planetary spacecraft and the analysis of data from these missions. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network for all planetary spacecraft.

Operations for Galileo began in FY 1990 for the spacecraft's 6-year journey to Jupiter. Galileo was launched by the Shuttle/Inertial Upper Stage (IUS) in October 1989 and will arrive at Jupiter in 1995 where it will conduct a comprehensive exploration of the Jovian System. Three gravitational assists will provide the additional energy required for Galileo's trajectory.

Operations will continue for the Magellan spacecraft which was launched in May 1989 by the Shuttle/IUS on a trajectory to Venus. Arriving at Venus in August 1990, the spacecraft began its mission of mapping a major portion of the planet with a ground resolution of about 150 meters.

Operations for Ulysses began in FY 1991 for the ESA spacecraft's mission to the polar regions of the Sun. Ulysses was launched in October 1990 on a Shuttle/IUS. During Ulysses' journey, it will receive additional energy from Jupiter and depart the ecliptic plane. It will study the relationship between the sun, its magnetic field and particle emissions as a function of solar latitude above 70°.

FY 1991 funds also support the two Voyager spacecraft which are now on trajectories that will take them into interstellar space. Voyager-1 continues to provide data on the interplanetary medium in that distant part of the solar system. Voyager-2 completed its grand tour of the solar system when, in August 1989, it made a spectacular close flyby of Neptune, providing our first detailed images of this distant planet. Highlights of this encounter included discovery of several previously unknown moons, and geyser-like surface eruptions. Voyager-2, now designated as the Voyager Interstellar Mission (VIM), is on a trajectory which will extend exploration beyond the outer limits of the Sun's sphere of influence. The principal objectives of the VIM are to investigate and characterize the outer solar system particles and fields environment and interstellar media, to provide data on the location of the heliopause in conjunction with Pioneer-10 and -11, and to continue the successful Voyager program of ultraviolet astronomy.

Pioneers-10 and -11 continue to explore the outermost edge of the solar system. Pioneer-10 will encounter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6-9 continue to collect information on the interplanetary magnetic field and solar wind as they orbit the Sun. The Pioneer Venus orbiter continues to obtain data on the Venusian atmosphere and magnetosphere and its interaction with the solar wind. Pioneer Venus was also the only U.S. spacecraft able to observe the Comet Halley at its closest approach to the Sun in 1985.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current estimate, which reduced FY 1991 funding by $12.3 million, reflects a Congressional reduction of $15.0 million for Mars Observer enhancements. An increase of $4.9 million to Galileo operations provides adequate manpower levels to support the Galileo Earth flyby. This is partially offset by reductions to the Ulysses, Pioneer and Voyager/Neptune programs.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding is required for the continued support of operation activities for the Pioneer, Magellan and Galileo missions, and data analysis activity for the above missions plus Voyager Neptune. Operational responsibilities for the Ulysses and Voyager Interstellar Missions will be transferred to Physics and Astronomy in FY 1992, since the data collected by these spacecraft are of primary interest to the space physics science community.

BASIS OF FY 1992 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Supporting research and technology.......	55,066	65,400	55,666	74,200
Advanced programs........................	12,106	20,100	5,100	14,700
Mars data analysis.......................	3.500	4.000	7,100	4.300
Total..................................	70.672	89.500	67.866	93.200

OBJECTIVES AND STATUS

The research and analysis program consists of three elements to: (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; and (3) define science rationale and develop required technology to undertake future planetary missions.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, and U.S. scientist participation on foreign missions.

The planetary astronomy activity includes all observations made by ground-based telescopes of solar system bodies, excluding the Sun. Emphasis is on the outermost planets, comets and asteroids. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high, and the data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. The planetary astronomy funding also provides for the continued operation of the Infrared Telescope Facility in Hawaii. The planetary atmospheres activity includes data analysis, laboratory, and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus, Jupiter, Saturn, Uranus and Neptune acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in this field.

The planetary geology/geophysics activity is a broadly scoped program that includes the study of surface processes, structure, and history of solid components (including rings) of the solar system and investigation of the interior properties and processes of all solar system bodies, both solid and gaseous. This program emphasizes comparative studies to gain a fundamental understanding of the physical processes and laws which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Magellan mission is of crucial importance.

The planetary materials/geochemistry activity supports an active scientific effort to determine the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites and through laboratory and theoretical studies of appropriate geochemical problems. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system, and its early history. This program is coordinated with the lunar sample and meteorite research, which is supported by other agencies, such as the National Science Foundation. The operation of the Lunar Curatorial Facility is also supported by this activity.

The instrument definition activity is directed toward ensuring maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation, which are optimized for such missions.

The objective of the advanced program activity is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (PDS) which will permit the archiving of these and all other data products in a manner which will promote and facilitate their use, is also supported.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current estimate reflects a reduction of $21.6 million, $15.0 million of which is due to the Congressionally-directed reduction in Lunar Observer Phase B Studies. $6.6 million was transferred to the Mars Observer program to maintain the September 1992 launch readiness date.

BASIS OF FY 1992 ESTIMATE

During FY 1992, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and advanced technology development for future missions. Ground telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. Funding will also support the upgrading and modernization of ground-based laboratory instrumentation in order to reduce maintenance costs and down time and to improve capabilities. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetary and tenuous cometary atmospheres. Geology/geophysics research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean, Saturnian, Uranian, and Neptunian satellite imaging data acquired by Voyager.

Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1992 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition activities will continue to support development of new state-of-the-art instruments for future missions. The Mars Data Analysis Program will support continued analysis of Mars data in preparation for new Mars missions, and development of the Planetary Data System to archive all planetary data for enhanced accessibility for all users will continue.

During FY 1992, research will continue in the study of origins of solar system to gain an understanding of the origin and evolution of planetary systems, and the paths of various elements and compounds throughout that evolution. Feasibility studies will also continue for future Lunar and Nars missions.

EARTH SCIENCE
AND APPLICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — EARTH SCIENCE AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Earth observing system....................	(74,000)	199,000	155,000	253,400	RD 6-7
Earth observing system data information system................................	--	36,000	36,000	82,600	RD 6-10
Earth probes (including Scatterometer)...	13,600	28,700	54,700	68,200	RD 6-12
Remotely piloted aircraft................	--	--	--	5,000	RD 6-14
Upper atmosphere research satellite mission....	55,200	66,000	64,000	18,200	RD 6-15
Ocean topography experiment..............	84,800	68,000	76,000	51,900	RD 6-17
Payload and instrument development.......	76,100	49,700	49,700	48,600	RD 6-19
Mission operations and data analysis.....	23,800	30,400	39,400	56,300	RD 6-21
Interdisciplinary research.....	8,600	2,400	12,400	2,500	RD 6-24
Modeling and data analysis...............	38,500	41,300	44,300	45,000	RD 6-25
Process studies........................	106,200	111,100	107,500	114,300	RD 6-28
Research facilities....................	27,399	28,900	28,900	29,600	RD 6-32
Total................................	434,199	661,500	667,900	775,600	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

EARTH SCIENCE AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
pistribution of Proeram Amount by Installation				
Johnson Space Center....................	58	--	--	--
Marshall Space Flight Center............	8,426	8,730	8,730	11,800
Goddard Space Flight Center..............	179,600	412,650	412,650	430,400
Jet Propulsion Laboratory...............	144,263	148,500	155,530	210,360
Ames Research Center....................	28,425	32,850	32,850	44,420
Langley Research Center......	21,873	23,500	23,500	31,780
Stennis Space Center....	377	1,170	540	730
Headquarters...........................	51,177	34,100	34,100	46,110
Total................................	434,199	661,500	667,900	775,600

OBJECTIVES AND JUSTIFICATION

The ongoing NASA program is making critical near-term contributions to understanding the Earth as an integrated system as well as to environmental issues including global warming and ozone depletion. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions, including contributing to the scientific research base in ozone monitoring, ocean circulation and atmospheric chemistry. All of these programs are precursors to "Mission to Planet Earth," the major element of which is the Earth Observing System (EOS).

The ability to measure the extent of both the natural and man-induced changes in our global ecosystem is only a preliminary step -- the capability to model and predict the consequences of global change is the ultimate objective. In order to provide a focused and effective mechanism for coordinating and directing federally-funded Earth science research, the U.S. Global Change Research Program (USGCRP) was initiated in early 1989, in which NASA has been a major participant. The full interagency USGCRP will be described in a separate document to be published in early 1991.

The specific objectives of the NASA Earth Science and Applications program are to improve our understanding of the processes in the atmosphere, oceans, land surface and interior of the Earth and advance our knowledge of the interactions between these environments. The program provides space observations of parameters involved in these processes and extends the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts as well as the development of new technology for global and synoptic measurements. NASA's research satellites, Shuttle/Spacelab payload program and airborne science and applications program provide a unique view of the planet Earth, its physical dynamics, and radiative and chemical processes which affect habitability and the solar-terrestrial environment.

A number of significant objectives have been established for the next decade. These include advancing our understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; characterizing the current state of the terrestrial landscape, including the biosphere and the hydrosphere; optimizing the use of space-derived measurements in understanding large scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; and improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction. Studies of the cycling of key biogeochemical elements, interactions between the biosphere and the climate system, the composition and evolution of the crust and the processes that shape the crust are essential to our understanding of the global environment.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation, flight of the instruments on the Space Shuttle, research satellites and airborne platforms; collection of in situ ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then collect appropriate data through remote and in situ means, which will address specific program objectives.

The Earth Observing System's primary objective is to document global change and to observe regional-to-global scale processes. Utilizing several satellites, the EOS will document global change over a 15-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models which may be used by policy makers and scientists in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

The Earth Probes program, as a part of the "Mission to Planet Earth", is designed to provide small, specialized satellites to complement data gathered by the Earth Observing System. These satellites require special orbits and spacecraft capabilities and will provide data on tropical rainfall (Tropical Rainfall Measurement Mission-TRMM), and ocean wind, speed and direction (Scatterometer), both necessary for better understanding global climate systems. In addition, satellites will be orbited to collect data on global ozone concentrations utilizing the Total Ozone Mapping Spectrometer (TOMS).

The Upper Atmospheric Research Satellite (UARS) will place a set of instruments in Earth orbit and make comprehensive measurements of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which are presently unobtainable. Instruments delivered during 1989 are being integrated into the observatory, consistent with the planned launch in 1991.

Development of the Ocean Topography Experiment (TOPEX) will be completed in FY 1992. The objective of TOPEX is to acquire precise observations of the surface topography of the ocean. These data, in conjunction with Scattterometer, will enable the first determination of the wind forcing and ocean current response of the global oceans. Spacecraft development efforts are underway at Fairchild Space and the Jet Propulsion Laboratory, leading to a June 1992 launch.

The objectives of the payload and instrument development program are to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data necessary to conduct basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft.

Current instrument developments include the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS); Active Cavity Radar (ACR); Light Detection and Ranging (LIDAR); and Shuttle Imaging Radar-C (SIR-C). This payload development program will also support the Earth Observing System (EOS) advanced technology development through in FY 1991.

Beginning in FY 1992, the mission operations and data analysis program will begin collecting data from the UARS and TOPEX missions. Ocean color data for research use will also be obtained from a spacecraft to be launched in 1992 or 1993. This imaging data will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of oceans, seas, and larger lakes.

The Nimbus spacecraft continues to collect unique data which is being used in the study of long-term trends of the Earth's atmosphere, oceans and polar ice, and provides near-real-time data. The Earth Radiation Budget Experiment (ERBE) was successfully launched in 1984 and continues to provide valuable data. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOM) by managing the implementation of the polar-orbiting NOM and Geostationary Operational Environmental Satellite (GOES) series on a reimbursable basis.

The interdisciplinary research program will continue integrating discipline-specific research activities into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies, such as those concerning processes controlling atmospheric methane concentrations, changes in land surface properties and their effect on climate, and the role of oceans in the global carbon cycle.

The modeling and data analysis program will focus on developing predictive models for global change and analyzing data sets to determine mechanisms at work in the global environment. The program will focus on two major areas--physical climate and hydrological systems, and biogeochemistry and geophysics.

The process studies program will utilize a variety of techniques to develop an understanding of the processes at work in the global environment and to determine interdependencies which may impact global change management strategies. The program will utilize existing data sets and will conduct field experiments which will enable researchers to better understand global environmental dynamics. Process studies concentrate on four major interdisciplinary categories--radiation dynamics and drology; ecosystem dynamics and biogeochemical cycles; atmospheric chemistry; and solid Earth science.

The research facilities program is composed of the laser research facility and the airborne science and applications program. The laser research facility supports studies and experiments in solid Earth science and provides support to flight programs such as TOPEX/Poseidon, which require precise Earth positioning information. The airborne science and applications program has previously provided platforms for observing ozone-depleting reactions in the atmosphere above the Arctic. This effort was a follow-on to the previous expeditions to the Antarctic. In addition, the airborne program has provided platforms for such diverse studies as soil moisture measurements, atmospheric pollutants detection, vegetation studies and studies in geology. In addition to this continuing research, the FY 1992 program will focus on providing flights for precursor EOS instruments in order to develop and refine techniques for measuring environmental change.

BASIS FOR FY 1992 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Instruments...........................	--	45,000	79,000	159,900
Observatories...........................	(74,000)	132,000	60,000	58,500
Science................................	--	22,000	16,000	35,000
Total................................	(74,000)	199,000	155,000	253,400

OBJECTIVES AND STATUS

The primary objective of the Earth Observing System (EOS) is to document global change and to observe regional-to-global scale processes. Utilizing a diverse but balanced suite of instruments carried on the EOS-A series of three polar orbiting platforms, the EOS-B series of satellites, and on European and Japanese polar platforms, the EOS will document global change over a 15-year period to provide long-term, consistent data sets for use in modeling and understanding global change processes. Each platform will have a five-year design life. This process and modeling research effort will provide the basis for establishing predictive global change models which may be used by policy makers and scientists in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion and deforestation of the rain forests.

The EOS program will provide comprehensive measurements of the physical climate of the Earth through measurements of the radiation budget from two polar-orbiting platforms at different times of day and night as well as measurements from a low-latitude satellite over the tropics. The atmosphere will be characterized by measuring global temperature, winds and moisture from the ground to the mesopause. The combination of sensors on EOS will provide multiparameter data to study precipitation processes, snow and ice processes, glacier mass balance and air-sea interactions. Passive microwave sensors, combined with cloud imagers, will provide simultaneous measurements of cloud-top temperature and rain rate. This will improve our understanding of precipitation formation within storms. The processes by which the oceans and the atmosphere exchange moisture, trace gases, heat and momentum will be studied using boundary layer measurements.

EOS will monitor many parameters that are indicators of the state of the environment, such as the spatial and temporal distribution of tropospheric and stratospheric gases (e.g., carbon dioxide, carbon monoxide, methane, ozone, oxides of nitrogen and sulfur compounds). In addition, interdisciplinary theoretical investigations will be conducted to utilize EOS and complementary data sets to study such phenomena as ecosystem distributions and conditions; biogeochemical fluxes at the ocean-atmosphere and land-atmosphere interfaces; fluxes of carbon and nutrients within terrestrial, freshwater and oceanic systems; and atmospheric composition.

Utilizing closely-coupled, complementary instruments, the EOS will be designed to observe regional and global scale processes such as El Nino, desertification, ozone levels and ocean circulation. The EOS will use both passive and active sensors in the visible, infrared and microwave spectrums. Global coverage will be provided every two days at 1 kilometer resolution using radiometers, spectrometers, and lidar.

The EOS observatory program builds upon Phase A and B studies conducted by the Space Station Freedom program. Three large platforms are currently planned for production to carry out the EOS-A series measurements. Studies are also being conducted which will evaluate alternate mission scenarios for the EOS-B series based upon scientific viability and cost effectiveness.

The project's scientific data processing components consist of Central Data Handling Facilities, a Data Archival and Distribution System, and an Information Management Center. These three elements comprise the EOS Data Information System (EOSDIS). The second phase of the EOS data information facility construction to house the EOSDIS at the Goddard Space Flight Center (GSFC) is included in the Construction of Facilities request.

EST

The EOS Data Information System (EOSDIS) project has been identified as a separate budget element, and funded at the Congressionally-directed level of $36.0 million in FY 1991. The EOS observatories (platforms) have been reduced a total of $72.0 million. Of the total reduction, $44.0 million was a result of Congressional direction and $28.0 million was allocated to the instruments. The EOS program has been segregated into its major components to reflect our funding plans for FY 1991. The EOS instrument line has been increased from previous plans to reflect the increased emphasis on the advanced sensors development and the importance of instrument readiness to the overall EOS schedule.

BASIS OF FY 1992 ESTIMATES

FY 1992 funding is required to continue to design of the EOS-A flight instruments which are to be selected in FY 1991. Instruments planned for the EOS-B series will continue conceptual definition in preparation for later flight selection. For the EOS-A instruments with design heritage, preliminary design reviews will begin in FY 1992.

FY 1992 funding is also required to continue development of the EOS-A observatories. Effort will be concentrated on development of long-lead components such as the high data rate recorders and thermal systems. The development schedule is currently under review and will take into account the pending instrument selection and the current budget.

FY 1992 funding is required for EOS science, primarily the EOS-A principle investigators and science facility teams. The principle investigators will begin development of the science algorithms that will decipher the data products from the science instruments. Each algorithm will be unique to the instrument and also reflect the scientific legacy of the Earth science research program. The science facility teams will perform the principle investigator roles for the facility class instruments. In response to several recent recommendations (i.e., the National Research Council and the recent Advisory Committee on the Future of the U.S. Space Program), an external engineering review will be undertaken during 1991 to examine additional alternatives for flying EOS instruments. In exploring these alternatives, the review shall ensure that there be no unacceptable degradation of the current EOS scientific objectives.

BASIS FOR FY 1992 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Earth observing system data information system................................	--	36,000	36,000	82,600

OBJECTIVES AND STATUS

A key element enabling the Earth Observing System (EOS) to meet the long-term science goals of Mission to Plant Earth is its Data and Information System (DIS). The EOSDIS will provide the processing, storage, and distribution of all the science data collected by EOS and the resulting scientific products. Additionally, EOSDIS will perform spacecraft and instrument command and control.

EOSDIS will be implemented as a distributed system, with a network of Distributed Active Archive Centers (DAACs) supporting experts developing science tools in designated disciplines. The DAACs will perform continuous processing of instrument data to derive the underlying scientific parameters of interest. The network will link the archived data and products so that investigators may access the entire set of holdings from any entry point. An information management service will help users locate data within the total archive. The network also will interface with international partner instruments and control facilities, and will provide operational data to agencies such as NOAA.

EOSDIS will be implemented by a "Core System" contractor, with contract award planned for 1992. Preliminary work to be performed by NASA will establish a "Version 0" EOSDIS, providing researchers with early access to data sets from precursor missions and from Earth Probes to be flown before EOS launches begin.

CHANGES FROM THE FY 1991 BUDGET ESTIMATE

The EOSDIS budget has been separately identified from the EOS program budget per Congressional direction.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding is required to establish DMCs and begin standardizing formats and retrieval capabilities for "pathfinder" data sets. Definition of EOSDIS functions must continue and be widely coordinated among DMCs and EOS platform and instrument developers. Science computing facilities will begin to be established for EOS investigators. Proposals for the EOSDIS Core System will be evaluated, and work initiated under contract.

BASIS FOR FY 1992 FUNDING REQUIREMENT

EARTH PROBES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Scatterometer..........................	13,600	17,800	17,800	24,000
Total ozone mapping spectrometer.........	--	10,900	21,900	29,900
Tropical rainfall measurement mission....	--	--	15,000	14,300
Total.................................	13,600	28,700	54,700	68,200
Launch vehicles (TOMS)...................	(2,000)	(4,000)	(6,400)	(12,100)

OBJECTIVES AND STATUS

The Earth Probes program is a component of Mission to Planet Earth and will provide an explorer-class program to address specific, highly-focused problems in Earth science. The program will have the flexibility to take advantage of unique opportunities presented by international cooperative efforts and technical innovation and will serve to maintain and increase Earth science research vitality.

These projects complement the Earth Observing System program by providing the ability to investigate processes which require special orbits or have other requirements such as a magnetically clean spacecraft for future gravitational investigations.

Planned Earth Probes include the Total Ozone Mapping Spectrometer (TOMS), with instruments on a free-flyer to be launched on an enhanced small class vehicle in 1993 and on the Japanese ADEOS Satellite in 1995; the NASA Scatterometer (NSCAT) also planned for launch on the Japanese ADEOS satellite, and the TRMM planned for launch in 1997.

The Scatterometer will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, will provide data on the effects of the oceans on the atmosphere, and will provide improved marine forecasting on winds and waves.

The TOMS instrument will provide uninterrupted data on total atmospheric ozone concentrations. Collection of this data was begun in 1978 with the launch of a TOMS instrument on Nimbus-7. The first TOMS Earth Probe will follow the TOMS instrument to be flown on the Soviet Meteor spacecraft, which will be launched in FY 1991.

The TRMM will measure precipitation in the tropical latitudes from a dedicated Earth probe. The spacecraft, integration and some instruments will be provided by the U.S. The launch vehicle and the rain radar will be provided by the Japanese. The TRMM will have completed definition and will begin development in FY 1991. The current plan is for launch in 1997.

CHANGES FROM FY 1991 BUDGET ESTIMATE

In FY 1991, the Earth Probes line item was augmented by $31.0 million per Congressional direction: $15.0 million to TRMM, $11.0 million to TOMS and $5.0 million to the Ocean Color Mission (SeaWiFS). Funding for the SeaWiFS is included under Earth Sciences mission operations and data analysis to reflect the proposed data purchase plan. The Scatterometer has also been incorporated into Earth Probes.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding is required to continue development of the NASA Scatterometer which is currently scheduled for a February 1995 launch on the Japanese Advanced Earth Observing System (ADEOS). In FY 1992, the NASA Scatterometer will complete development of the radio frequency subsystem and will begin system level integration. In addition, engineering models will be delivered to Japan during FY 1992.

FY 1992 funding is also required to continue development of the TOMS free flyer which is currently scheduled for a late 1993 launch. Spacecraft development contracts will be in place in late FY 1991, and system design and development will commence in FY 1992. In addition, work will continue for follow-on launches, including a 1995 launch aboard the ADEOS spacecraft.

Continued development of TRMM, which is currently scheduled for a late FY 1997 launch, is also funded in FY 1992. Spacecraft and instrument design will accelerate in FY 1992 leading to the Preliminary Design Review (PDR). The development schedule is currently under review and will be finalized in FY 1991.

BASIS OF FY 1992 FUNDING REQUIREMENT

REMOTELY PILOTED AIRCRAFT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Remotely piloted aircraft................	--	--	--	5,000

OBJECTIVES AND STATUS

The concept of remotely piloted aircraft (RPA) is to operate very light-weight aircraft at high altitudes for durations up to several weeks. The RPA idea resulted from a Department of Defense technology program. The effort in the Earth sciences research program will address the applicability of the RPA's to the flight of Earth sensing instruments. Opportunities to operate instrumented RPA's over terrestrial locations of interest will be evaluted as a complement to high altitude remote sensing. The RPA's offer the potential of a low-cost remote observation technique. The application of the technology to Earth sciences research will be studied and evaluated by established scientific researchers working with the industrial developers.

BASIS OF FY 1992 ESTIMATE

Funding will provide for the initial evaluation and planning of the application of the RPA concept to Earth sciences research, with emphasis on the feasibility for flight of currently-identified sensors, as well as their light-weight derivatives.

BASIS OF FY 1992 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget
		(Thousands of Dollars)		
Spacecraft	15,200	11,000	11,000	3,500
Experiments	40,000	55,000	53,000	14,700
Total	55,200	66,000	64,000	18,200
Mission operations and data analysis	--	--	--	(17,200)
STS operations	(6,800)	(58,500)	(13,600)	(34,200)

OBJECTIVES AND STATUS

The Upper Atmosphere Research Satellite (UARS) program is the next step of a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission, scheduled for a Shuttle launch in late 1991, is essential for understanding the key radiative, chemical and dynamical processes which couple together to control the composition and structure of the stratosphere. The UARS mission will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere. These measurements will complement the measurements of ozone and of atmospheric parameters affecting ozone that were made on Nimbus and SAGE. The UARS program is a critical element in overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics regarding production of chlorofluorocarbons. The UARS mission will also contribute to the assessment of the impact of stratospheric changes on our climate and will provide the data needed for a full understanding of the stratosphere. These understandings are essential for subsequent design and implementation of a long-term stratospheric monitoring activity.

The ten UARS experiments include infrared and microwave limb sounders which required advances beyond earlier capabilities in cryogenics, solid-state devices and microwave antennas. A Solar Backscatter Ultraviolet (SBW) instrument will be modified to fly on the Shuttle during'the UARS mission and to provide correlative data. In addition, development is underway on of the central ground data handling facility, which will permit near-real-time interactive utilization of data by the nineteen design and theoretical investigator teams.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that the system be developed on a timely parallel path with the flight hardware so that individual experiment data processing subsystems, including algorithms and the interactive data base, provide maximum interaction and effectiveness in the design and development phase of the program and are fully verified at launch time.

CHANGES FROM FY 1991 BUDGET ESTIMATE

A reduction of $2.0 million was made to provide funds for the TOPEX mission. There will be no impact on launch readiness.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funds are required to support spacecraft launch site activities at KSC and the launch of UARS on the Space Shuttle in late 1991. FY 1992 funding is also required to complete integration and test of the ground data handling facility including hardware and software verification activities prior to launch.

BASIS OF FY 1992 FUNDING REQUIREMENT

OCEAN TOPOGRAPHY EXPERIMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Ocean topography experiment (TOPEX)......	84,800	68,000	76,000	51,900
Mission operations and data analysis.....	--	--	--	(5,000)

OBJECTIVES AND STATUS

The goal of the Ocean Topography Experiment (TOPEX) is to utilize satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to significantly enhance our understanding of the oceans' general circulation and mesoscale variability. The capability of satellite altimetry to address this goal was demonstrated in 1978 by NASA's Seasat program. Such information is needed to better understand how the atmosphere drives the circulation of the oceans, how the oceans in turn influence the atmosphere and ultimately, the role of the oceans in climate.

NASA and the French Space Agency (CNES) are collaborating on TOPEX in order to exploit more fully the scientific value of the data. In exchange for this scientific collaboration and the flight of a French altimeter and tracking system, CNES will launch TOPEX in June 1992 on an Ariane launch vehicle. TOPEX is also being planned in concert with the World Ocean Circulation Experiment (WOCE), a major international oceanographic field program being planned under the auspices of the World Climate Research Program (WCRP). WOCE will combine satellite observations from TOPEX with traditional in situ Observations to enable the first comprehensive determination of the three-dimensional current structure of the global oceans. When further combined with ocean surface winds from the NASA Scatterometer (NSCAT), unique measurements of the oceans' driving force (winds) and the resulting ocean response (topography) will have been obtained.

During 1991, the satellite contract will complete the development phase, and integration and test of the spacecraft and sensors will continue. The joint NASA/CNES science team will continue its effort to develop and verify algorithms to produce consistent data products for the science teams.

CHANGES FROM FY 1991 BUDGET ESTIMATE

An additional $8.0 million was added to the TOPEX program, including $3.0 million by Congressional direction, to maintain critical schedules leading to launch in June 1992.

BASIS OF FY 1992 ESTIMATE

In FY 1992, TOPEX funding will support continued full-scale spacecraft system integration and test. Spacecraft delivery will occur in late CY 1991 for integration to the Ariane 4 launch vehicle. The CNES and Arianespace have signed contracts to provide launch services for a June 1992 launch.

BASIS FOR FY 1992 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Atmospheric payloads....................	20,100	10,700	10,700	14,600
Earth sensing payloads...................	32,200	31,700	31,700	34,000
EOS ATD................................	23,800	7,300	7,300	--
Total................................	76,100	49,700	49,700	48,600

OBJECTIVES AND STATUS

The Space Transportation System offers the unique opportunity for short-duration flights of instruments. The Earth Science and Applications program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation, from airborne to international flights of opportunity.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument flew in 1985 on Spacelab-3 and data analysis continues. In FY 1987, ATMOS commenced a ground observation program at Table Mountain Observatory which was completed with the delivery of ATMOS to KSC for the ATLAS-1 mission. The science results from the first flight of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the Earth's atmosphere was clearly demonstrated.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of troposphere carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two Shuttle flights, and data analysis continues. It is planned for three more STS flights, to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere. Reflight of MAPS is also planned on the Shuttle Radar Laboratory (SRL) series.

The Active Cavity Radiometer-1 (ACR-1) is designed to aid in the study of the Earth's climate and the physical behavior of the Sun by making solar constant measurements. Reflights of ACR-1 on the ATLAS series are planned. Other experiments have also been selected for reflight, including some instruments which were flown on the Shuttle orbital flight tests and Spacelab-1.

Components of the Shuttle Imaging Radar-B (SIR-B) will be used in building the next generation Imaging Radar instrument, SIR-C. The SIR-C will use multi-polarized, dual frequency sensor technology. The SIR-C is in the development and fabrication phase. System requirements review, antenna preliminary design review and system preliminary and critical design reviews are now complete. Flight aboard the Space Shuttle is scheduled for the first quarter of FY 1994. In October 1987, NASA signed a Memorandum of Understanding with the Federal Republic of Germany agreeing to joint missions of SIR-C with an x-band imaging radar to be provided by a joint German/Italian project (X-SAR). Preparations continue to commercialize the Large Format Camera.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution.

The refurbished TOMS instrument completed first integration and checkout on the Soviet Meteor Spacecraft early in FY 1991. Following an update to full flight configuration and calibration, TOMS and the Interface Adopter Module (IAM) will be returned to the USSR in 1991 for launch by the Soviets.

BASIS OF FY 1992 ESTIMATE

FY 1992 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities including data reduction, refurbishment for reflight and upgrading of the ground service equipment. The FY 1992 funding for ATMOS is required to support continuing flight on the ATLAS series, which include continued science team activities, data processing and analysis, and limited refurbishment. FY 1992 funding is also required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on future Shuttle ATLAS flights.

Development activities will continue on the international (U.S. and France) Light Detection and Ranging (LIDAR) airborne instrumentation following completion of critical design reviews in preparation for the integration and ground test of this multi-phase user program. First flight is projected for FY 1993. In this program, both NASA and France are supplying science knowledge to demonstrate first-time detail measurements of the atmosphere to aid in forecasting.

In FY 1992, funding is required for continued development of SIR-C, in preparation for launch in 1993. In 1992, all instrument integration and performance testing will be completed, as will testing of the antenna to the instrument. By October 1992, the thermal vacuum test will be done and the instrument will be prepared for delivery to the launch site.

BASIS OF FY 1992 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Upper atmospheric research satellite operations..........................	--	--	--	17,200
Ocean topographic experiment operations..	--	--	--	5,000
Ocean color mission data purchase........	--	--	5,000	13,000
Consortium for international earth science information networks..	(8,000)	--	8,000	--
Earth sciences mission operations and data analysis........................	23,800	30,400	26,400	21,100
Total................................	23,800	30,400	39,400	56,300

OBJECTIVES AND STATUS

The objective of the Earth Science and Applications mission operations and data analysis program is to acquire, process, and archive long-term data sets produced by spaceborne missions. These data relate to issues of global change in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operations of spacecraft, processing of acquired data, validation of the resulting data products by science teams, and development of new processing software by these science teams.

The Upper Atmosphere Research Satellite (UARS) is scheduled for launch in late 1991. After launch, this mission should provide a wealth of data related to the chemistry and dynamics of the atmosphere above the tropopause for a period of at least three years. Various instruments aboard UARS will measure temperature, composition, and winds in the Earth's atmosphere, as a function of altitude, over 98 percent of the Earth's surface, from 80 degrees South latitude to 80 degrees North. These data will provide important information related to maintenance and destruction of the ozone layer.

NASA's Ocean Topography Experiment (TOPEX) and the Poseidon mission of France's CNES, will be launched as a single ocean spacecraft mission, TOPEX/Poseidon, in June 1992. After launch, this mission should provide a data on the surface topography and currents of the Earth's oceans, for a period of at least three years. These data will provide critical information related to the circulation of the Earth's oceans and the Earth's climate.

NASA will purchase ocean color data for research use, to be obtained from a spacecraft to be launched in 1992 or 1993. This imaging data, to be obtained in several visible wavelengths, will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of the world's oceans, seas, and larger lakes.

On Nimbus-7, the Stratospheric Aerosol Measurement II (SAM-II) instrument continues to add to a 12-year data set on atmospheric aerosols and stratospheric clouds in the Earth's polar regions. Data from the Total Ozone Mapping Spectrometer (TOMS) instrument on Nimbus-7 continue to provide accurate maps of total atmospheric ozone, as they have since launch in 1978. This instrument will be joined in space by a TOMS instrument to be flown on the USSR's Meteor-3 spacecraft, to be launched in 1991.

Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments, on the NOAA-9 and NOAA-11 satellites, provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites, continuing the collection of a data set begun with the SBW instrument on Nimbus-7 in 1978. A carefully calibrated version of the same instrument, called Shuttle SBUV (SSBW), has been flown twice on the Space Shuttle and will continue to fly periodically in the early and middle 1990's. The SSBW provides correlative measurements so that TOMS and SBW instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.

On the Earth Radiation Budget Satellite (ERBS), data from the Stratospheric Aerosol and Gas Experiment II (SAGE-II) continue to provide vertical profiles of aerosols, ozone, and other trace gas species over Earth's tropical and mid-latitude regions, as they have since ERBS launch in 1984.

The Earth Radiation Budget Experiment (ERBE) is comprised of three identical instrument packages flying on NOAA-9, NOAA-10, and NASA's ERBS. These instruments continue to provide data illuminating the temporal and spatial variations in the Earth's radiation budget, which drive the Earth's climate, as they have since ERBS's launch in 1984. Data from the Earth Radiation Budget (ERB) instrument on Nimbus-7, and from the ERBE instruments, provide the only continuous data set on total solar irradiance ("solar constant") and its temporal variations stretching from 1978 to the present.

NASA's Alaska Synthetic Aperture Radar Facility (ASF), based at the Geophysical Institute, at the University of Alaska in Fairbanks, will acquire and process SAR data transmitted from the European Space Agency spacecraft ERS-1 in early 1991. Data from the Japanese JERS-1 and the Canadian RadarSat spacecraft will also be acquired and processed after launch of these spacecraft. These data will provide important information on the properties and dynamics of sea ice and other land and ocean processes in the polar regions.

The Consortium for International Earth Science Information Network (CIESIN) serves as an affiliated data center for NASA's EOS program. It will facilitate the access to and use of Earth science data for global change research and public policy making. The CIESIN is currently analyzing existing and future Earth science information resources and current national and international plans for data integration, analysis and modeling.

CHANGES FROM FY 1991 BUDGET ESTIMATE

In FY 1991, the Mission Operations and Data Analysis program was increased by $9.0 million. By Congressional direction, $5.0 million has been added for the Ocean Color Mission (OCM), and $8.0 million for the EOS Consortium for International Earth Science Information Networks (CIESIN) program. As part of the general reduction, $4.0 million was reduced from programs unrelated to the Congressional augmentations. These reductions will result in deferral of some data analysis activities.

BASIS OF FY 1992 ESTIMATE

Operations of the Nimbus-7 and ERBS spacecraft and processing and analysis of their data will continue, as will processing and analysis of data from NOM-based and Shuttle-based SBUV instruments. Processing and analysis of SAR data acquired at the ASF from ESA's ERS-1 will also continue and be augmented by similar processing and analysis of SAR data from Japan's JERS-1. Operations of the UARS and TOPEX spacecraft and processing and analysis of their data will begin in FY 1992. Processing and analysis of data from the TOMS instrument to be flown on the USSR Meteor-3 spacecraft will begin in FY 1992, after launch in late FY 1991. Processing and analysis of data from various NASA SAR instruments (including an airborne version) will continue, in preparation for flight of SIR-C in 1993. Funding for OCM will allow eventual purchase, processing, and analysis of ocean color data.

BASIS OF FY 1992 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH AND ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Interdisciplinary research and analysis..	8,600	2,400	12,400	2,500

OBJECTIVES AND STATUS

Interdisciplinary research activities are conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and the atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, including atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

CHANGES FROM FY 1991 BUDGET ESTIMATE

As directed by Congress, $10.0 million has been added for climate studies and individual research grants. Climate funding will augment NASA's current climate modeling program and associated global field campaigns. This program will enhance access and use of Earth science and related information by the scientific and policy-making community in pursuit of global change issues.

BASIS OF FY 1992 ESTIMATE

In FY 1992, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of oceanic processes, atmospheric dynamics and radiation, upper atmosphere/ troposphere chemistry, and land processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

BASIS OF FY 1992 FUNDING REQUIREMENT

MODELING AND DATA ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Physical climate and hydrologic systems modeling and data analysis.............	23,800	26,000	28,000	28,000
Biogeochemistry and geophysics modeling and data analysis.............	14.700	15.300	16.300	17.000
Total................................	38.504	41.300	44.300	45.000

OBJECTIVES AND STATUS

The research and analysis activities within the Physical Climate and Hydrologic System program provide a focus for contributing to an improved understanding of the fully-integrated geophysical climate system, its interactions and predictability, through the development and multi-disciplinary exploitation of global satellite observations of the Earth, numerical modeling, climate impact assessments, and sensitivity studies. The two principal components of the program are in the areas of climate modeling research and climate data analysis.

The objectives of the climate modeling research program are to develop and improve global circulation models which assimilate and optimize the use of satellite-derived data sets for understanding climate interactions; to help guide the design of the global observing system, and to improve the capability for reliable climate diagnosis and forecasting. The program builds on the broad foundation established over the past decade of research on geophysical modeling conducted under the NASA Atmospheric Dynamics and Radiation and Ocean Processes programs.

The objectives of the climate data analysis program are to assemble a long-term global record of climate parameters, with an emphasis on satellite remote sensing, for specifying and analyzing the state of the climate system and its variability. These include the full range of geophysical variables which describe the structure and composition of the atmosphere, oceans, land surfaces, and cryosphere, as well as their boundaries, interfaces, and external forcings. The program builds on earlier accomplishments achieved through such diverse research initiatives as the International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation and Budget Experiment (ERBE), the Global Atmospheric Research Program (GARP) and current activities in support of the Tropical Oceans Global Atmosphere Program (TOGA) and the World

Ocean Circulation Experiment (WOCE). These programs are elements of the World Climate Research Program (WCRP), sponsored by the World Meteorological Organization and the International Council of Scientific Unions. Such international relationships are strongly encouraged by the U.S. Global Change Research Program plan.

The biogeochemistry and geophysics modeling and data analysis has as its objectives the development of global change models dealing with all aspects of the biology, chemistry, geology, and geophysics of the Earth system, with the exploitation of satellite data in the monitoring of global change as well as the study of the mechanisms which are at work in the global environment. There are four major elements to the program: ocean biogeochemistry, atmospheric chemistry, geophysical modeling and analysis, and ecology and land atmosphere interactions.

In the ocean biogeochemistry program element, the emphasis is on data analysis efforts utilizing existing satellite data sets to understand better the variations in ocean productivity.

The atmospheric chemistry program element is centered on the numerical modeling and analysis of measurements trace constituents in the troposphere-stratosphere system. Numerical models are used to test our understanding of atmospheric chemistry and of the way in which meteorological processes affect the trace constituent distribution in the atmosphere. Models are also used to predict future changes to the chemical composition of the atmosphere.

Research in geophysical modeling and analysis consists of modeling and analysis of the Earth's internal structure and dynamics through measurements of the gravitational and magnetic fields, Earth rotation and polar motion, and geodetic properties. The spatial variability of the potential fields and the temporal variability of the motion fields are the critical observational parameters.

In the ecology and land atmosphere interactions program element, global scale observations are analyzed to better understand the current state of terrestrial ecosystems, to assess their natural variability, and to determine the impacts of anthropogenic forcings. Numerical models and multitemporal satellite observations are used to study sources and sinks of biogeochemical species and to investigate the interactions of climatic events such as El Nino with surface biology and atmospheric composition. Theoretical modeling of ecosystem functioning and land-atmosphere interactions is conducted using global circulation models with explicit, interactive biospheres.

CHANGES FROM FY 1991 BUDGET ESTIMATE

In FY 1991, modeling and data analysis line item received a $5.0 million Congressional augmentation which included $2.0 million for biogeochemistry and geophysics and $3.0 million for physical climate and hydrologic systems. A reduction of $1.0 million from each program was necessary to provide funds for the schedule-critical TOPEX mission. These reductions were taken in areas unrelated to the Congressional augmentation.

BASIS OF FY 1992 ESTIMATE

In FY 1992, particular emphasis will be placed on preparing stratospheric photochemical models for improving current atmospheric and physical oceanographic models. In the area of climate data analysis, funding is required for continuing the processing of satellite-&rived climate data sets. The ocean biochemistry program element will increase the emphasis on modeling of the chemical interactions between the oceans, land and atmosphere. In atmospheric chemistry, emphasis on multi-dimensional modeling of the troposphere will be increased. The studies in ecology and land atmosphere interactions will place increased emphasis on ecosystem sources of key trace species in the atmosphere.

BASIS OF FY 1992 FUNDING REQUIREMENT

PROCESS STUDIES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Radiation dynamics and hydrology.........	31,400	33,400	31,800	34,200
Ecosystem dynamics and biogeochemical cycles................................	20,500	21,000	20,600	23,300
Atmospheric chemistry...................	27,000	29,300	28,300	30,900
Solid earth science.....................	27,300	27,400	26,800	25,900
Total.................................	106,200	111,100	107,500	114,300

OBJECTIVES AND STATUS

The research and analysis activities within the radiation dynamics and hydrologic processes program combine a core effort of theoretical, laboratory, and field investigations essential to understanding the basic geophysical processes and their interactions which control climate. The two principal components of the program are in the areas of radiation and dynamic processes research and hydrologic processes research.

The objectives of the radiation and dynamics research program are to improve our understanding of the basic physical processes by which the atmospheric system transforms, stores and transports energy. Of all the exchange processes, radiation energy has a special role in climate because the energy balance of the climate system as a whole is determined by a balance between absorbed solar radiation and emitted thermal radiation. Gradients in the net radiation, drive the circulations of the atmosphere and oceans. Special emphasis is given to the processes responsible for cloud-radiation interaction and feedback. The first International Satellite Cloud Climatology Project (ISCCP) Regional Experiment (FIRE), which builds on the foundation established earlier under the NASA atmospheric dynamics and radiation research program, is a central focus for the program. The FIRE is an integrated research program whose objectives are: to expand our basic knowledge of cloud interactions with the environment and climate; to identify and simulate the physical and chemical processes involved in large-scale cloud systems; to quantify and improve current models for simulating large-scale cloud systems and the radiative properties of these systems; to improve cloudiness and radiation parameterizations used in global models; and to assess and improve the reliability of current cloud/radiation monitoring systems from space and from the ground.

The objectives of the hydrologic processes research program are to improve our understanding of the physical processes which govern the hydrological cycle and its impact on the atmosphere and oceans. The prediction of global change in the geosphere and biosphere will be one of the most important problems in environmental sciences in the 21st century. Estimation of the distribution and transport of carbon, nitrogen, sulfur, etc., cannot be obtained without knowledge of the atmospheric circulation and water cycle on regional and global scales. Knowledge of the distributions of water and its phase transformations, from vapor to liquid to solid, is paramount to understanding the energy sources and sinks which drive atmospheric and oceanic circulations. The availability of water is also a major factor affecting the distribution of the biomass and biological productivity. The biomass and land cover, in turn, play a role in controlling the absorption of solar radiation, evapotranspiration, and turbulent heat transfer.

The ecosystem dynamics and biogeochemical cycles program conducts research on the function of global ecosystems and the interactions of the Earth's biota with the atmosphere and hydrosphere. Particular emphasis is placed on land-atmosphere interactions, both physical and chemical; carbon cycling, especially ocean productivity; and the biophysics of remote sensing of ecosystems.

The goal of the ecosystem dynamics program element is to achieve an improved understanding of the role of the biosphere and the biologically-linked components of the hydrologic cycle in processes of global significance. Specific objectives are to develop understanding of landscape and oceanic patterns and processes, the factors controlling ecosystem function, the response of ecosystems to change, and interactions between physical and biological/ecological processes, including the surface energy balance. Airborne and spaceborne remote sensing measurements are used extensively to achieve these objectives and to extrapolate small-scale process information to regional and global contexts.

The goal of the biogeochemical processes program element is to achieve an improved understanding of the sources, sinks, fluxes, trends and interactions involving the biogeochemical constituents within the Earth system, with an emphasis on their major biospheric reservoirs, including oceanic, freshwater, and terrestrial systems. Specific objectives are to develop a better understanding of the cycling of carbon and key nutrients within ecosystems and between ecosystems and their abiotic environment, and to identify the sources of radiatively and chemically active trace gases and to quantify their major exchanges between the Earth's biosphere and its atmosphere.

The atmospheric chemical processes program is composed of two elements: the upper atmospheric research program (UARP) and the tropospheric chemistry program (TCP). The UARP is a large, comprehensive research program with NASA playing a leadership role as mandated by Congress under the Clean Air Act of 1976 and the FY 1976 NASA Authorization Act. The program aims at expanding our knowledge of the physical, chemical, and meteorological processes that control the concentration and distribution of atmospheric ozone, thereby providing the necessary input for large-scale global models used to predict the future state of stratospheric composition. The TCP is focussed on tropospheric chemical change, the natural and anthropogenic processes that cause it, and its effects on global climate and on the chemistry of the stratosphere through troposphere-stratosphere exchange.

One of the primary challenges in the study of the Earth as a system is understanding the extent and causes of atmospheric chemical changes and their consequences, including stratospheric ozone depletion and potential global climate change. Research activities include a wide range of field observations using satellites, balloons, aircraft, and ground-based measurement systems. The measurement projects are designed to study the troposphere and the stratosphere on a global scale. Thus, ecosystems ranging from tropical rain forest to Antarctica are encountered. The research covers a full range of altitudes, seasons, and solar energy input. The field experiments are complemented by laboratory studies in chemical kinetics, photochemistry, and spectroscopy.

The solid Earth science program conducts research in the fields of geology and geodynamics with the goal of improving our understanding of the evolution, structure, and dynamics of the Earth's interior and surface by testing hypotheses through a vigorous program of measurement and analysis of space-based geodetic, remote sensing, space-based geopotential, and related data. In geodynamics, emphasis is placed on understanding the rates and mechanisms of Earth's crustal deformation from local to global scale and how these reflect historical global change or influence current processes of global change. In geology, emphasis is placed on the interaction of the solid Earth with the hydrosphere, atmosphere and biosphere in programs under development and implementation in the early 1990's which address soil development and erosion, volcano-climate interaction, and coastal processes. The role of soil in the global carbon cycle is possibly the most poorly documented element of that cycle. Historical volcanic activity has been shown to have dramatic short-term (1-2 years) effects on atmospheric composition and it is important to understand the potential such activity to affect long-term trends in global climate change. Coastal subsidence or emergence phenomena represent the integrated result of complex processes including local erosion or deposition, regional tectonic variation including post-glacial rebound, and global sea level change.

CHANGES FROM FY 1991 BUDGET ESTIMATE

A reduction of $1.0 million was made to provide additional funds for the TOPEX mission and $2.6 million transferred to Planetary Mission Operations and Data Analysis (MO&DA) in order to provide necessary support for Galileo mission operations.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding is required in the area of radiation and dynamics research to continue studies of the processes associated with cloud-radiation feedback, ocean circulation and heat flux. Emphasis for the ecosystem dynamics and biogeochemical processes program will be on analyzing existing data sets acquired from a series of multisensor airborne campaigns. Both of the atmospheric chemical process programs will continue their activities to investigate and understand the global atmosphere through laboratory studies and field measurement campaigns. The solid Earth program will pursue its geodynamics research activities in large part through the Fiducial Laboratories for International Natural Science Network. The geodynamics program will continue to develop, in partnership with the European Space Agency (ESA), a geopotential research mission, ARISTOTELES, using gravity gradiometry and magnetometers to study at high resolution the variability of Earth's gravity and magnetic fields.

BASIS OF FY 1992 FUNDING REQUIREMENT

RESEARCH FACILITIES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Laser research facilities................	8,000	8,700	8,700	9,000
Airborne science and applications........	19,399	20,200	20,200	20,600
Total................................	27,399	28,900	28,900	29,600

OBJECTIVES AND STATUS

The objective of the laser research program is to measure the movement and deformation of the tectonic plates of the Earth. Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the global positioning satellite system (GPS) are used to determine precise position locations.

The United States and a consortium of eight European and Middle East countries continue measurements of crustal deformation in Greece, Turkey, and Italy. A mobile laser ranging station operated by the Federal Republic of Germany joins similar U.S. stations in deformation studies in the U.S.

The Airborne Science and Applications effort requires operation of two ER-2's, a C-130, and a DC-8 in order to support Earth-sensing and atmospheric research. Theses aircraft support other major segments of the space science and applications program dealing with the Earth, the oceans, and the atmosphere. They may serve as test beds for newly developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircrafts are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2's acquire stratospheric air samples and conduct in-situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms.

BASIS OF FY 1992 ESTIMATE

In FY 1992, measurements of plate motion between North America and Europe will be continued in cooperation with countries in Europe, the Middle East, Far East, South and Central America. Measurements of the motions of the Pacific Plate will be continued in cooperation with Japan and China. Regional crustal deformation measurements in western North America will continue in cooperation with NOM, Canada and

Mexico. The Caribbean studies will be continued and include more sites along the plate boundary and on the plate itself. The LAGEOS-1 and other satellites will continue to be used for studies of plate motion. NASA laser systems in the U.S., Pacific, South America, and Australia will be operated in cooperation with laser systems in 12 other countries. The LAGEOS-2, a joint mission with Italy, is presently under development by Italy and will be launched by the Space Shuttle in 1992.

FY 1992 funding will allow operation of the DC-8, two ER-2's, and the C-130. Operation of these aircraft will allow continuation of such projects as the collection and analysis of stratospheric air samples, testing of newly-developed instrumentation, the demonstration of new sensor concepts, the investigation of the Ozone Hole phenomena, and participation in numerous other field experiments such as the International Satellite Cloud Climatology Project (ISCCP) Regional Experiment (FIRE).

MATERIALS
PROCESSING
IN SPACE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

MATERIALS PROCESSING IN SPACE

SUMMARY OF RESC QUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
	(Thousands of Dollars)				
Research and analysis..................	12,566	13,700	13,700	16,600	RD 7-3
Materials experiment operations..........	84,301	79,900	84,900	85,500	RD 7-4
Space station utilization........	(4,975)	(15,000)	(3,000)	21,300	RD 7-5
Commercial microgravity R&D enhancements.	5.020	3.700	3.700	2.400	RD 7-6
Total................................	101.887	97.300	102.300	125.800	

Distribution of Proeram Amount bv Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center....................	1,525	1,366	1,326	2,583
Marshall Space Flight Center....	37,607	33,909	37,413	44,668
Ames Research Center....................	14	--	--	--
Lewis Research Center...................	27,771	30,058	31,057	41,963
Langley Research Center..................	2,088	2,970	2,333	4,982
Jet Propulsion Laboratory................	28,081	22,948	22,890	28,276
Goddard Space Flight Center.............	75	--	80	85
Headquarters............................	4.726	6.049	7.201	3.243
Total................................	101.887	97.300	102.300	125.800

OBJECTIVES AND JUSTIFICATION

The Materials Processing program uses the unique attributes of the space environment to conduct research in three primary areas: (1) Fundamental Science, which includes the study of the behavior of fluids, transport phenomena, condensed matter physics and combustion science; (2) Materials Science, which includes study of electronic and photonic material, metals, alloys, glasses and ceramics; and (3) Biotechnology, which focuses on macromolecular crystal growth and cell science. A goal of the program include developing a comprehensive research program in these primary areas to attain a more structured understanding of those physical phenomena made obscure by the effects of gravity. This understanding will provide the basis of a reliable predictive capability for processing operations and technology in both Earth and non-Earth environments. In FY 1992, both ground-based research and payload development will support this program goal.

Ground-based research supports definition studies for flight experiment candidates in areas such as containerless processing, solidification and crystal growth, fluids and combustion research and processing of biological materials. Research is conducted in drop-tubes, drop towers and aircraft.

The Materials Processing program provides a range of experimental capabilities. The program currently supports a wide variety of hardware development, from unique flight experiments necessary to conduct fundamental research to modular, multi-user research facilities that will be the cornerstone of microgravity science and applications research on Space Station Freedom. Experiments will principally be flown on the Shuttle and Spacelab.

BASIS OF FY 1992 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (MATERIALS PROCESSING)

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Research and analysis (ground-based).....	12,566	13,700	13,700	16,600

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects. Ground-based research leads to space investigations with potential for future applications. This activity also provides analytical support and technology development for future ground and space capabilities. Most research projects are initiated as a result of proposals from the scientific community which are extensively reviewed by peer groups prior to selection and funding.

BASIS OF FY 1992 ESTIMATE

Ground-based research and analysis will continue in FY 1992 in the areas of fundamental science, materials science, and biotechnology. Research will be conducted to define the role of gravity-driven influences in a variety of processes. A series of solicitations (NASA Research Announcements and Announcements of Opporunity), primarily in the area of fundamental science, will be released to focus and expand the science community involvement. This will allow for the development of strong candidates for future flight opportunities.

BASIS OF FY 1992 FUNDING REQUIREMENT

MATERIALS EXPERIMENT OPERATIONS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Materials experiment operations..........	84,301	79,900	84,900	85,500

OBJECTIVES AND STATUS

The Materials Experiment Operations program provides experiments for a wide range of flight opportunities. NASA currently supports the development of Space Transportation System (STS) middeck, Spacelab and cargo-bay experiments. This policy maximizes the effective use of the STS by developing hardware to meet experiment scientific and technical requirements. Preparations are underway to use Space Station Freedom as a major laboratory for conducting microgravity research, consistent with the strategy for orderly evolution of microgravity experiments-- from ground-based research, to the Shuttle, and then to Space Station. During FY 1991 and FY 1992, equipment development and delivery for the first United States Microgravity Laboratory (USML-1) Spacelab mission and other Spacelab missions will continue. In addition, research and experiment flight hardware development will continue in the fundamental sciences, an important area in Microgravity research.

CHANGES IN THE FY 1991 BUDGET

A Congressionally-directed increase of $5.0 million has been applied to resolving unanticipated technical problems encountered during integration and test of the three main experiments on USML-1, thus enabling the experiments to meet the 1992 launch date.

BASIS OF FY 1992 ESTIMATE

FY 1992 funding is required to continue basic and applied research activities as well as payload development effort, using STS middeck, Spacelab and cargo-bay experiments leading to several flights over the next few years, including International Microgravity Lab (IML-1), USML-1 and United States Microgravity Payload-1 (USMP-1) in 1992. Investigations are planned in fluid dynamics, glasses, electronic materials, biotechnology, metals and alloys, and combustion. Development will continue on fundamental science experiments as well as several pieces of advanced equipment in the areas of electronic crystal growth, biotechnology, metals and alloys, and containerless processing.

BASIS OF FY 1992 FUNDING REQUIREMENT

SPACE STATION UTILIZATION

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space station utilization................	(4,975)	(15,000)	(3,000)	21,300

OBJECTIVES AND STATUS

The Space Station Utilization program will perform the necessary planning and definition of payloads for the Space Science and Applications use of Space Station Freedom (SSF). Also, it involves definition of integration, operations, and training requirements to guide the planned development of Space Station and science support capabilities.

Several microgravity facilities have been identified for flight on Space Station including the Space Station Furnace Facility, the Modular Containerless Processing Facility, the Advanced Protein Crystal Growth Facility, the Biotechnology Facility, the Modular Combustion Facility, and the Fluid Physics/Dynamics Facility. Other options are being explored to address additional fundamental science questions and to offer opportunities to small and rapid response payloads.

BASIS OF FY 1992 ESTIMATE

Beginning in FY 1992, Space Station Utilization will consist of Space Station integration planning as well as the design and development of the planned microgravity facilities. The integration/planning function was previously budgeted within Physics and Astronomy, however due to the deferral of the Space Station attached payloads program (thereby delaying indefinitely any space physics or astronomy experiments), this activity has been transferred to the Microgravity Science and Applications budget.

In FY 1992, a science base for the Space Station--SSF resources requirements, unique user requirements, etc., will be compiled. Science utilization management planning activities for science and applications payloads, such as operations support and accommodations and requirements analysis will proceed.

During FY 1992, development will continue on the Advanced Protein Crystal Growth Facility and the Space Station Furnace Facility, the first of the SSF facilities planned for flight. The budget also supports continued definition studies for the remaining Space Station facilities.

i

BASIS OF FY 1992 FUNDING REQUIREMENT

COMMERCIAL MICROGRAVITY R&D ENHANCEMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Commercial microgravity R&D enhancements.	5,020	3,700	3,700	2,400

OBJECTIVES AND STATUS

The Commercial Hicrogravity R&D Enhancements budget supports several projects formerly managed by NASA's Office of Commercial Programs (OCP). The program funds the cost of modifying existing microgravity research hardware to accommodate members of the commercial user community and consolidates funding within the Office of Space Science and Applications (OSSA) for joint OSSA/OCP multiuser facilities.

BASIS OF FY 1992 ESTIMATE

The FY 1992 Commercial Microgravity R&D Enhancements budget supports continued development of the Crystal Growth Furnace for flight on the United States Hicrogravity Laboratory series, and will provide funding needed to accommodate commercial users on existing hardware, i.e., the Protein Crystal Growth Facility, and ground-based microgravity research facilities.

COMMUNICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS COMMUNICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced communications technology satellite (ACTS)......................	59,975	34,000	34,000	11,200	RD 8-3
Advanced communications research.........	12,275	12,500	11,358	15,300	RD 8-4
Search and rescue......................	1,218	1,400	1,400	1,300	RD 8-6
Radio science and support studies........	2,735	3,300	2,409	3,300	RD 8-7
Communications data analysis.............	1,449	1,600	3,333	8,300	RD 8-8
Total................................	77,652	52,800	52,500	39,400	

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Ames Research Center..	50	--	--	--
Goddard Space Flight Center..............	2,525	3,497	3,344	3,489
Jet Propulsion Laboratory................	5,321	4,603	6,128	5,657
Johnson Space Center.....................	--	--	80	--
Lewis Research Center...................	64,306	39,780	38,600	25,950
Headquarters...........................	5,450	4,920	4,348	4,304
Total................................	77,652	52,800	52,500	39,400

OFFICE OF SPACE SCIENCE AND APPLICATIONS COMMUNICATIONS

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program will develop advanced technologies and use these technologies in a joint experiments program with U.S. industry to prove the utility of on-board switching, using the ACTS baseband processor, and simultaneous communications transmissions to different terrestrial locations through an intricate, multibeam antenna.

Advanced communications research continues to provide the development of subsystem component technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Special emphasis is being given to technologies with high potential for improving spectrum utilization, satellite switching, and inter-satellite link technologies, since these technologies are the key to future growth of the communication satellite and terminal markets. An example of the technologies under study is optical space communications, which will extensively improve space communications capabilities. The mobile communications program has completed development of enabling technologies and is now ensuring the use of these technologies by the private sector.

The Search and Rescue program is an international cooperative program that has demonstrated the use of satellite technology to detect and locate aircraft or vessels in distress. The United States, Canada, France, and the Soviet Union developed the system, in which Norway, the United Kingdom, Bulgaria, Sweden, Denmark, Switzerland, Brazil, and India also participate.

The Radio Science and Support Studies program provides the technical basis to support U.S. and NASA interests in international and domestic communications regulatory forums. Propagation studies and measurements are performed in order to understand and account for the effects of propagation in the design and specification of space communications systems. Studies to enable new satellite applications are conducted.

Communications Data Analysis assists other federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster, and public service applications. The main areas of work are preparation for optical inter-satellite communications and operation of the Applications Technology Satellite (ATS-3). In FY 1991, activity now includes prototype ground experiment terminal development for the ACTS program.

BASIS OF FY 1992 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced communications technology satellite (ACTS)......................	59,975	34,000	34,000	11,200
STS operations..........................	(6,300)	(58,400)	(12,300)	(34,700)
Upper stage.............................	(6,700)	(13,200)	(12,800)	(5,800)

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program is planned to maintain U.S. leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites.

The U.S. user community, representing private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS is planned for an Space Transportation System/Transfer Orbit Stage (STS/TOS) launch in 1992.

BASIS OF FY 1992 ESTIMATE

During FY 1992, system test of the flight and ground segments will be conducted, final preparations for shipment to the launch site will be initiated, proceeding to the launch and on-orbit checkout.

BASIS OF FY 1992 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS RESEARCH

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced communications research.........	12,275	12,500	11,358	15,300

OBJECTIVES AND STATUS

The advanced communications research program emphasizes the development of high-risk technology required to maintain U.S. preeminence in the international satellite communications market, to enable new and innovative public services, and to meet the communications needs of NASA and of other government agencies. This program focuses on the "interconnectivity technologies" of on-board switching, inter-satellite links and antennas, as well as advanced optical and radio frequency technologies. Advanced studies are performed to determine the future satellite communications needs of the country and to define the technology required to meet those needs. The technology is developed and tested through an advanced proof-of-concept (POC) program. The POC devices and components are then integrated into a multiple terminal, satellite communications network in a laboratory where they undergo comprehensive evaluation.

The mobile satellite communications effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first-generation commercial system. A consortium of commercial firms has been formed to introduce mobile satellite communications in the U.S. NASA's current role in mobile satellite communications is to expedite the transfer of the NASA-developed technologies to the private sector and to stimulate the commercial development of mobile satellite communications through a barter agreement. Funding for the mobile satellite launch is included in the expendable launch vehicles budget. The future NASA research role, when the mobile satellite communications system is operational, will be aimed at testing power, bandwidth, and orbital-slot efficient ground segment technology. In addition, NASA plans to use the mobile communications systems to test data networking techniques and to support public service communications requirements.

In FY 1991, the satellite communications applications research program continues. The program objective is to advance satellite-based communications technology systems that show promise for use by the space communications industry, Competitive NASA Research Announcements which are issued on a periodic basis, are the sources of these technologies.

Work is continuing on advanced communications technologies. The optical space communications terminal, employing low-power lasers, will focus communications between satellites and ground terminals, satellites and low-Earth-orbiting spacecraft, such as the Space Shuttle or Space Station Freedom, and between satellites and other geosynchronous orbiting satellites, such as the Tracking and Data Relay Satellite (TDRS). The preliminary design of a prototype optical communications system has been completed. Technology development is also underway in the area of monolithic microwave integrated circuits (MMIC), which have significant potential for applications in multi-port spacecraft matrix switches, low noise receivers, and multibeam antenna arrays and beam-forming networks. NASA has held a number of discussions with industry to define key areas of communications technology that should be undertaken by NASA to benefit U.S. industry in this decade and beyond.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Funding has been reduced to provide for the ACTS experiment terminal development as directed by Congress, in addition to a minor decrease for its share of the general reduction.

BASIS OF FY 1992 ESTIMATE

The Research and Analysis program will continue to support development of the hardware necessary for future space communications satellite systems, encompassing both optical and radio communications technologies. In FY 1992, NASA will continue to work more closely with industry to identify future communications needs and fund promising technology developments through the NASA Research Announcement process.

BASIS OF FY 1992 FUNDING REQUIREMENT

SEARCH AND RESCUE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Search and rescue.......................	1.218	1,400	1,400	1,300

T S

The NASA role and budget for the international Search and Rescue program are limited to research and development that apply NASA technologies to advanced equipment design and techniques. For the U.S., National Oceanic and Atmospheric Administration (NOM) has responsibility for all aspects of operational Search and Rescue, while the Coast Guard and the Air Force perform the rescues. The international Search and Rescue partners are Canada, France, Soviet Union, Norway, United Kingdom, Bulgaria, Sweden, Denmark, Switzerland, Brazil, and India. The NASA budget contains no funding for Search and Rescue operations.

The Search and Rescue program, developed by NASA and international partners, has demonstrated the feasibility of using satellites to improve detection and location of general aviation aircraft and marine vessels during emergencies. As part of the post-development phase of the NASA Search and Rescue program, we are preparing for the application of NASA's skills to a wide range of public service endeavors.

BASIS OF FY 1992 ESTIMATE

Funding in FY 1992 will continue the NASA-unique research and development role in Search and Rescue, including the next generation satellite-borne Search and Rescue equipment, future system planning, and advanced technologies. As necessary, the FY 1992 budget will also support public service communications activities for disaster mitigation.

BASIS OF FY 1992 FUNDING REQUIREMENT

RADIO SCIENCE AND SUPPORT STUDIES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Radio science and support studies........	2,735	3,300	2,409	3,300

OBJI AND STATUS

Radio science and support studies provide the technical basis for regulatory and policy development to assure the orderly growth of existing and new satellite services. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. Emphasis is placed on: orbit and spectrum utilization studies, which include the development of frequency and orbit sharing techniques and strategies; design standards; and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary satellite orbit and the radio spectrum.

During FY 1991, the radio science and support studies program is conducting propagation studies to help minimize radio signal atmospheric interference problems in space communications as well as other advanced studies to enhance U.S. utilization of space by communications satellites.

CHANGES FRO?! FY 1991 BUDGET ESTIMATE

FY 1991 funding has been reduced to provide for the ACTS experiment terminal development directed by Congress.

BASIS OF FY 1992 ESTIMATE

Studies will continue to examine more efficient use of the radio frequency spectrum and geostationary satellite orbit. Funding will support development of the technical basis for standards development and regulatory decisions for space services at the national and international levels. Propagation studies and measurements will be carried out to fill the voids in data needed for design of new satellite applications for fixed communications, mobile communications, and sound broadcasting. Studies will be performed to identify new satellite applications.

BASIS OF FY 1992 FUNDING REQUIREMENT

COMMUNICATIONS DATA ANALYSIS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Communications data analysis.............	1,449	1,600	3,333	8,300

ECT AND STATUS

The Communications Data Analysis objectives are to support and to document a wide range of user experiments and demonstrations of advanced satellite communications. Previous programs to exploit experimental satellites, such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have successfully provided users with the experience necessary to make informed decisions regarding the adoption of new satellite communications capabilities. NASA's role in stimulating the use of unique space facilities has led to wider application of advanced technologies in commercial satellites that better meet the needs of potential users.

The three areas of emphasis of Communications and Data Analysis in FY 1991 will be: (1) prototype experiment ground terminal development and utilization for the Advanced Communication Technology Satellite (ACTS); (2) continued development of the ACTS Mobile Terminal *(AMT)* and plans for its utilization; and, (3) continued development of a mobile receiver for audio broadcasting via satellite.

Communications data analysis will also continue to support the Applications Technology Satellite (ATS) ATS-3, used by several government agencies and universities; and to support the development of mobile communications experiments utilizing the American Mobile Satellite Corporation (AMSC) system.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase from the FY 1991 budget estimate provides funds for ACTS experiment terminal development per Congressional direction.

BASIS OF FY 1992 ESTIMATE

Experiment ground terminal development and utilization for ACTS will accelerate to meet the ACTS launch date in 1992. Communications data analysis support of ATS-3 will continue.

INFORMATION
SYSTEMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

INFORMATION SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Information systems.....................	28,217	36,800	36,700	42,000

Distribution of Pronram Amount bv Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Goddard Space Flight Center...............	15,551	21,492	20,388	21,439
Jet Propulsion Laboratory...............	5,325	4,850	1,960	5,440
Ames Research Center.....................	4,162	4,832	5,782	6,200
Stennis Space Center.....................	95	--	--	--
Marshall Space Flight Center.............	--	2,500	3,000	3,500
Headquarters...........................	3.084	3,126	5,570	5,421
Total................................	28,217	36,800	36,700	42,000

OBJECTIVES AND STATUS

The Information Systems program is divided into four major discipline areas; scientific computing, science data management and archiving, science networking, and information systems research and analysis. The Information Systems program provides the advanced data systems to support the nation's space science and applications flight and research projects.

Scientific computing provides for the operation of the super-computing resources of the NASA Space and Earth Sciences Computing Center (NSESCC) in support of modeling and simulation efforts. The program also provides a supercomputing capability at the Jet Propulsion Laboratory (JPL) to support the research community. Also, included is the definition and development of capabilities necessary for efficient use of the space science and applications research and computing assets.

Science data management and archiving provides the Office of Space Science and Applications (OSSA) research community with reliable systems to archive and distribute data. The National Space Science Data Center (NSSDC) archives and distributes data acquired from spaceflight investigations. The OSSA researchers benefit from automated retrieval of archived data, a master directory for the location of distributed data sets by researchers, and delivery of data on advanced media as requested by users. Services now under development include catalog inter-operability for common searches across distributed databases and utilization of data exchange standards to facilitate automated assimilation of data by user applications.

The main area of science networking is the NASA Science Internet. NASA Science Internet is a computer networking service developed for NASA's space science and applications community to enable NASA researchers worldwide to connect to databases, to computational resources, and also to other scientists for interactive collaboration. A main objective is to provide transparent and reliable networking connectivity to support OSSA's flight missions and discipline programs, including joint projects with other agencies and international organizations.

Information systems research and analysis emphasizes the application of advanced computer and information systems technology to improve the effectiveness and efficiency of science data management, analysis, and visualization. During FY 1990, a NASA Research Announcement solicited proposals in this area. Over 325 proposals were received, from which 22 were selected for funding.

A major upgrade of the NSESCC was accomplished in FY 1990 with a Cray Y/MP supercomputer to provide a fourfold increase in computing capability. During FY 1991, a mass data storage system will be initiated to provide up to 10 terabytes of accessible data storage. During FY 1991 the JPL capability will be upgraded to a more up-to-date and reliable configuration.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The change from the FY 1991 budget estimate is the result of a Congressionally-directed general budget reduction.

BASIS OF FY 1992 ESTIMATE

The Information Systems program will continue emphasis on the application of computer science technologies to support the work of the NASA science disciplines. Funding is included for continued operation of the NSESCC, NSSDC and the JPL Supercomputer. The Information Systems program will continue to develop common software to support ongoing research in the space and Earth sciences. Science data networking needs will be met with the NASA Science Internet, allowing more users access to the network consistent with the recently-launched and near-term science investigations. A new OSSA-wide data management initiative will begin in FY 1992. This initiative will work in conjunction with multiple science discipline organizations to revitalize current data holdings and to put into place mechanisms for the systematic flow of science data into discipline-oriented archives for future missions.

COMMERCIAL
PROGRAMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
	(Thousands of Dollars)				
Technology utilization..................	23,700	24,400	24,400	32,000	RD 10-1
Commercial use of space.........	32,832	76,600	61,600	118,000	RD 11-1
Total.................................	56,532	101,000	86,000	150,000	

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS **TECHNOLOGY UTILIZATION**

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Civil systems	7,200	8,000	9,000	11,000	RD 10-4
Technology dissemination	6,400	6,900	6,900	8,000	RD 10-4
Technology evaluation and applications	10,100	9,500	8,500	13,000	RD 10-4
Total	23,700	24,400	24,400	32,000	
Distribution of Program Amount by Installation					
Johnson Space Center	415	510	4,240	2,550	
Kennedy Space Center	510	600	482	477	
Marshall Space Flight Center	340	260	433	497	
Stennis Space Center	940	1,110	577	645	
Goddard Space Flight Center	940	1,365	850	1,016	
Jet Propulsion Laboratory	1,050	1,000	466	491	
Ames Research Center	340	475	545	517	
Langley Research Center	640	698	740	789	
Lewis Research Center	440	704	530	598	
Headquarters	18,085	17,678	15,537	24,420	
Total	33,704	24,400	24,400	32,000	

PROGRAM OBJECTIVES AND JUSTIFICATION

The NASA Technology Utilization program is designed to strengthen the national economy and industrial productivity through the transfer and application of aerospace technology resulting from NASA's R&D programs. To accomplish this objective, NASA has established and operates a number of technology transfer mechanisms to provide timely access of useful technologies to the private and public sectors of the economy. Almost every part of U.S. industry is affected by the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

- To accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

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

- To develop applications of NASA's aerospace technology, including its unique facilities, to priority non-aerospace needs of the Nation.

OBJECTIVES AND STATUS

The Technology Utilization (TU) program promotes the transfer of technology developed in NASA's R&D programs to the public and private sectors of the U.S. economy. A network of Industrial Applications Centers, Technology Counselors, and NASA installation Technology Utilization Officers form the core of the Agency's technology transfer efforts. Technologies developed for the Nation's aerospace program are reused or reengineered to provide new products and processes in the areas of transportation, energy, medicine, public safety, and consumer goods. The goal of the program is to broaden and accelerate the technology transfer process to realize additional dividends on the national investment in aerospace research. This will also help the United States to maintain its competitive position in the international marketplace.

Activities in FY 1991 include:

- Improving the capability of the Technology Utilization Offices at the NASA Field Centers to increase the level of technology transfer activities. Implementation of a Technology Utilization Network System (TUNS) has been completed which will link together the NASA TU field center offices, the NASA Software Repository, Computer Software Management and Information Center (COSMIC), the Scientific and Technical Information Facility (STIF) and the Industrial Applications Centers to provide a quicker distribution of new technologies than has previously been possible.

- Promoting awareness of NASA's Technology Utilization program and resources available to the public and private sectors through a broad array of program materials, seminars and conferences.

- Maintaining the nationwide technology transfer network to continue the development of cooperative efforts with the Federal Laboratory Consortium, state-sponsored business and technical assistance center, and Small Business Development Centers. These linkages enable the Technology Utilization program to keep pace with growing industrial demand for information and technology transfer services.

- Completing implementation of the AdaNET program, designed to transfer existing and emerging Ada software and other software engineering technology from the federal government to the private sector through mechanisms such as information sharing and repository services and networks. NASA, the Department of Defense, and the Department of Commerce are participating in this program.

- Continuing the definition phase of the National Technology Transfer Center (NTTC), leading to initial implementation of the program later this year.

CHANGES FROM FY 1991 BUDGET ESTIMATE

For this budget, we have consolidated the previous budget categories for the TU program along functional lines in an effort to emphasize the major objectives of technology transfer: civil systems, technology dissemination, and technology evaluation and applications.

The Civil Systems content remains unchanged and includes the AdaNET and National Technology Transfer Center (NTTC). The funding for AdaNET has increased from $3.0 million to $4.0 million consistent with Congressional direction.

The Technology Dissemination category includes activities focused on dissemination of technology and includes the Industrial Applications Centers (IAC), Technology Utilization Network Operations (TUNS), and the Scientific and Technical Information Facility (STIF).

The Technology Evaluation and Applications category focuses on the development and evaluation of new technology and includes NASA Center technology applications, evaluation and support, and Tech Briefs. Funding has decreased by $1.0 million to provide for the AdaNET increase.

BASIS OF FY 1992 ESTIMATE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Civil systems...........................	7,200	8,000	9,000	11,000

In FY 1992 the AdaNET project will continue funding essential further developments and operations. This project is developing a national facility for acquisition and dissemination of government-generated software components for reuse by private and government agencies. The National Aeronautics and Space Administration, the Department of Defense, and the Department of Commerce are participating in this program.

Additionally, NASA plans to complete the preliminary definition stage for the National Technology Transfer Center (NTTC) in FY 1991. The NTTC will serve as a national focal point to aid U.S. industry in locating appropriate Federal technologies and technology transfer services to accelerate the flow of advanced technological resources into use and application. It is expected that the NTTC development processes will extend over the next five years, and will become fully integrated with existing technology transfer mechanisms and sources of useful technology resulting from Federally-sponsored R&D programs.

Technology dissemination..................	6,400	6,900	6,900	8,000

Technology dissemination program efforts will be directed at improving the IAC network's capabilities to respond to increasing demands for technology transfer products and services, This effort will include enhancing the speed and responsiveness of the information delivery process by broadening the geographical coverage of the network and linking up with the technology transfer efforts of the federal agencies and for the first time, state and local governments. An open competition is planned for six regional IAC's in FY 1991, which will lead to new contract awards in 1992.

Technology evaluation and applications....	10,100	9,500	8,500	13,000

Funding required in the FY 1992 budget estimate is critical to maintaining core technology utilization programs including technology identification activities and application engineering projects at all NASA field installations, technology evaluation, product development, and technology publications.

Funding for technology applications engineering projects will continue to support an array of projects in the areas of bioengineering and medicine, rehabilitation, manufacturing, materials and electronics. Additionally, the Technology Applications program will be revised and strengthened in FY 1992 to increase the effectiveness of technology development. Funding will be increased to support the applications of aerospace technology and resultant product development to three areas of national importance -- law enforcement, education, and environment.

Long range plans for NASA Technology Utilization will focus on efforts in assessing potential participants in U.S. industry, preparing information guidelines to support cooperative relationships throughout the NASA technology transfer network, as well as satisfying the anticipated increasing demand for TU publications and information.

COMMERCIAL
USE OF SPACE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS — COMMERCIAL USE OF SPACE

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Commercial applications and enhancements.	30,232	38,900	32,200	40,800	RD 11-3
Commercial development support...........	2,600	4,200	5,200	6,700	RD 11-4
Commercial transportation................	(3,600)	33,500	24,200	70,500	RD 11-4
Total................................	32,832	76,600	61,600	118,000	

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center.....	1,250	3,700	10,519	47,910
Kennedy Space Center.......	750	2,980	590	1,090
Marshall Space Flight Center.......	900	1,710	1,045	1,410
Stennis Space Center.....................	3,750	6,000	4,705	5,600
Goddard Space Flight Center..............	500	1,050	1,050	1,400
Ames Research Center.....................	400	750	425	550
Langley Research Center...	--	--	350	250
Lewis Research Center........	--	--	155	190
Headquarters...........................	25,282	60,410	42,761	59,600
Total................................	32,832	76,600	61,600	118,000

OFFICE OF COMMERCIAL PROGRAMS | **COMMERCIAL USE OF SPACE**

PROGRAM OBJECTIVES AND JUSTIFICATION

The goal of the Commercial Use of Space program is to support a national focus that develops opportunities for the expansion of U.S. private sector investment and involvement in civil space activities. The specific objectives of the program are to:

- Foster close working relations with the private sector and academia to encourage investment in space technology and the use of the in situ attributes of space--vacuum, microgravity, temperature and radiation for commercial purposes.

- Facilitate private sector space activities through improved access to available NASA capabilities and the development of new high technology space markets.

- Encourage increased private sector investment in the commercial use of space independent of NASA funding.

- Implement and support commercial space policy NASA-wide.

NASA's goal of expanding opportunities for U.S. private sector investment and involvement in civil space and space-related activities is pursued through a variety of interrelated programs. Through cooperative agreements such as Joint Endeavor Agreements (JEA's) and through our support to the Centers for the Commercial Development of Space (CCDS), we will increase the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of opportunities to use NASA's terrestrial and space-based facilities for commercial research.

Resources will be made available to obtain flight support experimentation hardware required by industrial researchers associated with NASA-sponsored programs. This may include across-the-bay carriers, such as Materials Science Laboratories, as well as middeck augmentation racks or derivatives thereof, and the leasing of private sector hardware developed to exploit commercial research and development in space. The use of ground-based research facilities, aircraft and sounding rockets for commercial experimentation will be given emphasis in order to provide limited access to the microgravity environment for appropriate commercial experiments.

In order to maintain momentum in Commercial Use of Space activities and to encourage an increase in private sector investment in space, NASA will continue to develop methods to facilitate private sector agreements and commitments to develop commercial opportunities in space. The development of agreements for the use of the Shuttle external tanks and private sector use of U.S. launch facilities reflect this effort. The use of Space Systems Development Agreements (SSDA's) will continue.

CHANCES FROM FY 1 BUDGET ESTIM

In the FY 1991 NASA appropriation, Congress directed a reduction of $15.0 million for Commercial Programs. In Commercial Use of Space, $3.0 million of this reduction is the result of transferring funding for the Wake Shield Facility to the Construction of Facilities appropriation, as directed by Congress. The remaining reduction has been accommodated as a result of delays in the Shuttle flight schedule, primarily within Commercial Transportation and Commercial Applications and Enhancements. Within Commercial Transportation, the Commercial Middeck Augmentation Module (CMAM) has been reduced by $7.8 million, consistent with a slip in the first launch to January 1993, and with revised dates for subsequent launches, per recently-concluded contract negotiations.

BASIS OF FY 1992 ESTIMATE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Commercial applications and enhancements.	30,232	38,900	32,200	40,800

The Centers for the Commercial Development of Space (CCDS) consortia of universities and private sector commercial enterprises are the primary focus of research activities intended to result in the commercial development of space. To date, 16 centers have been established and currently conduct research in such diverse areas as space propulsion, biotechnology, materials processing and space remote sensing. FY 1992 funding will continue support to the 16 centers.

Funding will be provided to increase flight readiness through projects focused to respond to industry identified requirements for hardware and flight opportunities. Continued development of space-oriented, ground-based facilities and equipment will expand the technical research data base which enables the private sector to make economic decisions to commit to space research and production. Through coordination with DOD, other government agencies, the private sector, academia, and state and local centers, guidance will be developed and provided for commercial microgravity research and development enhancements program.

FY 1992 funding is provided for the analytical and physical integration required for Space Shuttle payloads flown under Joint Endeavor Agreements (JEA's). Direct funding is provided to perform Space Shuttle optional services which have reimbursement deferred under some Space Systems Development Agreement (SSDA's). NASA's current SSDA's are with Spacehab, Geostar, and Space Industries Partnership.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Commercial development support...........	2,600	4,200	5,200	6,700

Rapidly changing economic, commercial and technical circumstances continue to require analysis to provide private sector coordination and feedback necessary to the program. In FY 1992, additional emphasis will be placed on our strategic planning, financial analysis, international competitiveness, and technical program support to implement an effective Commercial Space Development program, and to assist in the development of agency commercial space policy.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Commercial transportation................	(3,600)	33,500	24,200	70,500

Planned flights for commercial payloads will increase substantially in the FY 1991 - 1992 timeframe and are reflected in the increase in funding for commercial space transportation. In an effort to provide the CCDS payloads with timely and varied access to space, and to further support commercial space transportation capability development, major new initiatives began in FY 1991. These included augmentations to the existing sounding rocket program to lengthen payload exposure to the microgravity environment; development of the Commercial Experiment Transporter (COMET) expendable launch vehicle program which will provide the long duration microgravity exposure required for some commercial payloads (e.g., protein crystal growth); and lease of a commercially-provided payload module (CMAM) which will provide pressurized man-tended payload capability in the Shuttle cargo bay. This latter agreement with Spacehab was concluded in late 1990, and represents the Agency's first "anchor tenant" arrangement with a commercial entity,

AERONAUTICS AND
SPACE TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY FOR AERONAUTICS, EXPLORATION AND TECHNOLOGY

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
	(Thousands of Dollars)				
Aeronautics research and technology......	442,598	512,000	512,000	591,200	RD 12-1
Transatmospheric research and technology,,	59,027	119,000	95,000	72,000	RD 13-1
Space research and technology...........	284,029	495,900	290,400	421,800	RD 14-1
Exploration mission studies..............	(15.000)	37.000	--	--	
Total................................	785.654	1.163.900	897.400	1.085.000	

AERONAUTICAL
RESEARCHAND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS. EXPLORATION AND TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOMGY

SUMMARY OF RESOURCES REOUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
	(Thousands of Dollars)				
Research and technology base...	321,764	353,400	336,400	375,600	RD 12-3
Systems technology programs..............	120.834	158.600	175.600	215.600	RD 12-11
Total................................	442.598	512.000	512.000	591.200,	
Distribution of Program Amount By Installation					
Johnson Space Center.....................	85	--	--	--	
Kennedy Space Center.....................	112	--	--	--	
Marshall Space Flight Center.............	912	2,000	--	--	
Jet Propulsion Laboratory................	725	900	1,000	700	
Goddard Space Flight Center..............	544	600	800	500	
Ames Research Center.....................	165,702	187,800	188,600	199,500	
Langley Research Center..................	156,651	183,000	180,300	206,600	
Lewis Research Center....................	106,695	125,000	128,900	170,500	
Headquarters.............................	11,172	12,700	12,400	13,400	
Total................................	442.598	512.000	512.000	591.200	

OFFICE OF AERONAUTICS. EXPLORATION AND TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY

PROGRAM OBJECTIVES AND JUSTIFICATION

The goal of the NASA program is to conduct aeronautical research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the commercial avaiation industry, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security. With the U.S. challenged as never before in aeronautics, the FY 1992 estimate reflects the need to address critical barriers and strengthen technology development in selected high payoff areas that are vital to our long-term leadership in aviation. NASA's aeronautics program is focused on six strategic thrusts: (1) develop selected, high-leverage technologies for U.S. subsonic aircraft and to enhance the safety and productivity of the national aviation system; (2) resolve the critical environmental issues and establish the technology foundation for economical, high-speed air transportation; (3) ready technology options for revolutionary new capabilities in future high performance fixed and rotary wing aircraft; (4) develop critical technologies for future hypersonic vehicles; (5) pioneer fundamental research, crosscutting technology development, and validation of numerical simulation techniques to maintain the theoretical, experimental, and predictive foundation required for advanced systems; and (6) develop, maintain and operate critical national facilities for aeronautical research and for support of industry, DOD, and other NASA programs. In accomplishing these thrusts, the program will maintain NASA laboratory strength, including enhanced experimental and computational capabilities and staff excellence; ensure timely domestic technology transfer; ensure strong university involvement; and ensure strong support for and cooperation with the DOD, FAA, and industry partners.

BASIS OF FY 1992 ESTIMATE

The FY 1992 research and technology program is committed to providing a strong fundamental foundation for future advances in aeronautics, as well as to addressing the critical technological issues associated with the U.S. air transportation system; and to increasing the margin of the country's preeminence in aviation for national security. Technologies are being pursued which offer major advances in vehicle performance and capabilities, and which could provide a substantial positive impact on the U.S. aviation industry. Research efforts have been expanded in high payoff areas associated with a broad range of future vehicle applications including subsonic and high-speed transport aircraft. The demands for NASA's unique wind tunnels are continuing to increase with the emergence of new civil and military aircraft programs. In order to ensure wind tunnel availability to meet these demands, a major five-year revitalization program was initiated to modernize NASA's major wind tunnels for productive use well into the next century. This revitalization program will be entering its fourth year in FY 1992.

BASIS OF FY 1992 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Fluid and thermal physics research and technology...........................	32,100	32,200	(28,281)	--
Applied aerodynamics research and technology..........................	72,316	88,200	(88,200)	--
Aerodynamics research and technology.....	--	--	116,481	128,300
Propulsion and power research and technology...........................	67,918	75,700	71,663	84,100
Materials and structures research and technology..........................	40,069	41,400	37,210	42,800
Information sciences research and technology..........................	10,488	9,900	(5,192)	--
Controls and guidance research and technology..........................	35,382	37,300	(37,300)	--
Human factors research and technology....	17,310	17,800	(17,800)	--
Controls, guidance and human factors research and technology................	--	--	60,292	67,600
Flight systems research and technology...	38,255	40,600	40,454	42,100
Systems analysis.......................	7,926	10,300	10,300	10,700
Total...............................	321,764	353,400	336,400	375,600

OBJECTIVES AND STATUS

The overall objective of the research and technology base program is to provide a strong fundamental foundation for future aviation advances. Major emphasis is on fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict the physical phenomena, and appropriate experimental validation. These efforts ultimately lead to design and analysis tools with application to each of the six aeronautical strategic thrusts.

The fluid and thermal physics and the applied aerodynamics research and technology programs have been combined to form the aerodynamics research and technology program. Also, the information sciences, controls and guidance, and human factors research and technology programs have been combined to form the controls, guidance, and human factors research and technology program. The purpose of these changes was to consolidate related work to be consistant with the management structure and to align the work with the strategic thrusts in Aeronautics.

The aerodynamics research and technology program is advancing the understanding of fundamental fluid mechanics and aeroacoustics phenomena and providing new, validated aerodynamics technology applicable to future U.S. military and civil aircraft from subsonic to hypersonic speeds. During FY 1990 predictive capabilities, using computational fluid dynamics (CFD), were improved through the development of unstructured grid technology and higher-order-accurate methods; sophisticated, generic Reynolds stress turbulence models exhibiting greater flow realism and wider applicability were generated; and improved methods were derived for numerical simulation of aerothermodynamic flow phenomena associated with hypersonic cruise and maneuver vehicles, including real-gas chemistry. In FY 1991, research continues to be directed toward the development of faster and more efficient numerical algorithms, advanced grid generation techniques, and advanced measurement techniques to both improve and experimentally validate Euler and Navier-Stokes CFD codes for a wide range of problems. In application-focused aerodynamics efforts during FY 1990, flight research was initiated using a modified Boeing 757 with a hybrid laminar flow control (HLFC) glove to investigate the effectiveness of HLFC at full-scale flight conditions. The initial results were extremely successful in achieving 65 percent laminar flow on the wing upper surface. This flight research will continue in FY 1991 with evaluations of the sensitivity of HLFC to operating conditions and icing protection. In FY 1990, a large-scale interactional rotor/body aerodynamics wind tunnel test was conducted to obtain data for CFD code development and validation. Also, wind tunnel testing was provided in support of the light experimental helicopter program of the Army and the V-22 development of the Navy. In FY 1991, under a joint program between NASA, the U.S. Army and industry, experimental flight investigations will be conducted with a highly instrumented UH-60 Black Hawk helicopter to obtain data heretofore unavailable for loads and noise analysis. In FY 1990, short takeoff and vertical landing (STOVL) research continued the development of predictive methods of propulsion-induced aerodynamics and ground environment issues, such as force and moment generation, ground erosion, acoustics and hot gas ingestion. Hover tests, both in and out of ground effect, of a large-scale advanced powered-lift fighter concept were conducted. Hypersonic research focused on conducting stability and boundary layer transition analyses to derive transition prediction techniques. In FY 1991, CFD methods will continue to be developed for slender bodies and highly swept wings characteristic of supersonic cruise and hypersonic configurations, including emphasis on interacting vortex flows, wing leading-edge radius effects and variable camber devices.

The propulsion and power research and technology program provides the understanding of the governing physical phenomena occurring at the disciplinary, component and subsystem levels that will provide the basis for improved propulsion systems. Ongoing disciplinary research in instrumentation, controls and internal fluid mechanics is providing the foundation necessary for continued advancement at the component and subsystem level. Component and subsystems research is being conducted for a wide variety of applications, including subsonic transports, high-performance aircraft, supersonic cruise and hypersonic vehicles. Experimental measurements were completed during FY 1990 using the large, low-speed centrifugal compressor which confirmed aerodynamic flow separation predicted by analysis. In FY 1991, the analysis capability will be used to generate a new design eliminating the separation, and the compressor will be used to produce a complete code validation data base using nonintrusive detailed measurements of the flow field. Computational fluid dynamics was used to develop improved rotary-engine exhaust port and fuel injector designs in FY 1990, and tests which are underway in FY 1991 are expected to demonstrate an 8 percent improvement in brake specific fuel consumption. An experimental evaluation of a full-scale ejector for STOVL applications resulted in lower performance than expected due to end wall effects. Ejector tests will continue in FY 1991 to evaluate configurations with reduced end wall effects, determine transient response, and validate analytical prediction capability.

The first successful bench test of a fiber optic position encoder was conducted and is now undergoing qualification testing in preparation for flight testing as part of the optical propulsion management information system on a Boeing 737 and as part of the fiber optic control system integration test on an F-15 during FY 1991.

The materials and structures research and technology program is developing advanced materials, analysis methods, test methods and structural concepts to enable the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. Analytical research is focused on advanced computational methods from the micromechanics level through global response of full-scale aircraft, aeroelastic response and control, and multidisciplinary design and optimization. Airframe materials and structures research is focused on understanding material fundamental behavior and fabrication technology for light metals and composites. A constitutive model for textile composites was used to predict static strength and fatigue life for establishment of design requirements using new material forms. Adaptive analysis methods demonstrated new nonlinear solution techniques for predicting buckling and failure behavior in curved complex panels. Engine materials and structures research is directed toward enabling uncooled hot sections operating at over 3000° Fahrenheit and dynamically stable, lightweight, rotating engine components. A combined experimental/analysis method to predict structural response of ceramic composites for engine structures was demonstrated. Specific emphasis is being placed on airframe inspection technology to detect flaws and disbonds, and a successful demonstration was accomplished using thermal imaging to locate disbonds on a Boeing 737 aircraft fuselage structure.

The controls, guidance and human factors research and technology program provides a technology base supporting future aircraft designs for safer and more efficient operations and greatly expanded flight envelopes. In FY 1990, the first in-flight detection of a microburst was accomplished in a series of flight tests conducted at Orlando, Florida, in conjunction with the Federal Aviation Administration (FAA). Also in FY 1990, in a series of flight evaluations conducted cooperatively with the FAA, the Department of Defense and industry, performance characteristics of both the military precision-code and the civil-code differential global positioning system (DGPS) were investigated. A number of fully automatic landings were made using the civil code signals. In the area of human factors, NASA worked very closely with the

FAA during the past year to develop the National Human Factors Plan and will continue developing the strategy for implementing the plan in the coming year. During FY 1991, several automated cockpit decision aids were evaluated in flight and air traffic controller decision aids were evaluated using live traffic data obtained from the FAA.

Flight systems research and technology addresses a broad range of needs in aviation safety, flight test methodologies and high-performance aircraft. In aviation safety, the effect of heavy rain on lift loss has been established for a typical airfoil section using the Aircraft Landing Dynamics Facility (ALDF). Wind tunnel testing will resume on aircraft model configurations following the design and installation of a new rain spray simulation system. The results of the subscale model helicopter rotor tests conducted in the icing research tunnel are being used in the development of a code to predict rotor performance in icing conditions. The short takeoff and vertical landing (STOVL) technology development program is focused on hot gas ingestion, ground effects, integrated propulsion flight control simulation, and the development of propulsion components such as augmentors, ducts and diverter valves for the transport of high-temperature airflow. The high angle-of-attack research program continues to explore maneuverability and agility technology. Continued validation of prediction methods with wind tunnel and flight data are enabling aircraft designers to develop highly maneuverable advanced concepts and to design modifications for existing aircraft to enhance the performance. Advanced CFD methods have been used to calculate the flowfield around the full F-18 configuration with excellent comparisons to data obtained from F-18 baseline flight research. The multi-axis thrust vectoring control system (TVCS) installed on the High Angle-of-Attack Research Vehicle (HARV), has allowed expansion and utilization of the high angle-of-attack envelope. Flight research in FY 1991 with the TVCS will yield unique data for aerodynamics, controls and operations.

The aeronautics systems analysis element conducts long-term technology assessments, identifies technology applications, and performs sensitivity analyses and trade-off studies from which effective research and technology programs can be developed to meet future civil and military aeronautics requirements. Studies conducted under the systems analysis element focus on defining research and technology needs for specific vehicle classes. Current efforts include conceptual design studies for high-speed rotorcraft and hypersonic vehicles. Other studies are investigating technology trade-offs for subsonic and supersonic transport aircraft to enable the most effective use of resources. In addition, the studies serve to develop advanced analytical techniques and design and integration capabilities.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The research and technology base has been reduced by $17.0 million which has been reallocated to the systems technology area to support the high-performance computing program. This 1991 reduction of $17.0 million includes $2.0 million previously earmarked for precursor work in high-performance computing and $15.0 million which is being applied to this program as a result of Congressional action on the FY 1991 budget request.

Within the aeronautics research and technology base, the previous fluid and thermal physics research and technology and applied aerodynamics research and technology programs have been combined into a single line entitled aerodynamics research and technology. In addition, three other programs, information sciences research and technology, controls and guidance research and technology, and human factors research and technology have been combined into a single program entitled controls, guidance and human factors research and technology.

The changes by the discipline programs are as follows:

The current estimate for aerodynamics research and technology reflects realignment of $32.2 million from fluid and thermal physics research and technology and $88.2 million from applied aerodynamics research and technology to aerodynamics research and technology. A total of $3.9 million was reallocated to the high-performance computing program. This redirection of funds will impact the progress of analytical research associated with external fluid dynamics and will curtail some research efforts by the Institute for Computer Applications in Science and Engineering (ICASE) scientists supporting NASA programs in fluid dynamics and acoustics.

The current estimate for propulsion and power research and technology reflects a $4.0 million reduction from internal computational fluid mechanics to support the high-performance computing program. This will result in redirection of basic algorithm development for internal fluid flows as well as delays in the incorporation of these algorithms in advanced codes and the associated validation.

The materials and structures research and technology program was reduced by $4.2 million to support the high-performance computing program. This will delay progress in structural modeling methods currently under development, such as advanced finite elements, boundary elements, and probabilistic structural mechanics, as well as their integration into a unified method.

The current estimate for control, guidance, and human factors reflects realignment of $9.9 million from information sciences research and technology, $37.3 million from controls and guidance research and technology, and $17.8 million from human factors research and technology into the new line entitled controls, guidance and human factors research and technology. A total of $4.7 million was reallocated from computer science and high-performance computing activities within the controls, guidance and human factors research and technology program to the high-performance computing program. Of this amount, $2.0 million was funding that had been earmarked for precursor work on high-performance computing, which will not result in any programmatic impact. Redirection of $2.7 million will delay research in some fundamental computer science efforts, including activities at the Research Institute for Advanced Computer Science (RIACS) and at universities.

The flight systems research and technology program was reduced by $146 thousand to support the high-performance computing program. This redirection impacts research efforts by ICASE scientists who support a variety of NASA programs.

BASIS OF FY 1992 ESTIMATE

In aerodynamics research and technology, emphasis will be placed on the development and validation of computational design tools, generation of advanced testing methods, and the investigation of viscous flow mechanisms. The advanced analytical methods developed by this research will be used to predict aircraft aerodynamic parameters more accurately and efficiently. The refocused fundamental transition fluid mechanics research program, in conjunction with increased simulation and modeling activities, will produce an improved understanding of transition physics and result in new flow control technologies for reducing aircraft drag at high speeds. Subsonic aircraft aerodynamics research will also be emphasized in FY 1992 by providing the tools required to improve aerodynamic efficiency and reduce noise. Supersonic cruise research in the area of airframe/propulsion integration will develop fundamental methodologies in support of high-speed research. Rotorcraft research will involve wind tunnel testing for active control of noise and vibration and extensive airloads flight testing. Research efforts will also provide enabling technology for fighter/attack aircraft to achieve enhanced maneuver performance, efficient store carriage and separation across the speed range, increased efficiency at subsonic speeds, and key technologies for STOVL capability.

Propulsion research will continue to emphasize improved understanding of the governing physical phenomena at the disciplinary, component and subsystem level leading to future high-payoff improvements in capability and efficiency. Discipline research will continue on development of advanced computational analyses that are three-dimensional and viscous, and which include reacting flow and heat transfer. Emphasis will be placed on turbomachinery and flow physics, along with the related improved diagnostics for validation measurements. The development of a multistage turbomachinery analysis code will be completed and validation initiated using experimental data from a large, low-speed axial compressor currently under construction. Applied research will continue on high-pressure core concepts that offer a 20 percent improvement in thermal efficiency relative to current subsonic commercial engines and will emphasize low-emission combustors and turbines capable of operating with minimal cooling. In the hypersonics area, research will continue to develop the understanding of high-energy fluid phenomena, dynamic models, advanced concepts, and the diagnostic and facility technologies for high-speed flight at Mach 8 and above. Piloted flames will be experimentally evaluated as an aid for low-pressure supersonic combustion, and mixing enhancement concepts will be evaluated in both fundamental rigs and shear layer facilities for supersonic combustion, using nonintrusive diagnostics, such as molecular velocimetry using silane seeding.

Materials and structures technology will continue to focus on enabling the design of safe, lightweight, airframes and lightweight, durable, fuel-efficient engines. Toughened composite materials and thin-gage light metal alloys will be used to fabricate and test small-scale test articles of lightweight airframe concepts; advanced analytical methods will be expanded to encompass the aeroelastic response of entire aircraft; and probabilistic methods will continue to be developed for engine structures. Significant emphasis will be placed on computational structural mechanics including a university-based center of excellence. The capability for local/global structural analysis of a complex wing structure that includes damage-tolerant design requirements will be demonstrated. Increased emphasis will be placed on basic materials and structures research for supersonic and hypersonic applications, including analysis of supersonic propulsion components and prediction of aerothermomechanical load environments.

In the controls, guidance and human factors research and technology program, a number of technology products are reaching the state of maturity in which they may be validated in flight or in operational field tests in FY 1992. Operational tests of air traffic controller automation aids leading to increased system capacity will be initiated in cooperation with the FAA. Automated nap-of-the-earth rotorcraft guidance concepts will begin flight evaluation in a cooperative effort with the Army. Research in flight crucial systems will be more focused on fly-by-light/power-by-wire applications. Increased emphasis will be placed on developing analytical and experimental methods for assessing electromagnetic effects on candidate system designs. The airborne wind shear sensor program will conduct flight evaluations of both infrared and Doppler radar sensors to characterize performance in the presence of ground clutter and rain backscatter effects. Human factors research will continue to focus on flight management, human engineering methods and cockpit automation aids. Flight evaluation of automated diagnostic aids, data link information transfer, and in-flight planning/replanning aids will be conducted this year using the transportation systems research vehicle.

In flight systems research and technology, icing buildup effects on airfoil performance and aviation safety will be determined and used to develop three-dimensional analytical codes for aerodynamic performance and ice accretion predictions.

Small-scale tests will be conducted to acquire data on the accretion and buildup of ice on swept wings for code development and validation. Heavy rain testing will resume after the design and installation of a new wind tunnel rain simulation system.

Potential benefits and assessments of the aerodynamic, propulsion system, structural and flight control system interactions resulting from multi-axis thrust vectoring at high angles of attack will be the focus of the F-18 high angle-of-attack research program. Methods of prediction for high angle-of-attack aerodynamics will be validated through correlation with CFD, wind tunnel and flight results. Accelerated application of vortex control methods will be the emphasis in the program. Finalized design for mechanical/forebody controls will be completed. Pneumatic control techniques will be refined and designs developed for application to the F-18 HARV. In the STOVL program, work on critical technologies will be continued including the completion of the development of transition flight control criteria, demonstration of a method for integrated propulsion flight control systems design, and completion of aerodynamic and heat transfer research on valves and ducts using half-size scale models. These efforts will be used to validate the integrated controls design methods, develop controls and handling qualities criteria, and to develop design criteria for hot gas ducts and valves in support of an advanced STOVL concept.

Airborne information management system development and flight evaluation will continue. Single-axis optical air data system flight tests and evaluation will be conducted, and a three-axis optical air data system suitable for use in flight research will begin the research and development process. A variety of both fixed- and rotary-wing aircraft will be used to support flight research. These high-performance support vehicles will be flown as chase aircraft in support of research aircraft described under high-performance aircraft systems technology (F-18, F-15, F-16XL). Specialized training for critical personnel, as well as maintenance of flight data facilities, aircraft instrumentation, and flight data processing, is also included in this activity.

In FY 1992, the aeronautics systems analysis element will continue development of analytical and multidisciplinary design methods. Supersonic cruise studies will continue investigations of propulsion/airframe integration methods for conventional and novel engine concepts and refine economic analytical capabilities. High-speed rotorcraft studies will perform analyses of economic factors and critical technologies to provide a knowledge base for technology development. High-performance aircraft studies will be initiated to investigate maneuverability and agility metrics to determine their relative influence on aircraft sizing and design. Studies for subsonic aircraft will continue investigations of airframe and propulsion system integration techniques which can provide significant economic and productivity increases.

BASIS OF FY 1992 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
High-performance computing...............	--	--	17,000	17,000	RD 12-12
Materials and structures systems technology...........................	28,143	39,900	39,900	40,100	RD 12-14
Rotorcraft systems technology...........	3,556	5,100	5,100	5,200	RD 12-17
High-performance aircraft systems technology...........................	9,691	10,500	10,500	11,100	RD 12-18
Advanced propulsion systems technology...	13,152	15,000	15,000	15,400	RD 12-19
Numerical aerodynamic simulation.........	41,798	44,100	44,100	45,400	RD 12-21
High-speed research.....................	24,494	44,000	44,000	76,400	RD 12-22
Advanced subsonic technology............	--	--	--	5,000	RD 12-25
Total................................	120,834	158,600	175,600	215,600	

	1990 Actual	1991 Budget Estimate	1991 Current	1992 Budget Estimate
	(Thousands of Dollars)			
High-performance computing..............	--	--	17,000	17,000

OBJECTIVES AND STATUS

The High-Performance Computing and Communications (HPCC) is a multi-agency endeavor which involves NASA, the Department of Energy, the National Science Foundation, the Defense Advanced Research Projects Agency, the Department of Commerce, National Institutes of Health, and the Environmental Protection Agency. The initiative is consistent with, and supportive of, the Administration's strategy for national leadership, as expressed in the Office of Science and Technology Policy (OSTP) report, "A Research and Development Strategy for High-Performance Computing," (November 1987). The HPCC is the Agency's implementation of its portion of the Administration's plan for "The Federal High-Performance Computing Program," (September 1989). NASA's role in the national program includes acquiring experimental hardware for testbeds and developing software and algorithms in computational aerosciences, Earth and space systems sciences, and remote exploration and experimentation; and supporting the development of the national research and education network. The goal of NASA's portion of HPCC is to accelerate the development and application of high-performance computing technologies to meet NASA's science and engineering requirements. These technologies include applications algorithms and programs, systems software, peripherals, networking, and the actual high-performance computing hardware, all of which will be demonstrated in small, scalable, testbed systems as a step toward full-scale computational capabilities. This program will enable teraflops (10^{12} floating point operations per second) computer capabilities essential for computational design of aerospace vehicle systems and for predicting long-term global change.

NASA is a leader in advanced computational sciences and systems and is in a position to exploit high-performance computing to more efficiently achieve NASA goals. The initiative is focused to enable broad advances in aerospace vehicle design, space and Earth systems science, and space exploration programs. The approach leverages current NASA leadership, while broadly strengthening its capability for sustained high-performance computing research.

In FY 1991, research activities will be more tightly focused on the development of computational methods for massively parallel computing systems and on modeling of multidisciplinary interactions. Efforts will be employed to better understand the partitioning of complex internal fluid mechanics problems for application to a massively parallel computer architecture and will also emphasize modeling complete propulsion systems at increasing levels of detail. Portions of the current program will be refocused to more directly support the grand challenge in computational aeroscience. These efforts include in-house activities to develop algorithms for multidisciplinary applications on parallel computing testbeds, as well as several focused university efforts through the Institute for Computer Applications in Science and

Engineering (ICASE), Research Institute for Advanced Computer Science (RIACS) and the Institute for Computational Mechanics in Propulsion (ICOMP). FY 1991 research endeavors will be able to use massively parallel computing systems at several sites, including the Connection Machine (CM-2) at Ames Research Center, Intel 860 systems at Ames, Langley and Lewis Research Centers, the Masspar system at Goddard Space Flight Center, and the newly announced Intel Touchstone Delta machine at the California Institute of Technology. NASA will actively participate as a partner with other government agencies and key universities in the concurrent supercomputing consortium and will begin implementing, nearly one full year earlier, the responsibility to coordinate the federal software and algorithms research within the federal high-performance computing program. Additionally, a network connection will be installed from the University of Tennessee Space Institute to NASA to provide connection to the NASA science internet.

CHANGES FROM FY 1991 BUDGET ESTIMATE

As a result of Congressional action on the FY 1991 budget request, NASA was directed to absorb $15.0 million in aeronautics for application to high-performance computing. This $15.0 million when combined with $2.0 million, previously identified by NASA within the aeronautics research and technology base for precursor work in high-performance computing, results in a total of $17.0 million in FY 1991. The funding was reallocated from the research and technology base, and a new program within systems technology was created for high-performance computing.

BASIS OF FY 1992 ESTIMATE

The HPCC is focused on three areas of application: (1) integrated, multidisciplinary computational aerospace vehicle design; (2) multidisciplinary modeling and analysis of Earth and space science physical phenomena; and (3) remote, autonomous space operations and data acquisition.

Technology now permits a new generation of large-scale massively parallel computer architectures with the potential of being scaled to the teraflops range by the mid-1990's. The HPCC is unique in that it will bring together interdisciplinary teams of computer scientists and computational physicists to develop the technology necessary to bring a teraflops of computational power to bear upon the grand challenges unique to NASA. Key to exploiting large-scale massively parallel computers is the development of effective systems software. To encourage vigorous research into the underlying theory and concepts of high-performance parallel computing, NASA will foster interactions among academia, industry and national laboratories. NASA will strengthen the basic research in high-performance computing in the NASA Centers and institutes and in universities.

Testbeds are a crucial part of this initiative because they provide a key tool for interdisciplinary research teams to develop applications and systems software and to evaluate scalable hardware architectures. They are the vehicle for evaluating applications, systems software, hardware architectures and peripherals. NASA has considerable expertise with small-scale experimental parallel computer testbeds. A key to successful exploitation of massively parallel computing power will be the blending of application-driven and architecture-driven computer systems and software to most effectively meet NASA's needs. Prototype testbeds of 3 gigaflops will become operational in FY 1993, 20 gigaflops in FY 1994, and 50 gigaflops in FY 1995. The testbeds will not be replacements for the numerical aerodynamic simulation system or any of NASA's other computational facilities, but rather will serve as proof of concept of systems which, when scaled up and properly supported for operational use, could be used by those computing facilities.

Systems software to be developed under this program includes operating systems, compilers, programming environments and visualization software. Some important operating system developments include dynamic load balancing of the processors in the parallel system and the processors in the distributed system, and distributed operating systems which permit a heterogeneous system. Of additional importance will be the programming languages, compilers and programming environments because they are the algorithm developers' interface to the high-performance computing system. Debugging programs on massively parallel and/or distributed systems is significantly more difficult than on more traditional systems. This is a new area of research which will require the development of new techniques and their incorporation into systems to aid user productivity. Interim systems software will be completed in FY 1994 and the final systems software suite will be completed in FY 1996.

The testbed systems must be on a research network so that they can be accessed by others working in support of the Federal High Performance Computing Program. Only through such networking will applications developers have access to as broad a range of architectures as possible. Through cooperation with other federal agencies, NASA will become a node on the national research and education network. Having systems software designers, systems architects and applications developers working together on these testbeds to attack NASA's grand challenges is key in the initiative. NASA interconnects to the national research and education network, at 45 megabits/second, will become operational in FY 1993.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology............................	28,143	39,900	39,900	40,100

OBJECTIVES AND STATUS

The objective of the materials and structures systems technology program is to develop advanced materials and structural concepts for future advanced aircraft propulsion systems and primary structures. This program is divided into two elements, advanced high-temperature engine materials and advanced composite materials.

The objective of the advanced high-temperature engine materials technology program is to develop the technology for revolutionary advances in materials to enable the development of 21st century transport aircraft propulsion systems. Major consideration is being given to propulsion systems that will be friendly to the environment in terms of minimizing pollution and noise, and that will be economical via reducing fuel consumption per passenger mile, reducing direct operating costs, extending life and improving reliability. This will require very high thrust-to-weight (20 to 1) gas turbine engines with durable, long-life, hot-section components which can endure sustained operation without cooling air. Key to these applications are materials capable of operating at much higher temperature and strength levels than now possible. Materials currently in use, such as titanium alloys and nickel-based superalloys, offer only minor potential gains in performance. The candidate advanced materials include ceramic matrix composites, metal matrix composites, intermetallic matrix composites, and polymer matrix composites. These materials are vital to attaining higher turbine inlet temperatures for sustained supersonic cruise, higher thrust-to-weight engines, and for uncooled engine hot-section components which provides greater efficiency. In addition, analytical codes to conduct design, predict life and establish failure mechanisms will be developed to enable effective utilization of these new classes of materials by engine manufacturers.

The objective of the advanced composite materials systems technology program is to develop advanced materials and innovative structural concepts to fully exploit the benefits of composite materials for cost-effective primary structures for future aircraft applications. The program objectives will be accomplished through materials development, design and fabrication of innovative structural concepts, structural analysis and improved life prediction methods, and demonstration of improved structural performance through subscale and large-scale component tests representative of advanced composite airframe structures. Technology verification objectives are to demonstrate advanced composite structures at the element/subcomponent level as an essential building block leading to full-scale primary structures. The program goals are to develop cost-effective primary structural concepts and fabrication techniques that will reduce acquisition cost by 25 percent and reduce structural weight by 30 to 50 percent for resized aircraft. In order to achieve these program objectives, a new approach for composite design methodology must be developed. The integration of design concepts and advanced fabrication using new material forms must be established to fully exploit the benefits of composites. The understanding of failure mechanisms and behavior under complex loading is critical to establish the data base for innovative design with composites. This program will focus on new structural concepts using cost-effective fabrication techniques such as advanced thermoforming, multidirectional weaving, pultrusion, filament winding and advanced fiber placement techniques.

<u>BASIS OF FY 1992 ESTIMATE</u>

For FY 1992, advanced high-temperature engine materials will include emphasis on fibers and fiber coatings, interfaces, oxidation-resistant coatings, high-temperature testing capabilities, and accelerated test techniques for time-dependent failure phenomena. Strong, stiff, lightweight reinforcement fibers, capable of being appropriately sized and chemically and mechanically stable for extended periods at elevated temperatures, are a central focus of this program. Silicon carbide, alumina and beryllide fibers remain candidates. A current critical issue involves developing fibers and fiber coatings which are compatible with intermetallic matrix composites on a thermal expansion basis. Consideration is being given to oxidation-resistant coatings for both polymeric matrix and intermetallic matrix composites. For polymeric matrix composites, processibility of polymer resins remains a critical issue. For ceramic matrix composites, a critical issue is the development of small-diameter fibers for satisfactory engine component performance at temperatures to 3000° Fahrenheit. Also for ceramic matrix composites, matrix fabrication options are exploiting the superior mechanical behavior of low-density, porous materials. Mechanical and durability experimental testing capabilities for long-term exposure in oxidizing environments to 3000° Fahrenheit are being developed. Thermomechanical fatigue tests of lamina-scale metal matrix composite model materials are indicating significant potential degradation and failure mechanisms in elevated-temperature composites. Accelerated methods for rapidly and accurately simulating long-term time-temperature-stress responses of composites in laboratory tests are urgently being pursued. Multiple-path analytical modeling methods are being developed and verified to help guide the optimum selection and utilization of compatible candidate fiber/coating/matrix materials.

During FY 1992, the major emphasis on advanced composite design and fabrication will continue to focus on three techniques to reduce acquisition costs: (1) advanced fiber tow placement, (2) resin transfer molding (RTM), and (3) woven textile pre-forms. This research will be directed toward exploiting new composite fabrication and design concepts. A family of design configurations for both fuselage and wing concepts will be evaluated and large-scale demonstration test articles will be selected for design and fabrication. This process will be based on evaluation of subcomponent flat-panel tests and damage-tolerance evaluations of various design concepts which include integral, continuous, stiffened structures, honeycomb structures and woven/stitched structural forms. A major factor in this evaluation will be a detailed comparison of design performance based on analytical predictions and experimental results with associated cost models for various fabrication techniques. This process will enable the selection of affordable innovative composite design concepts. The first generation wing box tests will be completed and results will be used to compare performance behavior to predictions. Concepts for fuselage crown panels will be fabricated and tested to provide baseline data used in the establishment of design requirements for the fuselage barrel section. A six-foot wing panel using a stitched/RTM process will be fabricated and tested, and used to quantify performance of new tailored resin systems formulated for RTM processes. Advanced analysis methods, including probabilistic modeling of composites for improved life prediction and analysis of composite failure mechanisms, will provide assessment of new design concepts and define design needs to meet future aircraft system requirements. The identification of candidate high-temperature composites with a 60,000-hour lifetime and a 400° Fahrenheit temperature capability will be accomplished, and methods to address critical design and performance predictions will be evaluated. Various approaches for accelerated testing under combined thermal/mechanical loading will be accomplished as part of the effort to establish airframe design and life prediction requirements. The goal is to establish viable materials forms and structural concepts that achieve a structural weight performance of 4.5 pounds/square foot and represent a 30 to 40 percent improvement over existing design capability.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft systems technology...........	3,556	5,100	5,100	5,200

OBJECTIVES AND STATUS

The rotorcraft systems technology program is focused on integrating technologies of aeroacoustics and high-speed configurations. Emphasis continues to be placed on high-speed rotorcraft research, particularly for promising opportunities for tiltrotor aircraft.

In FY 1991, the NASA-developed comprehensive noise prediction code called ROTONET has added an empirically designed module to address tiltrotor noise. Validation of the code continues with tests of slowed rotors and the initial V-22 evaluations occurring, to meet the prediction accuracy goal of 1.5 decibels. To meet a goal of 80 percent noise reduction, industry has completed analysis of five promising, novel ideas. Several will be selected for feasibility testing.

In high-speed rotorcraft research, XV-15 tiltrotor noise with advanced blades was measured in hover and the results analyzed to determine the footprints of possible civil operations from vertiports. A prop-test rig of the V-22 rotor was tested to 300 knots in a second entry in the 40x80-foot wind tunnel to examine the limits of the performance envelope for the U.S. Navy. Download tests completed in small scale showed that slot blowing can reduce this force by 15 percent, which can increase payload by 10 percent. In addition, studies to quantify and prioritize research opportunities in tiltrotor technology showed the market importance of research improvements in noise, steep approaches, and cockpit design.

BASIS OF FY 1992 ESTIMATE

In noise technology, innovative noise concepts will be pared down to conduct small-scale feasibility tests. Fabrication will begin on the large-scale rotor test apparatus for the 40x80-foot wind tunnel. Completion is expected in FY 1993. This apparatus will be used for correlation of wind tunnel and flight testing, as well as tests not possible in flight. Initial comprehensive noise testing will begin on the V-22 and the advanced bladed XV-15. The XV-15 tiltrotor is also scheduled to fly certification profiles for noise abatement and examine failure modes and handling qualities. Download concepts will be further examined in preparation for full-scale demonstrations.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology............................	9,691	10,500	10,500	11,100

OBJE(S AND STATUS

The objective of this program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research and flight research involving tests of advanced aircraft concepts and systems.

The high angle-of-attack research program is obtaining a flight-validated data base for design of highly agile aircraft. Instrumentation and modification of the F-18 High Angle-of-Attack Research Vehicle (HARV) has been completed. The thrust vectoring control system enables controlled flight to higher angles-of-attack. The F-15 highly integrated digital electronics control (HIDEC) facility was successfully used to complete the flight demonstration of a first-phase self-repairing flight control system (SRFCS) concept which provided fault detection, reconfiguration, pilot alert and maintenance diagnostics information. The primary goal of SRFCS work is to reduce aircraft losses resulting from flight control system failures. Installation and ground checkout of a single-engine performance-seeking control (PSC) concept has been completed on the F-15 HIDEC. The long-term PSC goal is to optimize engine, inlet and flight control performance in real time over the full flight envelope. The Vertical/Short Takeoff and Landing Research Aircraft (VSRA) YAV-8B Harrier instrumentation was completed. The VSRA flight research program is designed to investigate display and integrated flight and propulsion control concepts, primarily for the hover and transition regime of flight. The F-106 vortex flap flight experiment has completed flight testing with flap positions of 30 and 40 degrees. These flight tests conclude the F-106 vortex flap flight activity. An assessment of the predicted improvements in takeoff, landing and maneuvering performance that can be achieved from a vortex flap will be conducted. The second X-29 aircraft has completed the originally planned flight tests to assess the high angle-of-attack characteristics of the unique forward-swept wing configuration. Flight control system changes to explore the excellent high angle-of-attack flying qualities are being designed. Two unique F-16XL aircraft have been loaned to NASA by the U.S. Air Force for high-speed research. A cooperative NASA/industry research effort was initiated to assess a point design concept for supersonic laminar flow and drag reduction on the F-16XL. A second, more systematic, investigation of supersonic laminar flow possibilities is planned for the highly swept wing configuration of the F-16XL. Flight research results will be used to establish design criteria for application to future supersonic civil and military aircraft.

BASIS OF FY 1992 ESTIMATE

Flight research on several advanced concepts is planned. Flight research will be performed using the F-18 HARV, which has been modified with the addition of a multi-axis thrust vectoring system to provide for controlled flight at high angles of attack. Full envelope flight evaluation of the two-engine PSC using the F-15 HIDEC aircraft will be conducted. Final development and ground checkout of a propulsion-enhanced flight control concept is to be substantially completed during FY 1992. This concept will be demonstrated on the F-15 HIDEC using differential and collective engine thrust as a means of providing emergency flight control. Flight research to investigate supersonic passive laminar flow in support of the high-speed research program is expected to be initiated during FY 1992 using the F-16XL aircraft. System integration/validation testing of the throttle control servos software will be completed in the ground development facility, while system checkout of the YAV-8B VSRA aircraft and system interfaces are completed in a hangar to support planned flight research of various display and integrated propulsion flight control concepts.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology...	13,152	15,000	15,000	15,400

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components. This program consists of two elements, the advanced turboprop systems program and the general aviation/commuter engine systems technology program.

Activities in the advanced turboprop systems program are devoted to establishing the feasibility of low noise ultra-high bypass concepts and providing the broad research and technology analytical and experimental data base necessary for achieving maximum source noise reduction for subsonic propulsion systems. Research completed in FY 1990 included the development of a three-dimensional Euler analysis capability for ducted propellers, wind tunnel tests of advanced ducted propeller models for aerodynamics, acoustics and installation aerodynamics, the final verification of interior noise prediction and control technology based on the NASA and industry turboprop flight programs, and an in-depth analysis of the enroute noise data base acquired using the propfan test assessment aircraft to determine the effects of the atmosphere on aircraft-to-ground noise propagation. Research in FY 1991 will include the experimental evaluation of short, thin nacelles for ducted propeller propulsion systems to determine efficiency, noise levels and the capability to operate at high-angles-of-attack. Wing-mounted ducted and unducted propulsion system installations designed for minimum interference drag will be experimentally evaluated to determine maximum performance potential and validation of an advanced Euler code. Analytical research will include the coupling of a three-dimensional unsteady Euler code with advanced structural and acoustic codes to obtain an improved capability to predict ducted-blade aeroelastics and system source noise.

In the general aviation/commuter engine systems technology program, the objectives are to raise the performance level of small turbine engines to approximately that of large transport turbine engines with a decrease in fuel consumption of 30 percent. Research continues on radial flow turbomachinery to reduce the impact of small components on propulsion system efficiency. The work is focused on providing a detailed understanding of the design parameters that affect component performance through the development of analytical codes and the associated experimental data base for verification. In FY 1990, advanced analytical codes were used to evaluate the viscous effects in a radial turbine and a centrifugal compressor in preparation for experiments to obtain detailed high-speed flowfield data to determine the capability of the codes to predict compressibility effects. In addition, fundamental experimental research demonstrated the potential of effervescent fuel injection to produce uniform sprays. In FY 1991, a cooled radial turbine and a 3000° Fahrenheit composite combustor liner will be experimentally evaluated.

92

In FY 1992, the emphasis in advanced turboprop systems research will be the understanding and control of source noise mechanisms, propulsion/airframe installation aerodynamics, and the development of improved aerodynamic, structural and acoustic analysis techniques for ultra-high bypass subsonic propulsion systems. Source noise research will include experimental and analytical analysis of advanced blade shapes for improved aerodynamics that reduce noise-generating mechanisms, experimental study of active noise control aimed at control of noise at the fan source, and an experimental evaluation of advanced liner treatment concepts. Installation aerodynamics research will include a wind tunnel evaluation of an ultra-high bypass nacelle designed for zero interference drag at Mach 0.85 flight speed, as well as low-speed wind tunnel tests to determine takeoff performance and an initial evaluation of installed noise levels. A three-dimensional unsteady Euler code for ducted ultra-high bypass systems that provides the basis for analytical evaluation of advanced low-noise concepts and the required aerodynamic input for accurate source noise prediction will be developed.

The general aviation/commuter engine technology effort will continue to demonstrate component improvements through the practical application of validated analysis codes that will enable high-performance small engine systems. In support of combustor research, the validation of a three-dimensional Navier-Stokes two-phase, reacting flow code will be completed, and the capability for operation of uncooled composite combustor liners at 2800° Fahrenheit will be verified. For turbomachinery, validation will continue for a three-dimensional viscous analytical capability to predict aerodynamics and heat transfer in cooled radial turbines and viscous flows in high-speed centrifugal compressors. A high-speed, high-pressure ratio three-stage axial compressor will be evaluated with nonintrusive diagnostics to determine detailed flowfield information for verifying the ability of the analytical codes to predict compressibility effects in axial flow turbomachinery.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Numerical aerodynamic simulation.........	41,798	44,100	44,100	45,400

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the nation's capabilities in computational fluid dynamics (CFD) and other areas of computational physics by developing a preeminent computational capability for numerical simulation of aerodynamic flows. Ongoing research and technology base efforts in computational aerodynamics will benefit significantly from the advanced computational capabilities to be provided by the NAS program. This program will provide the computational capabilities required to obtain solutions to problems which are currently intractable, allowing solutions of the full Navier-Stokes equations and enabling the prediction of performance of complex aircraft geometries. In order to ensure this degree of computational capability, the NAS program is pursuing the following objectives: (1) acquire pathfinding, state-of-the-art, high-speed processors; (2) provide a uniform, user-friendly system with equivalent capabilities for local and remote users; (3) provide an auxiliary processing center for secure processing; (4) investigate and incorporate parallel architecture machines into future generations of the NAS; (5) provide a hardware and software development environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices; and (6) continue to research and develop an increasingly sophisticated system of hardware/software tools and environment to assist the user in performing CFD tasks and to improve productivity.

The numerical aerodynamic simulation (NAS) system continued its national operation supporting more than 1350 accounts within NASA, DOD, other government agencies, industry and academia. Higher performance mass storage hardware, using the software introduced in FY 1990, was integrated into the NAS system to accommodate the increased performance capabilities provided by High-speed Processor (HSP) 2 and future HSP's. A new local high-speed network, based on current prototype development, was deployed and the remote network upgraded with new gateway hardware and software. User interface and scientific visualization software under development became operational. To meet the challenge of providing increased operational computing capability for aerospace applications, pathfinding research will continue in parallel architectures and algorithms with mapping of specific aerodynamic simulation problems onto advanced computational platforms. Operating, user interface and visualization software research continues with emphasis on the incorporation of expert systems and distributed systems technology. System research and prototyping were conducted to provide improved capabilities for simulation setup and results analysis. The principal objectives were to improve configuration geometry and computational grid generation and to interactively perform analysis on very large unsteady flow solution data bases in an efficient manner.

BASIS OF FY 1992 ESTIMATE

The number of research groups will stabilize around its current level, continuing the diversity of NASA, DOD, other government agencies, industry and academia users. A third high-speed processor to replace the first such machine will be placed in operation. Other elements of the extended operational configuration will continue to be enhanced in the areas of advanced graphics, sophisticated work stations, and UNIX-based mass storage system. Communications for local and remote users will be upgraded. Research will continue in architectures and algorithms for mapping of specific aerodynamic simulation problems onto advanced computational platforms.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
High-speed research.....................	24,494	44,000	44,000	76,400

OBJECTIVES AND STATUS

Studies have indicated that, with sufficient technology development, future high-speed aircraft could be economically competitive with long-haul subsonic aircraft. Currently, however, critical environmental concerns about atmospheric impact, airport noise and sonic boom present powerful private sector disincentives. The high-speed research program is addressing these barrier environmental issues and developing the basis for evaluating technology advances that can provide the necessary environmental compatibility.

The atmospheric effects element of the program includes theoretical and experimental research to assess the impact of stratospheric aircraft. Issues to be addressed include depletion of ozone, perturbations to atmospheric chemistry on a global scale, and the potential for long-term climate change. A hierarchy of theoretical models is being developed and applied with the assistance of laboratory and in-flight measurements to reduce the large uncertainties in predictions made with current global models. In FY 1991, a primary goal is an initial atmospheric assessment with two-dimensional and three-dimensional models for dispersion and mixing of emissions. Laboratory measurements of critical rates for heterogeneous reactions in the background atmosphere will be completed, and significant progress made toward development of instrumentation needed for atmospheric measurements from aircraft platforms. Aircraft system studies will also be conducted in this element of the program and will provide a framework for related technology efforts by determining the impact of environmental requirements on aircraft vehicle systems and the commercial viability of proposed technology solutions. Through these studies, key technology needs will be identified and the overall program plans adjusted accordingly. During FY 1991, engine manufacturers will provide alternative propulsion configuration recommendations for conceptual aircraft installation evaluation, and aircraft manufacturers will evaluate the effects of operating altitude and Mach number on ozone depletion.

The emissions and source noise element of the program is providing the technology base for reduced engine emissions and exhaust noise by developing improved analytical models, performing laboratory scale experiments, and testing engine level components to confirm feasibility of meeting environmental goals, such as Federal Aviation Regulation (FAR) 36, Stage 3 noise levels. During FY 1991, flame tube experiments will be completed on low nitrogen oxide (NOx) combustion concepts and the results used to improve and validate analytical codes. Experimental studies of fundamental nozzle concepts to determine the effects of geometry on plume mixing and exhaust noise reduction will also continue, and initial candidate low-noise nozzle configurations testing will be completed. These experimental results will be compared to analytical predictions to gain insight into further possible noise reduction.

The objectives of the community noise and sonic boom element are to develop advanced aerodynamic and aircraft configuration technologies that are integral to lowering takeoff and landing approach noise and achieving sonic boom signatures acceptable to humans and to physical structures. Meeting the airport noise objective requires the development of accurate system noise reduction methodologies and wing high-lift systems, as well as evaluation of engine placement effects and optimization of landing and takeoff procedures. In FY 1991, high-lift systems research will continue with theoretical analysis, small-scale wind tunnel tests, and piloted simulator studies of aerodynamic concepts to determine their operational payoffs. Sonic boom research is focusing on human acceptability criteria, as well as the development of low-boom configuration concepts and predictive methodologies. In FY 1991, wind tunnel tests of initial low boom aircraft configurations will be completed, and in-home sonic boom simulation experiments will be conducted to establish an annoyance data base. Laminar flow control research for aerodynamic drag reduction is also a key part of this element due to its high potential leverage on aircraft and engine size and, thus, noise and sonic boom. Efforts during FY 1991 will include a study of swept wing crossflow effects in a low disturbance wind tunnel and the development of boundary layer transition sensors for future flight experiments.

The objective of the enabling propulsion materials element, being initiated in FY 1992, is to develop the critical material systems required for long-lead propulsion system requirements. The specific material systems area required for environmentally acceptable engine concepts are advanced ceramic composites for combustor design and advanced intermetallic composites for lightweight exhaust nozzles.

BASIS OF FY 1992 ESTIMATE

In FY 1992, the high-speed research program will continue to address critical environmental compatibility issues and establish a foundation for subsequent decisions on future high-speed civil transport technology and development programs. Results of heterogeneous chemical studies will be incorporated in models of the lower stratosphere to improve predictions of the effect of aircraft on ozone. Initial aircraft-based measurements will also be conducted to verify these models. Using the results of laboratory experiments on reduced NOx combustion concepts, engine combustor component technology will be initiated, and computational analyses will continue to be enhanced. The most promising variable-cycle engine concepts will also be selected by aircraft manufacturers in FY 1992 from weight, range and noise performance evaluations. In addition, preliminary capability to satisfy the FAR 36, Stage 3, community noise goal will be assessed through testing of scale model jet noise suppressors and aircraft high-lift devices, such as the vortex flap concept.

Based on completed aerodynamic analyses, wind tunnel tests, and evaluation of human response to simulated over-pressure signatures, a decision will be made concerning the viability of low sonic boom concepts. If acceptable supersonic overland flight appears achievable, development of low boom aircraft configurations will continue, possibly leading to flight tests in later years. If it is decided that supersonic flight must be limited to over water, efforts will be concentrated an the development of sonic boom prediction capability for operational considerations and for environmental impact statements.

Development and evaluation of supersonic laminar flow control to reduce aircraft drag and weight will continue with wind tunnel tests and an F-16XL aircraft flight investigation of boundary layer transition characteristics.

For FY 1992, the enabling propulsion materials program will focus on development of two advanced material systems for critical areas in engine design and development. These two material systems are ceramic matrix composites for low NOx combustor design applications, that require uncooled 3000° Fahrenheit operation temperatures, and intermetallic matrix composites for the weight-critical engine exhaust nozzle. The program activities will involve integration of design and material requirements, including material processing and fabrication methods, to achieve the required technology data base for rapid transfer of new material systems to design applications. The establishment of detailed structural performance requirements, which provide guidance for material system development, will be accomplished. This will include establishment of fundamental material characteristics and consideration of component producibility. Initial emphasis will be placed on establishment of matrix property requirements and compatibility with reinforcement fibers, including temperature, strength, thermal stability and fiber diameter. A team approach will be established to obtain an integrated research infrastructure which includes the material suppliers, universities and the propulsion industry. This will be used to establish the integrated research tasks to develop the material system requirements based on design needs, evaluation of various fabrication and process methods, development of new innovative material forms, and evaluation of component performance using complex analytical models to assess structural performance and life for new material systems operating in a realistic environment.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced subsonic technology............	--	--	--	5,000

OBJECTIVES AND STATUS

The objective of the advanced subsonic technology program is to accelerate the development of nondestructive evaluation technology to ensure the safe operation of aging transport aircraft in the National Airspace System and to provide the technology base for confident application and certification of Fly-by-light/power-by-wire controls systems to civil transport aircraft. Substantial growth is projected in the number of subsonic transport aircraft required to meet future transportation demands. Air traffic in the U.S. is projected to double in the next twelve years with similar growth expected in Europe and Asia. This high demand will result in both a large new aircraft market opportunity for U.S. industry and delayed retirement of older aircraft, doubling the number of in-service aircraft over twenty years old by the end of the next decade. Specific high-priority technology will focus on development of cost-effective nondestructive evaluation technology for rapid inspection of fatigue and corrosion damage in older transport aircraft. It will be critical to ensure the structural integrity and safety of these older aircraft. Current technology for in-service inspection and quantitative damage assessment of structures for disbonds, fatigue cracks and corrosion is inadequate. Cost-effective, large-area nondestructive evaluation technology with advanced sensor concepts must be developed. Fracture analysis methodology for aircraft structures with multiple-site damage fatigue cracks must be developed and verified. Fly-by-light/power-by-wire (FBL/PBW) technology has the potential to provide lightweight, highly reliable, electromagnetically immune control and power management systems for new transport aircraft. Technology will be developed for confident application and certification of integrated FBL/PBW. Efforts will be focused on optical components and subsystems, an advanced electrical power management and distribution system, development of analytical and experimental methodologies for assessing electromagnetic environment effects, and development of system architecture designs and validation methods appropriate for certification.

BASIS OF PY 1992 ESTIMATE

The program builds on NASA's ongoing research and technology base activities to carry out focused advanced technology development activities related to future subsonic transports. The aging aircraft program builds on NASA's extensive expertise in acoustic and thermal inspection methods, fatigue of metallic materials, and stochastic modeling for structural life prediction. Development of these technologies will provide rapid, cost-effective inspection procedures for improved safety of future airframe structures.

The emphasis in FBL/PBW will be placed on flight evaluation of a number of optical sensor concepts in order to assess their performance in the flight environment. Definition of the electromagnetic environment and development of hazard models for use in evaluating component and system designs will also be initiated.

TRANSATMOSPHERIC
RESEARCH
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS. EXPLORATION AND TECHNOLOGY — TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Transatmospheric research and technology	59,027	119,000	95,000	72,000	RD 13-2

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Marshall Space Flight Center	50	--	--	--
Ames Research Center	4,061	3,000	3,500	4,400
Langley Research Center	7,383	7,000	5,100	7,500
Lewis Research Center	11,178	5,000	3,600	5,300
Headquarters	36,355	104,000	82,800	54,800
Total	59,027	119,000	95,000	72,000

OFFICE OF AERONAUTICS, EXPLORATION AND TECHNOLOGY **TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY**

OBJECTIVES AND JUSTIFICATION

The Transatmospheric Research and Technology program is a portion of the joint NASA/Department of Defense (DOD) National Aero-Space Plane (NASP) program. The program objective is to develop and then demonstrate, in an experimental flight vehicle, the technology required to permit the nation to develop reusable, single-stage-to-orbit (SSTO) vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing.

The program was revised and rescheduled in the summer of 1989, based on the President's endorsement of the National Space Council's recommendations to extend the second, current phase of the program, which focuses on technology development. Important work remains in propulsion, materials and structures, controls, and applications of computational fluid dynamics. Emphasis is also placed on integrating these technologies into a single vehicle concept to assess both vehicle and technology potential. A decision in the second quarter of FY 1993 will determine whether to proceed to Phase 3, which consists of designing, constructing and flight testing an experimental flight vehicle, the X-30.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The Transatmospheric Research and Technology program has been reduced by $24.0 million as a result of Congressional action on the FY 1991 budget request.

BASIS OF FY 1992 ESTIMATE

The FY 1992 estimate is consistent with the recommendation of the National Space Council and will provide for continuation of the full spectrum of technology development. This effort ranges from vehicle concept development to advancements in specific technologies, such as technologies for hypersonic propulsion and extremely high-temperature materials.

The work will be conducted by government agencies, acting in concert with a single team of previously competing NASP prime contractors. The contractor team, formed in 1990, consists of three airframe companies (General Dynamics, McDonnell Douglas, and Rockwell International) and two engine companies (Pratt & Whitney and Rocketdyne). The integration of the contractors' efforts into a limited joint-venture partnership brings the benefits of broadening the available technological base, as well as utilizing the strengths of each company in the development of a single, new vehicle concept.

The NASP program now has two basic thrusts: vehicle-concept development and technology development. The former is accomplished almost entirely by the contractors. Results of the technology development, accomplished by both contractors and government agencies, are fed directly into the vehicle development. Contractor teaming has enabled a significant degree of technology focusing and the concentration of all efforts toward the specific requirements of the new concept.

Materials development and characterization remains a significant part of technology development. The list of advanced, high-temperature materials being worked includes advanced carbon-carbon with special oxidation-resistant coatings and a set of titanium-aluminide alloys with and without fiber reinforcement. The unique structural concepts under continuing development for NASP include a graphite-epoxy, cryogenic fuel tank recently installed in a representative experimental fuselage section for thermal/mechanical loading tests. Other very advanced structures include those for actively cooling segments of the engine and the leading edges of both the wings and engine cowl.

Some of the most challenging aspects of technology development remain in the area of propulsion. This work is still moving toward the testing of large-scale engine concepts in ground-based facilities. Work at the lower speeds (Mach numbers of 0 to 6) will continue to address component performance and component/vehicle integration. Focusing on the airframe-engine concept will require one propulsion system concept to be refined and carefully integrated with the airframe. The supersonic combustion ramjet (scramjet), which remains the essential feature of the propulsion system, will be developed further with improved computational and experimental methodologies. This will lead to a large-scale, Mach 8, ground concept demonstration test prior to the decision to build and flight test the X-30.

Aerodynamic experiment and analysis, particularly at hypersonic speeds, will guide vehicle concept evolution. Advanced methods of predicting the transition of three-dimensional boundary-layer flows to the turbulent condition with greater heat transfer and drag will be developed for NASP applications. Such work relies heavily on computational fluid dynamics (CFD) tools and some special experiments to validate CFD predictions. The CFD methods also are providing improved three-dimensional analysis capabilities for internal flows and even real gas effects at flow conditions beyond Mach 12. Wind-tunnel tests on aerodynamic performance and propulsion-airframe integration are required across the speed range for the new vehicle concept.

Some of the more important subsystems to be fully developed provide for the production, storage and utilization of slush hydrogen, a mixture of solid and liquid hydrogen. The benefits of slush over liquid hydrogen (density and thermal capacity) allow for a smaller, lighter vehicle, but also lead to new challenges in terms of both overall thermal management and systems design.

SPACE RESEARCH
AND TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIXATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS. EXPLORATION AND TECHNOLOGY — SPACE RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base.............	125,033	125,700	125,700	141,600	RD 14-5
Civil space technology initiative (CSTI) program.......................	121,373	171,000	119,000	114,300	RD 14-13
Exploration technology program..........	27,468	179,400	27,500	52,000	RD 14-17
In-space technology experiments program..	10,155	19,800	11,200	16,000	RD 14-19
Space automation and telerobotics........	--	--	--	82,900	RD 14-21
Exploration mission studies..............	(15,000)	37,000	7,000	15,000	RD 14-23
Total................................	284,029	532,900	290,400	421,800	

Distribution of Program Amount By Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center....................	15,853	48,100	16,800	25,300
Kennedy Space Center....................	1,649	5,400	2,000	4,500
Marshall Space Flight Center.............	57,260	110,300	57,200	64,600
Goddard Space Flight Center..............	9,647	9,800	10,800	71,600
Jet Propulsion Laboratory................	33,798	63,600	35,400	35,400
Ames Research Center....................	26,735	43,400	27,600	34,200
Langley Research Center..................	50,305	67,300	53,900	63,500
Lewis Research Center....................	50,875	111,800	50,100	68,400
Headquarters............................	37,907	73,200	36,600	54,300
Total................................	284,029	532,900	290,400	421,800

PROGRAM OBJECTIVES AND JUSTIFICATION

The overall goal of the space research and technology program is to ensure continued U.S. leadership in space by providing advanced, enabling technologies, validated at a level suitable for user-readiness, for future space missions. To achieve this goal, a broad base of advanced technology is required for vehicle and subsystems concepts, components, devices, and software. This is achieved by developing technical strengths in the engineering disciplines within NASA, industry, and academia and performing critical technology validations that facilitate the transfer of new technology with a high level of confidence to future space missions. This program supports five thrusts related to space platforms, space transportation, space science, exploration and breakthrough technologies.

To accomplish the technology for these thrusts, the Space Research and Technology program is composed of two complementary parts: the research and technology base (R&T Base) program and the focused technology programs. The objective of the research and technology base program is to gain a fuller knowledge and understanding of the fundamental aspects of phenomena in critical disciplines. Within the research and technology base program, high-leverage technological advances and concepts are brought to the level of demonstrating proof of principle. The base program is the seedbed for generating the more mission-focused technology programs.

Focused programs, based on requirements provided by the potential users of the technology, develop technology for specific future applications and deliver products in the form of proven hardware, software, design techniques and data. In FY 1991, three focused programs are currently underway, the Civil Space Technology Initiative (CSTI), the Exploration Technology program, and the In-Space Technology Experiments program (IN-STEP). In FY 1992, the telerobotics and artificial intelligence programs, which previously were conducted as part of the CSTI program, and technology demonstration elements of the Flight Telerobotic Servicer (FTS) program, which was previously conducted as part of the Space Station Freedom program, will be combined into a new focused program entitled Space Automation and Telerobotics Technology.

The CSTI program is a positive first step to increase the agency's technical strength and provide options for future Earth orbit, high-priority civil space goals. The CSTI is developing technologies to enable efficient, reliable access to Earth orbit; enhance operations in Earth orbit; and increase the effectiveness of science missions in Earth orbit. The Exploration Technology program, a vital element of the national space policy, is developing critical capabilities to enable bold missions, both human and robotic, to expand human presence and activities beyond Earth's orbit into the solar system. It will push

U.S. technology forward through a strong partnership between NASA, industry, and universities. The Space Automation and Telerobotics Technology program will strengthen the technology base for NASA programs to use automation and robotics to complement and reduce reliance on human presence for some aspects of space operations. Proof-of-concept testing for mission-critical engineering concepts will be an important product of the focused technology programs and will directly support the continuing evolution and maturation of mission plans.

An important element in accomplishing the OAET goal is the development of selected space technology experiments for flight validation. The In-Space Technology Experiments program will develop key flight experiments to provide valuable information for solving critical technology problems.

Exploration Mission Studies are continuing to develop the necessary analytical foundation on which future decision can be based regarding the Space Exploration Initiative.

CHANGES FROM FY 1991 BUDGET ESTIMATE

A reduction of $205.5 million is reflected in the space research and technology program. This is the net effect of a reduction of $210.0 million directed by Congress, offset by the reallocation of $4.5 million to this program from other programs within the agency budget to support exploration mission studies. In addition, $2.5 million was reallocated within the space research and technology program to support exploration mission studies.

BASIS OF FY 1992 ESTIMATE

In FY 1992, the research and technology base program will continue to serve as the seedbed for new technologies and capability enhancement. In FY 1992, additional emphasis will be placed on newly emerging high-leverage technologies, including aerothermodynamics, materials and structures, and systems analysis. The narratives that follow discuss in greater detail highlights of FY 1991 accomplishments and planned FY 1992 activities.

The four focused technology efforts, the Civil Space Technology Initiative (CSTI), the Exploration Technology program, the In-Space Technology Experiments program, and the Space Automation and Telerobotics program, will continue to develop technologies and concepts for specific applications by the user. The CSTI and Exploration Technology programs will enable bold new missions and significantly enhance current capabilities to access, operate and explore in space. The IN-STEP, begun in FY 1990, will continue to develop experiments to validate critical technologies in the actual space environment. The new focused effort in Space Automation and Telerobotics will include the technology demonstration elements of the FTS program and the technology efforts in telerobotics and artificial intelligence programs previously supported by the Civil Space Technology Initiative. The technology developed by the space research and technology program efforts will reduce mission costs and enhance safety and reliability.

The objectives of the CSTI program are focused on research in three broad categories -- transportation, operations, and science technology. The research is targeted at opportunities with clearly defined and objectives to validate technology advances. Specific program elements are: propulsion, power, science sensor and data technology, large structures and control, and vehicle technology.

The Exploration Technology program, major segments of which were begun in FY 1989 under the Pathfinder program, will continue building a set of technologies to enable future robotic or manned solar system exploration missions. The exploration technology program is divided into eight major thrusts: space transportation, in-space operations, surface operations, lunar support, lunar and Mars science, information systems and automation, nuclear propulsion, and innovative technologies and exploration technology analysis.

The In-Space Technology Experiments program is an important program which began in 1990 and is designed to develop key flight experiments to provide fundamental data in the space environment, validated, advanced space technologies for improving the effectiveness and efficiency of current space systems and to provide major advancements for future systems. Previous efforts over the past few years have identified advanced, highly innovative technology concepts that require testing or validation in the actual space environment in order to obtain data that cannot be acquired in ground-based laboratories, to reduce the risk to the potential users and facilitate the transfer of advanced technologies into future space missions and to begin to prepare for conducting technology experiments using Space Station Freedom.

In FY 1992, the new focused effort in space automation and telerobotics will include the technology demonstration elements of the FTS program (previously conducted as part of the Space Station Freedom program) and the telerobotics and artificial intelligence programs (previously conducted as part of the Civil Space Technology Initiative). In FY 1992, for the FTS, the first space demonstration flight hardware's integration and testing, system environmental testing, and system software testing will be concluded and extensive ground-based technology development will be supported. The telerobotics program will support the integration and demonstration of technology for space telerobotics to enhance operational capability and the decrease cost of space operations. The artificial intelligence program will exploit artificial intelligence for control of multiple subsystems with the capability for automated reasoning and recovery from unanticipated failures. The application of this technology to future exploration, Space Station, Space Shuttle and space science missions will result in higher degrees of onboard autonomy and reduction in manpower required in mission control.

Exploration Mission Studies will continue to be focused on providing the technical, programmatic, and cost analyses required to support future national decisions on a specific Space Exploration Initiative architecture.

BASIS OF FY 1992 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Aerothermodynamics research and technology..........................	13,040	11,100	13,700	15,400
Space energy conversion research and technolo..............................	12,900	12,800	11,500	12,800
Propulsion research and technology.......	12,230	13,800	14,800	16,700
Materials and structures research and technology..........................	20,425	16,000	19,000	20,900
Information and controls technology......	--	--	22,600	26,400
Space data and communications research and technology.......................	8,437	8,900	(8,900)	--
Information sciences research and technology............................	6,900	15,100	(9,500)	--
Controls and guidance research and technology............................	5,331	4,700	(4,200)	--
Human support technology................	--	--	4,400	5,200
Human factors research and technology............................	4,159	3,900	(3,900)	--
Space flight research and technology.....	18,811	15,500	15,500	17,300
Systems analysis.......................	6,000	6,200	6,500	7,800
University space research................	16,800	17,700	17,700	19,100
Total................................	125,033	125,700	125,700	141,600

OBJECTIVES AND STATUS

The objective of the research and technology base program is to increase knowledge and understanding of the fundamental aspects of phenomena in critical engineering disciplines. The research and technology base program consists of eight program elements: aerothermodynamics, space energy conversion, propulsion, materials and structures, space flight, systems analysis, information and controls, and human support. In addition, the university space research program, supported by the research and technology base, includes research in critical areas to enhance and broaden the capabilities of the nation's academic community to participate more effectively in the U.S. civil space program. Some programs were consolidated to reduce fragmentation and to allow for a more cohesive management structure. A description of the objectives and status of the elements of the research and technology program follows.

The aerothermodynamics program provides for fundamental understanding and prediction of the detailed aerodynamic and thermodynamic loads experienced by high-speed vehicles during ascent, entry and maneuver in both Earth and other planetary atmospheres. This activity is enabling to the successful development and design of advanced aerospace vehicles and is pursuing the following objectives: (1) development and application of advanced computational methods and numerical techniques covering the entire spectrum of continuum, transitional, and rarefied flows; (2) development of accurate and detailed real-gas chemistry and high-speed turbulent flow models and the efficient integration of these models with standard computational flow codes; (3) establishment of a high-quality ground and flight experimental data base for code validation and verification; (4) direct correlation and comparison of computations with available ground and flight data; (5) establishment of a detailed aerothermal loads data base and development of fully integrated analysis techniques; and (6) enhancement of engineering design codes and advanced configuration analysis capability to support rapid evaluation of future vehicle/mission concepts. Progress continues to be made in development of advanced CFD codes which incorporate thermochemical nonequilibrium effects and coupled radiation; development of a flight test capability sufficient to validate computational predictions and provide correlation for ground test data bases; and extending the level of sophistication and efficiency of engineering design codes for configuration assessment.

The objective of the space energy conversion program is to develop technology alternatives that improve performance, reliability, and cost effectiveness of space power both for manned and unmanned space operations, including autonomous Earth-orbiting and planetary exploration spacecraft. To meet the challenge, improvements of a factor of two to five and increased life potential are being sought in various solar power generation components, chemical energy conversion systems, energy storage systems, electrical power management and distribution, as well as thermal management systems. For spacecraft photovoltaic and energy storage technologies, the goal is to improve the total system performance enough to permit a 50 percent increase in payload mass, while not increasing the spacecraft overall mass. For environmental control and life support systems, the goal is to provide a technology base in chemical processing techniques to support future human space missions. Progress continues to be made in the successful testing of a solar array that is five to ten times lighter than existing arrays. Progress also continues to be made in extending the lifetime of nickel-hydrogen battery design and reducing mass by a factor of two.

The propulsion program focuses on a number of critical technology areas that will greatly improve our ability to gain access to and operate in space in a much more efficient manner. One focus is on extending our knowledge and understanding of fundamental rocket engine chemical and physical processes to enhance future component designs and to predict component performance and life more accurately. Research efforts in this area emphasize the development of a better understanding of rocket engine combustion stability and turbomachinery internal fluid and dynamic processes, including predictive modeling. In addition, very high-performance low-thrust electric propulsion systems research addresses technology issues and advanced concepts for electrothermal, electrostatic and electromagnetic propulsion for improved thruster life and performance. Research on auxiliary propulsion will develop concepts for control of space vehicles. Another area of high potential involves the use of very high energy-density propellant combinations, such as liquid oxygen with metallicized fuels, that offer promise of significantly enhancing space transportation capabilities with much more efficient transportation vehicle designs. Progress continues to be made in several areas. Ion engine discharge chamber erosion rates have been reduced by a factor of 20 to 50 and a hydrogen arcjet was successfully demonstrated between 5 to 24 kilowatts at specific impulses over 1400 seconds. In addition, progress continues in advanced fluid film bearings, fiber-reinforced high heat-flux combustion devices, low-leakage rotating seals, and high-efficiency turbine stages.

The materials and structures program focuses on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of large space structures and advanced space transportation systems with significant improvements in performance, efficiency, durability, and economy. Major technical areas of emphasis focus on fundamental understanding of the processing, properties and behavior of advanced space materials; development of lightweight space-durable materials; computational methods in chemistry to enable the prediction of physical properties and environmental interactions involving materials under space and reentry conditions; nondestructive measurement science for advanced materials; tribological aspects of materials behavior in the space environment; and the development of a wide variety of metallic, intermetallic, ceramic and carbon-carbon materials for thermal protection systems. Structures technology focuses on the development of erectable and deployable structural concepts; methods for in-space construction, monitoring, and repair of large complex structures; dynamics of flexible structures and vibration suppression; new structural concepts for active cooling of hot structures and cryogenic tanks for advanced Earth-to-orbit rocket propulsion systems, future space transportation vehicles, and orbital transfer vehicles; and efficient analysis and design methodology for advanced space structures, including multidisciplinary analysis and optimization. During the past fiscal year, analysis of the data returned by the Long Duration Exposure Facility (LDEF) has improved the definition of the low Earth environment, such as in debris and micrometeoroid modeling, and has proven very valuable in directing the continued development of tailored polymers, advanced metals and composites. Space structures research demonstrated in-space construction of a large truss; advanced fabrication methodology was developed for hot structures; and materials were evaluated for more durable thermal protection systems.

Areas addressed by the information and controls program include computer science, advanced data concepts, photonics, communications, sensors and controls. In the computer science area, the thrusts of the research are in access to and management of very large scientific data sets; software engineering tools for generating very complex and very reliable software; and innovative, but potentially highly effective, computational approaches such as neural networks. The communications area focuses on research to enable Ka band deep space communications capabilities and provide the technology base for space-to-space and space-to-ground optical communication links. The primary objective of the photonics research is to develop opto-electronic components and system concepts to enable high-speed optical sensing and computing. The sensors research area is aimed at novel sensing and electronic devices for high-energy (gamma, x-ray, ultraviolet) observation missions. In the controls area, the goal is to shorten by orders of magnitude the time to compute controls solutions for complex systems. New computational approaches have been developed and are being successfully integrated into advanced computational controls tools.

In the human support program, human factors research will provide new technology to model human performance, including physical and cognitive capabilities for use in zero gravity. Extravehicular operations by astronauts will be aided by a new technology in a high-pressure extravehicular glove design and new thermal control methods for life support will be developed. Closed-loop life support chemical processing technologies will provide recycled air and water for crew consumption to eliminate or significantly reduce mission resupply requirements. Progress continues to be made in the development of a set of techniques which collectively are called virtual interactive environment workstation or artificial reality. A data base for virtual exploration of the Mars surface and an Earth-analog environment will be established in FY 1991.

The purpose of the space flight research and technology program is to support the flight testing of enabling and enhancing technologies which require the actual space environment for validation. Flight data obtained from in-space research and experimentation will be used to validate and verify analytical models, prediction techniques, and ground test methods and facilities. This program encompasses the identification and definition of future in-space flight experiments generated within U.S. industries, universities and the government; the continued design, fabrication, and flight certification of several experiments in preparation for space validation that were initiated prior to FY 1990 (including the Light Detection and Ranging In-Space Technology Experiment (LITE), development of a space platform-mounted laser sensor to measure earth atmospheric constituents and instrumentation for the Orbiter EXperiments (OEX) mounted in the Space Shuttle); and the development of unique, special purpose experiment hardware systems to facilitate technology validation in the space environment. Thirteen flight experiments will finish their design definition phases. These experiments are: Cryo-system, Permeable Membrane, Two Phase Flow, Sodium Sulfur Battery, Inflatable Paraboloid, Jitter Suppression, Middeck Active Controls, Joint Damping, Hydrogen Maser Clock, Liquid Motion in a Rotating Tank, Tank Venting, Tank Pressure Control, and Electrolysis. Two experiments, Optical Properties and Fire Safety will complete feasibility studies. Several new experiments, initiated from the Announcement of Opportunity AO-91, will begin their feasibility studies.

The objectives of the systems analysis program are to identify technology requirements for key future mission concepts and technology opportunities for enabling new and improved future mission concepts, to integrate these into a comprehensive set of technology planning options, and to generate candidate plans to develop these technologies in a timely manner. This effort is closely coordinated with the spaceflight mission program offices to identify the technology requirements for their future mission concepts and technology opportunities for enabling new and improved mission approaches for space transportation, science spacecraft, and large space systems. Progress continues to be made in defining the critical technologies associated with Earth science observations for understanding global change and on defining technologies for future astrophysics missions beyond the Great Observatories; the identification of high priority technologies which will increase reliability and reduce operations costs for the current Shuttle system (Shuttle evolution), developments for future unmanned launch vehicles, and next generation manned vehicles.

The objective of the university space research program is to enhance and broaden the capabilities of the nations's engineering community to participate more effectively in the U.S. civil space program. It is an integral part of the strategy to strengthen the nation's space research and technology base. The program elements include the university space engineering research center program, which supports inter-disciplinary research centers at nine universities; the university innovative research program, which provides grants to individuals with outstanding credentials; and the university advanced space design program, which funds advanced systems study courses at the senior and graduate levels. Significant technical, research and educational benefits have begun to be demonstrated from the university space engineering research centers, including attracting, retaining, and training graduate students and increased industry cooperation support.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The space research and technology base funding has not changed from the original FY 1991 budget estimate; however, within the program some restructuring has occurred and a number of funding realignments have been made, as described below:

The aerothermodynamics program reflects an increase of $2.6 million in FY 1991, which consists of $1.0 million to support wind tunnel operations at Ames Research Center and $1.6 million to support generic hypersonic research.

The space energy conversion program reflects a reduction of $1.3 million. This action consists of a realignment of $0.5 million in life support work to human support research and technology and a reduction of $0.8 million in power systems and thermal management to support other high priority needs in generic hypersonic research and wind tunnel operations. The propulsion program has been increased by $1.0 million. This adjustment primarily reflects an increase in lower cost Earth-to-orbit propulsion technology for future heavy lift launch vehicles. The materials and structures program has been increased by $3.0 million, which includes $2.5 million for generic hypersonic research and $0.5 million to support the 8-foot high temperature tunnel at Langley Research Center.

Three research and technology base programs (space data and communications, information sciences, and controls and guidance) have been combined into a single program Information and Controls. The current estimate reflects a reduction of $6.1 million. The FY 1991 budget estimate included a significant increase in information sciences to support advanced sensor and cooler research; however, due to other high-priority needs, we were unable to fully support the planned growth in this area. This resulted in a decrease of $3.8 million. The balance of the reduction ($2.3 million) was in information science ($1.8 million) and controls and guidance ($0.5 million).

The systems analysis program has been increased by $0.3 million to support generic hypersonic research. The human factors program has been combined with life support work, previously carried in the space energy conversion research and technology program, and renamed human support research and technology. This resulted in a realignment of $3.9 million from human factors and $0.5 million from space energy conversion into human support research and technology.

The human factors programs has been combined with life support work, previously carried in the space energy coversion research and technology program, and renamed human support research and technology. This resulted in a realignment of $3.9 million from human factors and $0.5 million from space energy conversion into human support research and technology.

BASIS OF FY 1992 ESTIMATE

The focus of the aerothermodvnamics program in FY 1992 will be to advance the understanding of chemical and radiative nonequilibrium flow phenomena necessary to reduce design risk and uncertainties. This will be accomplished by expanding the capability of computational techniques to accurately predict these flow phenomena in addition to the conduct of appropriate experimental testing to verify and validate the codes.

In FY 1992, several approaches in the space energy conversion program are being pursued to improve the efficiency of converting thermal power into electrical power. These approaches include higher efficiency thermoelectric materials, the advanced (threefold improvement) alkali metal thermoelectric conversion system, and improved (three- to fivefold reduction in weight) solar dynamic power systems. The solar dynamic program includes development of: (1) high-temperature thermal energy storage; (2) lightweight, high-concentration-ratio solar concentrators; and (3) lightweight, high-efficiency thermal receivers. Research is also continuing on higher efficiency (50 percent increase) radiation tolerant solar cells. In addition, research continues in developing a lighter (two to four times lighter) lithium rechargeable battery for space science missions.

In the propulsion program in 1992, a propulsion evaluation system for advanced transportation vehicles will be implemented to better assess the potential payoffs of technology improvements to propulsion systems and innovative propulsion concepts. In lunar/planetary propulsion, system-level conceptual studies will identify exploration vehicle/propulsion concepts designed to use planetary-derived propellants. Advanced propulsion concept studies will continue toward the objective of identifying fruitful areas for agency emphasis and the critical experiments necessary to prove their potential. Numerical modeling will be completed and system level assessments conducted of innovative plasma rocket concepts. In addition, electrodeless thruster concepts will be tested.

In materials and structures, the FY 1992 program will emphasize evaluation of materials systems returned from the Long-Duration Exposure Facility (LDEF) which will provide a baseline for assessing stability and long-term durability of advanced materials and coating systems requiring a 20-year service life in both low Earth orbit and geosynchronous Earth orbit. Space environmental effects on materials, such as radiation and atomic oxygen effects, will be assessed using degradation models to describe environmental interaction and accelerated test methods to simulate the space environment. Computational chemistry will be used to model material interaction phenomena on the molecular level. Advanced materials and structural concepts will be explored for integral cryogenic tanks and thermal protection systems, including advanced metallic and composite cryogenic tank concepts and durable, woven, ceramic thermal protection systems, for future space vehicles. The effort in space structural concepts will place continuing emphasis on automated construction methods required for large orbiting scientific instruments and space platforms. The payoff is to minimize astronaut extravehicular activity time and reduce mass and packaging volume by up to 50 percent by enabling advanced design concepts. Research on deployable concepts focused on large-area precision structures, such as antennas of the type needed for advanced Earth observing instruments also will be continued.

The information and controls program will emphasize maintaining a solid university base in computational and computer science. Photonic research will emphasize device development in opto-electronic integrated circuit technology for spaceborne optical electronic systems, such as optical computing. Data and communications research will be directed toward software engineering research, advancing electro-optic technology for laser communications, and evaluating the potential impact of high-temperature superconducting materials on future communications system components. Research on high-efficiency monolithic millimeter-wave circuit technology and high-performance electron beam technology will be pursued for advanced deep-space and satellite communications. Sensor research will continue to concentrate on development of solid-state laser systems for enhanced atmospheric science, ranging and altimetry, and other remote sensing applications. In the controls and guidance area, emphasis is being placed on the development of analytical tools for the design of control systems for precision pointing and control of large flexible spacecraft and for avionics systems technology for advanced transportation vehicles.

In the human support area, emphasis will be placed on new methods of presenting visual information via computer-based displays and technology to visualize virtual environments for exploration. New methods for thermal management of zero-gravity suits will be tested to verify predicted performance gains. Advanced, expert system-based human/computer interfaces will be tested using actual data. In addition, technology requirements for in-space biomedical support will be defined. Research will continue on developing efficient air, water, and waste processing technologies, sensor and monitoring instrumentation and controls technology for air and water quality, as well as the development and validation of computerized simulation techniques to support and guide the research effort.

For FY 1992, funding for the space flight area will be utilized to provide definition of 15 technology experiments selected as part of a November 1989 Announcement of Opportunity (AO). An AO will be released in early FY 1991 to identify a new series of technology experiments which are directed toward solutions to critical technology needs identified at the 1988 IN-STEP Workshop. Feasibility studies will be conducted on these new experiments during FY 1992. Assembly of the components for LITE will be initiated in preparation for a launch readiness date of 1993.

The systems analysis program in FY 1992 will continue to support studies to identify technology needs and benefits for advanced transportation, space science and space platform systems. The emphasis of the transportation systems effort will be on launch vehicle concept design studies to assess technologies for the next generation of manned launch vehicles. Technology options to be studied address staged and single-stage-to-orbit vehicles, horizontal and vertical takeoff vehicles, rocket and airbreathing vehicles, and combined engine concepts. For spacecraft systems, efforts will focus on the development of spacecraft systems analysis tools and modeling capabilities, performing studies on technologies for the next generation of astrophysics observatories, and studying the critical technologies necessary for enabling the projected data rates of future science missions.

In FY 1992, the university space research program funding will continue the support to the nine incumbent centers of the university space engineering research program. Support will continue for eminent researchers selected in FY 1989 and FY 1990 for participation in the space university investigators research program, and additional three-year grantees will be included. In addition, support for the advanced design research program will also continue.

BASIS OF FY 1992 FUNDING REQUIREMENTS

CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Operations	21,973	26,100	21,803	32,400
(Power)	(10,824)	(11,100)	(10,405)	(10,600)
(Large structures and controls - controls/structures interaction)	(11,149)	(15,000)	(11,398)	(21,800)
Transportation	57,645	101,400	56,760	63,500
(Propulsion)	(21,645)	(31,400)	(21,760)	(28,700)
(Vehicle)	(36,000)	(70,000)	(35,000)	(34,800)
Science	19,622	18,500	18,203	18,400
(Information technology)	(14,912)	(13,700)	(13,531)	(18,400)
(Large structures and controls - precision sagmented reflectors)	(4,710)	(4,800)	(4,672)	--
Automation and Robotics*	22,133	25,000	22,234	(27,900)
Total	121,373	171,000	119,000	114,300

* Transferred to the new focused program, Space Automation and Telerobotics staring in FY 1992.

OBJECTIVES AND STATUS

The Civil Space Technology Initiative (CSTI) program, begun in FY 1988, is focused on research in technologies to enable reliable, lower cost access to space and to support operations in space and science missions from Earth orbit. The CSTI program is a vital component of NASA's Space Research and Technology program, intended to maintain NASA's technical strength and to provide options for high-priority civil space goals of the future. The research is targeted at opportunities with clearly defined end objectives to validate technology advances.

In FY 1992, the CSTI program has been restructured from five areas into three major thrust areas as shown above. In addition, the remaining area (automation and robotics) conducted as part of the Civil Space Technology Initiative since its initiation in FY 1988, has been transferred to a new focused program, Space Automation and Telerobotics. This restructuring provides a more cohesive structure for managing the program and to align with Agency missions that will benefit from the technology developed in the individual tasks. The activities in each of the three CSTI thrust areas are discussed below.

Operations in Earth orbit, and in some instances ground operations, will be enhanced by technologies in the ongoing areas of high capacity power and controls/structures interaction. The high-capacity power program will provide the technology for advanced energy conversion systems, radiators, heat pipes, and power control components necessary to achieve a fivefold increase in the electrical power obtainable from the SP-100 reactor and will double the power-to-weight ratio of the current SP-100 system being developed under Exploration Technology as part of the tri-agency program. The control/structures interaction (CSI) program focuses on unifying the controls and structures disciplines into a multidisciplinary technology to enable accurate prediction of in-space behavior and maximize the performance of large flexible space structures. Program emphasis includes analysis and design methods, CSI concepts, verification test methods, qualification methods and on-orbit experiments.

To support future transportation systems, two elements, Earth-to-orbit (ETO) propulsion and the Aeroassist Flight Experiment, are funded. The ETO program provides for both the acquisition and verification of needs-focused advanced technologies for the evolution of future transportation propulsion systems. New analytical methodologies and design tools, validated experimentally in test rigs and in large-scale combustion devices, turbopumps, and in the controls and monitoring test laboratory, will be made available to industry and government engineers and technicians for application to future flight hardware development programs. The ETO program is aimed at providing the technological know-how and those test-proven development tools needed for future safe and reliable, low-cost and operationally efficient space transportation propulsion systems.

The Aeroassist Flight Experiment (AFE) will provide the flight data base to resolve critical aerothermodynamic and thermal protection system issues intrinsic to the design of spaced-based, aeroassisted orbit transfer vehicles. The AFE will permit the validation of computational fluid dynamics codes necessary for the design of these vehicles and will test materials and guidance and navigation techniques in the actual flight environment which cannot be adequately or fully simulated in ground tests. The critical design review for the carrier vehicle and aerobrake were completed and fabrication of a full scale aerobrake structural test article was initiated. The Phase I System Safety Review was held in March 1990. Critical design reviews for five of the experiments were successfully accomplished. Several major subsystem components have been ordered and a number of significant structural and heating development tests have been completed. However, component delivery, experimental hardware, and completion of fabrication of the carrier vehicle structural test article will be delayed because of the budget reductions in FY 1991.

The science area consists of science sensor technology and high rate/capacity data systems. Future science missions will be enabled and enhanced by technology development in the areas of science sensors, data systems, and telescope technologies. The sensors program will develop more advanced sensors to enable observation of Earth, the solar system, and the universe. The sensors can be characterized as having significantly increased sensitivity, resolution, and/or longer life than those previously available. Data systems will focus on technology improvements for future high-speed, high-volume data handling systems. This program will provide both architecture definition and needed component technologies. Further, the precision segmented reflector program is scheduled in FY 1991 to complete the development of critical enabling technology for large orbiting astrophysical telescopes operating in the submillimeter spectrum. Advanced lightweight reflector panels were developed; panel control methodology was demonstrated; and a high-precision erectable support truss concept was designed, fabricated and tested.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The CSTI program has been reduced by a total of $52.0 million, which includes a decrease of $49.5 million as a result of Congressional action on the FY 1991 budget request and a reallocation of $2.5 million to support Exploration Mission Studies. The Congressionally-directed reduction was accommodated by decreasing the operations area by $5.7 million ($2.0 million from telerobotics, $0.1 million from artificial intelligence, $0.4 million from high capacity power, and $3.2 million from controls/structures interactions) and the transportation area was reduced by $43.8 million, including $8.8 million from Earth-to-orbit propulsion and $35.0 million from the Aeroassist Flight Experiment. The reallocation of $2.5 million to support Exploration Mission Studies resulted in reductions of $1.5 million in the operations area ($0.4 million from telerobotics, $0.3 million from artificial intelligence, $0.3 million from high capacity power, and $0.5 million from controls/structures interactions); $0.8 from the transportation area (Earth-to-orbit propulsion); and $0.2 million from sensor technology in the science area.

BASIS OF FY 1992 ESTIMATE

In the operations area, within the control/structures interaction program an effort will be initiated to develop smart materials for vibration control and isolation and will enhance the development of technology focused on space interferometers and large Earth observing platforms. In the power area, based on the completion of the linear alternator, an improved heater head, and other key component technology, a Stirling engine will be fabricated and tested at 1050 degrees Kelvin in late FY 1992. In addition, testing of a multi-couple thermal electric conversion system at a projected figure of merit of 0.85 (as compared to the current 0.7) will be completed. Other technology activities include: testing of a water heat pipe at 450 degrees Kelvin for use with a Stirling engine; testing of refractory liner material for a 850 degrees Kelvin carbon-carbon heat pipe; and completion of the feasibility demonstration of a lithium-sodium-potassium pumped-loop radiator at 550 degrees Kelvin.

In the transportation area, the Earth-to-orbit propulsion technology program will focus on the emplacement of large-scale technology validation testing facilities in each of three major areas: combustion devices, turbomachinery, and systems and controls monitoring. In parallel with these focused subsystems evaluation capabilities, an estimated 12-15 additional technology products are expected to be validated in 1992 in the Space Shuttle main engine technology testbed at the Marshall Space Flight Center. In the Aeroassist Flight Experiment (AFE), as a result of the FY 1991 budget reductions and current funding priorities, the AFE program is undergoing extensive replanning and rephasing. It is expected that the flight date will slip between 12 and 15 months in FY 1992. The carrier vehicle structural test article fabrication will be completed and tested to confirm the structural design. The guidance, navigation, and flight control system design will be completed and procurement of long lead time components initiated. The airborne support equipment design will be completed. The fabrication of the flight aerobrake is to be initiated and thermal protection tile installation started. Experiment designs will be completed and fabrication initiated.

In the science area, the science sensor technology activities in FY 1992 will continue to be based on development of detectors in the 4- to 17-microns region using multiple quantum-well and mercury zinc telluride devices, in the 30- to 300-microns region using blocked impurity band phenomena, and in the submillimeter wave region on quantum-well local oscillator and superconducting tunnel junction mixers. A solid-state laser technology for LIDAR applications will continue to be developed. In addition, the science sensor technology element will include an augmented effort to develop advanced mechanical coolers and infrared detectors with performance and lifetime characteristics required by future Earth observing missions. The high rate/capacity data activities will continue using four-processor, very high-speed, integrated circuit multiprocessors and will continue development of a brassboard space flight optical disk recorder module. Preliminary design of experimental onboard digital processors and correlators will be continued.

BASIS OF FY 1992 FUNDING REQUIREMENTS

EXPLORATION TECHNOI PROGRAM

	1990 Actual	1991 Budget Estimate	1991 Current t	1992 Budget Estimate
		(Thousands of Dollars)		
Space transportation....................	4,145	38,000	6,000	9,000
In-space operations.....................	1,890	23,000	2,000	--
Surface operations......................	13,533	62,000	13,800	20,000
Human support...........................	2,330	25,400	3,500	16,000
Lunar and mars science....................	570	4,500	700	--
Information systems and automation.......	--	10,500	--	--
Nuclear propulsion......................	--	11,000	500	7,000
Innovative technologies and systems analysis...............................	--	5,000	1,000	--
Mission studies.........................	5,000	--	--	--
Total.................................	27,468	179,400	27,500	52,000

OBJECTIVES AND STATUS

The Exploration Technology program, segments of which were begun in FY 1989 as the Pathfinder program, is an activity that develops advanced technologies applicable not only to the Space Exploration Initiative (SEI), but also to the nation's entire civil space effort. A focused activity, the Exploration Technology program supports future decisions. It is organized into eight technology areas: space transportation, in-space operations, surface operations, human support, lunar and Mars science, information systems and automation, nuclear propulsion, and innovative technologies and exploration systems analysis.

The technologies included in space transportation are related to timely and cost-effective transportation to and from the Moon and Mars, for both robotic and piloted exploration missions. The surface operations area supports technology for advanced planetary operations, such as space nuclear power and in-situ resource utilization. The human support program addresses the technology for improving astronaut productivity, maintenance, and health, with minimal or no dependence on resupply of expendables for life support. The technology developed in the nuclear propulsion program area will address several approaches for utlizing space nuclear propulsion systems to improve transfer vehicles supporting missions to Mars.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The Exploration Technology program reflects a $151.9 million reduction directed by Congress. This was accommodated by reductions of $32.0 million in space transportation, $21.0 million in in-space operations, $48.2 million in surface operations, $21.9 million in human support, $3.8 million in lunar and Mars science, $10.5 million in information systems and automation, $10.5 million in nuclear propulsion, and $4.0 million in innovative technologies and exploration technology analysis.

BASIS OF FY 1992 ESTIMATE

In the area of space transportation technology, research will continue in areas such as cryogenic hydrogen-oxygen engines for space transfer vehicles and for ascent/descent propulsion, including a breadboard and technology for extensive throttling capability, long life with multiple firings, integrated engine diagnostics and controls, and design for engine space-basing and servicing.

In the area of surface operations technology, the requested funding is for the interagency space nuclear power program, SP-100, and is consistent with funding levels contained in NASA's Memorandum of Understanding with the Departments of Energy and Defense.

In the area of human support technology, research will continue in regenerative life support systems technology, including air revitalization, water reclamation, environmental monitoring and control, and bioregenerative life support; extravehicular activity suits, including highly-dexterous, high-pressure gloves, suit end effectors and tools, and portable life support systems, including thermal management systems, and carbon dioxide removal; exploration human factors, including human-automation-robotic systems, artificial environment human-machine interfaces, and development of basic human performance models for exploration missions. Research will be started in radiation protection technology, including the development of radiation transport computer models and radiation protection shielding materials and structures.

In the area of nuclear propulsion technology, research will be supported in both nuclear thermal rocket propulsion technologies, capable of long-life and multiple starts and nuclear electric propulsion technologies, for future human mission to Mars application.

BASIS OF FY 1992 FUNDING REQUIREMENT

IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
In-space experiments....................	10,155	19,800	11,200	16,000

OBJECTIVES AND STATUS

The purpose of the In-Space Technology Experiments Program (IN-STEP) is to develop key flight experiments that will provide validated, advanced space technologies to provide major improvements in the effectiveness and efficiency of future space systems. Previous efforts in the research and technology base have identified and defined advanced technology concepts that require testing or validation in the actual space environment in order to reduce the risk to potential applications and to increase the rate of transfer of advanced technologies into future space missions. Examples of these technologies include behavior of fluids in the microgravity environment, which is essential for the design of advanced thermal management systems; effects of the space environment on spacecraft; variable gravity effects on heat transfer; effect of contaminates on space systems; and in-space construction techniques (welding).

IN-STEP will coalesce many unique space technology concepts into defined flight experiments and will provide for the development of the flight hardware. This program will concentrate on experiments performed primarily on the Shuttle mid-deck, "get-away special" cans, or combined on cross-bay structures such as hitchhiker. Many will serve as precursors to experiments that will use the Space Station Freedom facilities. The two major elements of this program are the NASA experiments and industry/university experiments.

Included in these advanced technology experiments are several NASA concepts, such as the REturn FLux contamination Experiment (REFLEX), the Thermal Energy Storage Materials Testing (TEST) experiment, the Debris Collision Warning Sensor (DCWS) experiment, and several innovative concepts currently in the definition phase. The REFLEX experiment will identify the types and quantities of contaminates surrounding the spacecraft. The TEST experiment will validate concepts for storage of energy on spacecraft for use when normal energy sources (such as solar) are unavailable. The DCWS experiment will validate a sensor concept which measures and identifies small debris in low Earth orbit that could be detrimental to spacecraft and space structures, and the safety of man. This debris is currently undetectable by ground radars and telescopes or current space sensors. These experiments should complete the design phase during FY 1991 and be in the hardware development phase for space flight experiments.

The industry and university technology experiments program was initiated with a solicitation for flight experiments in **1986** which resulted in the identification of over 200 innovative space technology concepts. Forty-one experiments were selected for definition or development. Thirty-six of the most critical experiments have completed the definition phase for in-space flight experiments. These 36 experiments will compete in an Announcement of Opportunity with other industry and university concepts for continuation into the flight hardware design, fabrication, and testing phase. Five other experiments have completed design studies and are initiating the detailed design, fabrication, and ground certification in preparation for flight testing. Typical examples of these five experiments are the Tank Pressure Control (TPC) and the Experimental Investigation of Spacecraft Glow (EISG) experiments. The TPC experiment will validate predicted mixing and thermal stratification characteristics of fluids in a zero-gravity environment influenced by jet-induced flow. The glow experiment will study the causes and effects of ram-induced radiation observed about certain materials when subjected to the space environment. A better understanding of the glow phenomena may reduce erosion of space structures and may provide an effective means of identifying/characterizing future spacecraft.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The In-Space Experiments Technology program was reduced by **$8.6** million as a result of Congressional action on the **FY 1991** budget request. This will result in delay and/or cancellation of several NASA and industry/university experiments.

BASIS OF FY 1992 ESTIMATE

The **FY 1992** funding will provide for the continued development of the selected space technology experiments for flight validation on the Space Shuttle and/or Expendable Launch Vehicles. The scientific community will obtain flight data from the first IN-STEP industry and university experiment - Tank Pressure Control (TPC). These data, collected in the 1991 flight, may significantly reduce cost and complexity of fluid tanks in future spacecraft. Two other experiments will be tested in the middeck of the Space Shuttle: Heat Pipe Performance and Middeck zero-gravity Dynamics (MODE). The Heat Pipe experiment will test performance under different extreme conditions that may occur in spacecraft applications. Understanding heat pipe limitations will lead to their widespread use in space systems. MODE will provide basic information on the behavior of structures in microgravity reducing the risk for large systems.

Five experiments will be completing their flight hardware: Thin Foil Mirrors (TFM), Laser Oscillator (SUNLITE), Glow (described above), Emulsion Chamber (ECT), and Solar Array Plasma Interaction (SAMPIE). TFM will test new types of protective coatings for x-ray mirrors. The SUNLITE will validate an ultra-stable, solid state laser oscillator that can be used to improve frequency and time standards for global positioning systems. The Emulsion Chamber experiment will characterize the space radiation environment and will lead to improved performance of sensors and microcircuits. SAMPIE will evaluate the effects of low orbit plasma interference on high-voltage solar cells. It will improve the effectiveness and lifetime of high-voltage solar cells to be used on advanced satellites and platforms.

BASIS OF FY 1992 FUNDING REQUIREMENTS

SPACE AUTOMATION AND TELEROBOTICS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Flight telerobotics servicer*............	(79,400)	(106,300)	(106,300)	55,000
Telerobotics**..........................	(11,064)	(13,400)	(11,045)	14,800
Artificial intelligence**................	(11,069)	(11,600)	(11,189)	13,100
Total..................................	(101,533)	(131,300)	(128,534)	82,900

OBJECTIVES AND STATUS

The goal of the space automation and telerobotics program is: to develop and demonstrate the technology required for a Flight Telerobotics Servicer (FTS); to develop space telerobotics technology to enhance operational capability and decrease cost of space operations; and to exploit artificial intelligence for control of multiple subsystems with the capability for automated reasoning and recovery from unanticipated failures. The program focuses on advanced teleoperation, robotics and supervisory control (telerobotics) to be applied to potential FTS system evolution. An additional element of the program is a challenging sequence of demonstrations of telerobotics technology applied to processing of launch vehicles, which serve as a focus for research efforts in NASA, university and industry laboratories. Additional demonstrations will validate capabilities to service satellites and assemble space structures.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The changes in telerobotics and artificial intelligence were previously discussed as part of the CSTI FY 1991 budget changes.

BASIS FOR FY 1992 ESTIMATE

In FY 1991, detailed design of the first FTS Development Test Flight (DTF-1) software coding and subsystem testing will be completed. In FY 1992, DTF-1 integration and testing, system environmental testing, and system software testing will be concluded. The DTF-1 Shuttle integration process, including all required documentation and safety reviews, will be completed in FY 1992. The mission date for DTF-1 is still under review at this time. Other FY 1992 activities will include extensive ground-based technology development

* FTS is funded under Space Station Freedom in FY 1990 and FY 1991.
** Funded under Civil Space Technology Initiative in FY 1990 and FY 1991.

and the establishment of a high-fidelity ground-based robotic space system simulation capability. Vigorous review of the additional DTF flight options will be conducted including assessment of the potential for a second DTF experiment which may include technologies to increase autonomous capabilities and ground control of DTF-1.

This technology effort will focus on providing real-time, fault-tolerant control for flight critical systems and on developing, testing and validating increasingly complex autonomous systems, starting with automation of a single critical function and progressing to coordinated control of multiple critical functions. The application of this technology to future exploration, Space Station, Space Shuttle and space science missions will result in higher degrees of onboard autonomy and reduction in manpower required in mission control. This technology will enable increased safety and likelihood of mission success by permitting more intelligent control and warning systems and by permitting the onboard system to dynamically replan around existing failures.

BASIS OF FY 1992 FUNDING REOUIREMENTS

EXPLORATION MISSION STUDIES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Exploration mission studies..............	(15,000)	37,000	7,000	15,000

OBJECTIVES AND STATUS

Exploration mission studies are conceptual studies to develop the preliminary technical, scientific and programmatic data needed to enable future national decisions on the architecture, or approach, that will serve as the basis for implementation of the Space Exploration Initiative (SEI). In essence, these studies provide the data needed to shape and integrate current and future NASA activities against the ultimate goal of building a lunar outpost and undertaking human missions to Mars.

During FY 1990, Outreach and Synthesis activities were initiated to ensure that a very broad range of space exploration alternatives are identified and evaluated. The Outreach activity consisted of three separate efforts: (1) a direct solicitation to reach out to academia, professional associations, NASA employees, and the general public, for innovative ideas, (2) an American Institute for Aeronautics and Astronautics (AIAA) effort which polled the AIAA membership for ideas, and (3) a review of federally sponsored research which might be applicable to the exploration effort. The Outreach efforts were completed in November 1990. To integrate the results of these efforts, a Synthesis Group was formed. The charter of the Synthesis Group is to formulate a set of significantly different exploration architecture options, to assess the enabling technologies required to implement an exploration program, and to identify near-term schedule options. The Synthesis effort will be completed in March of 1991. NASA will incorporate the results of the Synthesis Group into its analysis and other SEI activities utilizing the funds requested for Exploration Mission Studies.

CHANGES FROM THE 1991 BUDGET ESTIMATE

Although funds were authorized in FY 1991 for Exploration Mission Studies, no funds were appropriated. In accordance with the language contained in the October 18, 1990, Conference Report, a subsequent reprogramming request of $7.0 million has been submitted to continue preliminary SEI conceptional design studies.

BASIS OF THE FY 1992 ESTIMATE

In FY 1992, the funds requested for Exploration Mission Studies will enable more in-depth analysis of promising SEI architectures and technologies identified by the Synthesis Group, thereby implementing the President's policy that initial planning for the Space Exploration Initiative would focus on technology development and architecture analysis.

The mission studies will use architectures as a framework for analyses needed to develop systems concepts for space transportation, planetary surface system, and supporting infrastructure; and mission and operations concepts; all of which are needed to develop an integrated set of requirements for ongoing and future activities.

The studies will, as a result, establish requirements which apply to the set of architecture options. These include requirements in such areas as: science options for exploration; human support systems and procedures; advanced technologies; Space Station Freedom support to SEI; Earth-to-orbit heavy lift launch vehicle capabilities; robotic missions to support and complement human exploration; and general infrastructure requirements, such as communication, data acquisition and management, and facilities.

SAFETY RELIABILITY
AND QUALITY
ASSURANCE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY AND MISSION QUALITY | **SAFETY, RELIABILITY AND QUALITY ASSURANCE**

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Safety, reliability, maintainability and quality assurance..................	22,630	28,000	28,000	25,700	RD 15-2
Applied technolo.........................	--	5.000	5.000	7.900	RD 15-2
Total................................	22.630	33.000	33.000	33.600	

Distribution of Proeram Amount bv Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center.....................	1,080	2,150	2,200	2,300
Kennedy Space Center...	796	600	1,350	1,700
Goddard Space Flight Center...............	1,645	2,400	2,750	2,900
Jet Propulsion Laboratory................	3,260	3,650	3,900	3,900
Ames Research Center....................	150	200	300	350
Stennis Space Center...	120	150	400	550
Langley Research Center..	2,380	2,800	1,900	2,800
Marshall Space Flight Center.............	1,321	2,100	1,500	2,100
Headquarters............................	10,503	15,250	15,800	13,200
Lewis Research Center..	1.375	3.700	2.900	3.800
Total................................	22.630	33.000	33.000	33.600

OFFICE OF SAFETY AND MISSION QUALITY — **SAFETY, RELIABILITY AND QUALITY ASSURANCE**

OBJECTIVES AND JUSTIFICATION

The Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) program continues to actively support NASA agency-wide goals. This is achieved by the implementation of procedures that reduce program risk, and add to safety, reliability, quality assurance, maintainability, systems assessment, establishment of technical standards, and program assurance (including independent assessment and trend analysis activities). Specific program activities are:

- Develop and implement top-level NASA safety policies, and define program-specific safety requirements.
- Develop independent mission safety evaluation for each mission, and an independent capability to perform technical assessments to support the SRM&QA decision process.
- Provide technical guidance and support to NASA programs, including Shuttle readiness reviews and launch operations.
- Support a risk management program that provides management visibility into problems and technical risks, and provides analyses and corrective actions.
- Conduct independent quantitative risk assessments and perform hazard analyses.
- Assure development and maintenance of systems to communicate problems and provide tools which analyze trends and predict and prevent serious problems.
- Review and evaluate NASA and contractor SRM&QA activities to verify conformance with established policies and procedures.
- Upgrade existing software standards, guidebooks, and training; and identify software management product assurance and automated work stations.

- Support industrial, aviation, fire protection, and ground operations safety activities.

- Foster a Total Quality Management (TQM) philosophy throughout NASA and its contractors and suppliers.

Substantial effort is currently being devoted to ensuring that appropriate safety and reliability requirements are integrated into the earliest phases of future manned and unmanned space flight systems, as well as the aeronautics programs. Support on a NASA-wide/industry basis continues in the areas of integrated circuit product assurance, materials treatments and processes, microcircuit radiation effects evaluation, and aerospace and system safety-related matters.

The SRM&QA has initiated a certification program for mechanical parts. Efforts include a subtier supplier control system and a process which will identify the relationship between out-of-tolerance conditions and loss-of-strength, optimize parts reliability, and reduce risk. Testing of ionizing radiation and investigation of solder fatigue related to long-term space programs is also planned.

Software complexity is being addressed in depth. Recent NASA missions have required larger, more complex critical software than those of the past. A comprehensive software management and assurance program which addresses NASA's critical software intensive systems has been developed. Methods, procedures, and tools to evaluate software assurance within the software process will be continued to keep pace with advanced systems.

A review of the Space Transportation System (STS) Advanced Solid Rocket Motor (ASRM) is being conducted. Formal technical assessments are forwarded to program management in support of their decision-making process.

Methods and procedures to identify and analyze risk associated with the Space Station Freedom (SSF) program are currently being addressed. On-orbit meterology and calibration capability for the SSF is being developed. Key activities include the review of design/development issues, e.g., on-orbit fire safety, structural vibration, fabrication timeliness, on-orbit maintenance and repair, thermal control, and design of electrical power systems.

A formal "Lessons Learned" program is in work to assure that all technical and operational lessons and ensuing knowledge will be captured and recorded in appropriate documentation.

The Office of Safety and Mission Quality is extensively and aggressively involved across all levels of NASA programs. Emphasis continues to be placed on providing leadership to all operational, programmatic, and institutional activities of the agency.

BASIS OF FY 1992 ESTIMATE

The SRM&QA program provides leadership to all operational, programmatic, and institutional activities of the Agency in areas of its responsibility. The integration and ensured compliance of firmly defined policies and procedures for SRM&QA throughout the Agency is the key ingredient of this leadership. The capability to perform independent "second look" assessments of major technical issues and decisions requires further enhancement, and the information systems essential to support the SRM&QA decision-making process need improvement.

FY 1992 funding supports a new technical standards program, which will provide a central focus for those technical disciplines necessary to produce safe and reliable hardware required to achieve NASA objectives. Fracture control technologies and safe life analyses to assure long-term in-space durability of payloads, spacecraft, and human habitat will be improved. Enhanced testing and qualification methods for qualification techniques for electrical and electronic components and assemblies and other end-items will be developed. The FY 1992 budget includes the planned conversion of contractor FTE's to civil service in support of this effort.

ACADEMIC
PROGRAMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Educational affairs....................	16,497	23,300	25,800	27,600	RD 16-2
Minority university research.............	14,204	16,800	17,200	22,000	RD 16-10
Space grant college and fellowship.......	6,797	10,000	12,100	15,000	RD 16-16
Total................................	37,498	50,100	55,100	64,600	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

AC EDUCATIONAL AFFAIRS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Graduate student researchers.............	6,500	6,900	6,900	7,000	RD 16-4
Summer faculty fellowships...............	3,631	3,800	3,800	4,000	RD 16-5
Innovative research.....................	2,390	2,700	2,700	2,900	RD 16-6
Space applications......................	3,976	2,800	2,800	2,800	RD 16-7
*Aerospace education services (AESP).....	(2,613)	3,905	6,000	6,100	RD 16-8
*Innovative education..................	(1,426)	3,195	3,600	4,800	RD 16-8
Total................................	16,497	23,300	25,800	27,600	

* FY 1990 funding is included in the Research and Program Management (R&PM) account.

Distribution of Program Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Ames Research Center.....................	873	1,053	1,153	1,183
Goddard Space Flight Center..............	905	982	1,082	1,112
Jet Propulsion Laboratory................	866	937	1,043	1,073
Johnson Space Center....................	879	964	1,187	1,217
Kennedy Space Center....	285	465	796	826
Langley Research Center...	998	1,125	1,230	1,260
Lewis Research Center...	874	958	1,183	1,213
Marshall Space Flight Center.............	1,005	960	1,195	1,225
Stennis Space Center...	325	539	716	746
Headquarters...........................	9,487	15,317	16,215	17,745
Total................................	16,497	23,300	25,800	27,600

OBJECTIVES AND JUSTIFICATION

The NASA Education Affairs goal is to conduct aerospace educational programs and activities to inspire and support, in elementary through graduate school, students to prepare themselves for careers in science, engineering, and technology. This goal is accomplished through a strategy containing three elements: (1) capture student interest in science, mathematics, and technology at an early age; (2) channel more students into science, engineering, and technology career paths; and (3) enhance the knowledge, skills, and experiences of pre-college teachers, college and university faculty.

The specific objectives of the Educational Affairs program are:

- To involve the pre-college educational community, students, teachers, and administrators in better understanding the knowledge derived from NASA research and development and its application to the study of mathematics, science and technology;

- To encourage elementary level students to take greater interest in mathematics, science, and technology through the use of advanced instructional technology, development of strong teacher resource centers, curriculum materials designed for the elementary level, and the initiation of cooperative relationships with private industry, local school systems, and community organizations;

- To significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications and space technology to meet the continuing needs of the national aerospace effort;

- To facilitate the direct interaction, further the professional knowledge and stimulate the exchange of ideas between university faculty members and NASA scientists and engineers;

- To support innovative research at U.S. institutions of higher learning that is in the formative or embryonic stage and that would appear to have significant potential to advance space science and applications programs; and,

- To provide for the development and use of a core, long-term U.S. national university capability to conduct multiyear, Earth science discipline-oriented applied research and remote sensing.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The total increase of $2.5 million in FY 1991 is additional funding appropriated to expand NASA's Aerospace Education Services outreach programs to communities with high minority representation by hiring additional specialists, equipment, and vans, and the initiation of an outreach educational program to community colleges.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers.......	6,500	6,900	6,900	7,000

OBJECTIVES AND STATUS

The Graduate Student Researchers program, initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research at a NASA Center or to carry out a program of study or research at their home institution. From 1980-1984, approximately 40 new awards were made each year. In 1985, NASA doubled the size of the program to make 80 new awards each year. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately 275 graduate students pursuing the masters or doctorate degrees.

BASIS OF FY 1992 ESTIMATE

The FY 1992 request will allow for the continuation of the current program including the continuation of the Graduate Student Researchers program at the Kennedy Space Center initiated in FY 1991, as well as continuing to increase the number of annual awards available yearly at each NASA center.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Summer faculty fellowships..............	3,631	3,800	3,800	4,000

OBJECTIVES AND STATUS

The NASA Summer Faculty Fellowship program has completed 27 years of operation. This program provides highly beneficial opportunities for engineering and science faculty throughout the United States by allowing participation in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefited NASA, universities, faculty, students, and the Nation.

The Summer Faculty Fellowship program enables university faculty to spend ten weeks working directly with scientists and engineers at NASA Centers on problems of mutual interest. Participants must have a minimum of two years teaching experience and must be citizens of the United States. The program is designed to further the professional knowledge of faculty members, to stimulate an exchange of ideas between participants and NASA, and to enrich the research and teaching activities of the participants' home institutions. This activity is operated cooperatively with the American Society for Engineering Education (ASEE).

Approximately 200-250 university faculty are supported annually for ten weeks. Evaluations conducted by ASEE of the program indicate that approximately 30-40 percent of the participating faculty subsequently receive NASA research grants or contracts.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding level supports program continuation at current activity levels.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Innovative research......................	2,390	2,700	2,700	2,900

STATUS

Over the past decade, it has become increasingly apparent that a key to the future health and well-being of the space science and applications program lies in having the capacity to explore new ideas or novel technical approaches to research. In response to this need, the Innovative Research program was established within the Office of Space Science and Applications to support research which, while still in its formative stage, has already demonstrated potential for significant advances for Space Science and Applications programs. The program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their inter-disciplinary nature or because they are in some sense, speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within particular science discipline resources.

The Innovative Research program was initiated in 1980. Announcements of the availability of funds and NASA's interest in receiving proposals for this type of research have been issued in 1980, 1982, 1985, and 1988. The next announcement is planned for 1991. Emphasis in the program is on the support of innovative research at universities and colleges. The program also emphasizes support to new researchers who have only recently completed graduate training. The primary criterion for inclusion in the program has been originality and the promise for innovation of the work being proposed. Over the past several years, a number of major technical advances have resulted from research supported by this program, such as the development of new infrared detector technology using nonstandard scientific approaches.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding will provide for continuation of the current program and allow a few additional awards to be initiated.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space applications......................	3,976	2,800	2,800	2,800

OBJECTIVES AND STATUS

The objectives of the Space Applications program are to provide, through university grants, for the development and use of a core U.S. national university capability to conduct multiyear, discipline oriented basic and applied research in space applications; and to establish and maintain multidisciplinary remote sensing techniques and the use of those techniques in furthering the understanding of Earth sciences. This program has been the major impetus for the development of a geographically distributed network of universities which now comprise the prime source of research and the development of techniques designed to use remote sensing data in the study of global Earth science processes and Earth resources management.

BASIS OF FY 1992 ESTIMATE

This program has achieved considerable success in developing a community of researchers knowledgeable in remote sensing science and in contributing toward the overall evolving maturity of spaceborne remote sensing. In FY 1992, the Space Applications program will focus on working with the university community to prepare for the space-based remote sensing of the Earth in the Space Station era. In this time frame, the Earth Observing System (EOS) will be a key tool for moving both the fundamental and applied aspects of Earth system science forward. The EOS is a complex set of instruments with which the university community must become more familiar if this nation is to maintain its leadership position in Space Applications. In addition, key research thrusts, such as Global Change, must include university researchers as well. University involvement in the space based aspects of this program will provide the training and long-range research core which will be able to exploit data collected on decadal time scales.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Aerospace education services (AESP)......	(2,613)	3,905	6,000	6,100

OBJECTIVES AND STATUS

The Aerospace Education Services Program (AESP), previously known as Spacemobile, is a vital outreach program. The AESP specialists, all former teachers themselves, stimulate millions of students and teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics and technology. From September to June each year AESP specialists visit schools throughout the United States, conducting student assemblies and teacher workshops. During the summer, AESP specialists conduct teacher workshops at the NASA Centers and various colleges and universities. Funding for this program was transferred in FY 1991 from the Research and Program Management appropriation in order to consolidate funding for the Educational Affairs program.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $2.1 million reflects Congressional direction. The additional funding will allow for the hiring of additional education specialists, to continue upgrading of the vans and provide for additional equipment.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding will allow for continuation of the current program with increased funding targeted toward adding additional specialists and upgrading aerospace models and vans.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Innovative education....................	(1,426)	3,195	3,600	4,800

OBJECTIVES AND STATUS

The Innovative Education program includes a series of programs targeted pre-college teachers and students. The goal is to enhance and improve the teaching of science, mathematics and technology at the elementary and secondary level by using aeronautics and space as a theme and motivational factor. Programs included are: NASA Education Workshops for Math and Science Teachers (NEWMAST), NASA Education Workshops for Elementary School Teachers (NEWEST), the Space Science Student Involvement Program (SSIP), Space Exposed Experiment Developed for Students (SEEDS), Teacher Resource Centers, and the Summer High School Apprentice Program (SHARP). Funding for this program was transferred from the Research and Program Management appropriation in order to consolidate the Educational Affairs program in FY 1991.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $405 thousand reflects implementation of Congressional appropriation action. This increase will establish an educational outreach program to community colleges.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding will allow for continuation of the current program with increases in the level of activity targeted toward underrepresented minority students through the SHARP activity, expansion of the Regional Teacher Resource Centers across the nation, establishment of a pilot program with community colleges to ensure the continuation of quality technicians for the aerospace effort, and for development of curriculum materials for use in the classroom.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Historically black colleges and universities.....................	10,004	9,100	9,100	11,000	RD 16-12
Other minority universities..............	2,000	4,000	4,400	4,700	RD 16-13
Graduate student researchers program (underrepresented minority focus)......	2,200	2,200	2,200	3,300	RD 16-14
Undergraduate student researchers program (underrepresented minority focus).......	--	1,500	1,500	3,000	RD 16-15
Total................................	14,204	16,800	17,200	22,000	

Distribution of Proeram Amount bv Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center....................	616	786	802	872
Kennedy Space Center....................	245	472	593	612
Goddard Space Flight Center...............	737	850	1,413	905
Jet Propulsion Laboratory...............	--	--	--	500
Ames Research Center.....................	492	259	742	789
Stennis Space Center....................	184	292	275	324
Langley Research Center..................	3,848	2,770	2,742	1,840
Marshall Space Flight Center.............	1,265	632	1,459	1,230
Headquarters............................	6,703	10,593	8,594	14,480
Lewis Research Center...................	114	146	580	448
Total................................	14,204	16,800	17,200	22,000

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

The goal of the NASA Minority University Research and Education program is to improve and expand the research capability of selected Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), and to encourage the development of a resource pool of talent through a strong research focus and alliances between HBCUs, other minority universities, majority research universities, industry, and other Federal research and development agencies. One of the objectives of the President's goal in math and science education is to increase the number of women and minority graduate and undergraduate students receiving degrees in math science and engineering. NASA endeavors to achieve this goal through the aggressive implementation of the initiative for HBCUs; by developing closer relationships with minority universities other than HBCUs; and by continuing the Graduate Student Researchers program (Underrepresented Minority Focus); and the Undergraduate Researchers program (Underrepresented Minority Focus) established in FY 1991.

NASA's HBCU initiative is mandated by Executive Order 12677, which requires Federal agencies to increase significantly the involvement of HBCUs in Federally sponsored programs. Congress also mandated NASA, in FY 1985, to build closer relationships with other universities that educate large numbers of minority students who are underrepresented in science and engineering. Additionally, NASA is being responsive to the Executive Order on Educational Excellence for Hispanic Americans, signed on September 24, 1990, which directs Federal Agencies to be actively involved in helping advance educational opportunities for Hispanic Americans. NASA has implemented those initiatives through research and training grants sponsored through the Minority University Program in the Office of Equal Opportunity Program. Beginning in FY 1992, the NASA Institutional Program Offices will become more directly involved and responsible for the selection, funding and conduct of minority university research. The program offices will work collaboratively with the Office of Equal Opportunity Programs to determine how those minority institutions and principal investigators will ultimately compete successfully in NASA's mainstream research processes. This new process will also facilitate NASA's efforts to comply with the Congressional mandate that 8 percent of NASA's total procurements go to small and minority businesses including HBCUs and minority universities.

To encourage the development of talent at the undergraduate and graduate level, NASA will continue the Undergraduate and Graduate Student Researchers Programs (underrepresented minority focus). The Undergraduate Student Researchers program (USRP/UMF) was introduced in FY 1991 based on the recommendations of NASA principal investigators. The concept also is consonant with the recommendations of the National Task Force on Women, Minorities, and the Handicapped in Science and Technology, which urged the establishment of a variety of scholarships, fellowships, hands-on research experience and other support to capture and develop these groups. It has become increasingly apparent that many promising minority high school graduates with excellent grade point averages and SAT scores enter college, but do not elect science and engineering fields. Further, many of the minority science and engineering students who succeed at the undergraduate level and who have the ability to do graduate level research, never consider research as a career option. Through the Graduate Student Researchers Program (underrepresented minority focus), NASA principal investigators involve minority students pursuing master's and Ph.D. degrees in areas of interest to NASA in NASA-sponsored research projects. The objective of both these programs is to build a pipeline of talented underrepresented minority students and ensure increased numbers for graduate studies.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Historically black colleges and universities......................	10,004	9,100	9,100	11,000

OBJECTIVES AND STATUS

The objectives of the HBCU program are to continue to increase and strengthen their research infrastructure, curricula and faculty capabilities; help develop a cadre of minority undergraduate and graduate science and engineering researchers at the HBCUs; and involve private sector institutions in the NASA/HBCU initiatives. Beginning in FY 1992, the long-term goal is for the NASA program offices and field centers to assume full managerial and funding responsibility for HBCU research initiatives, and ensure growing participation in NASA's mainstream research processes.

In FY 1991, NASA competitively selected eight HBCU Research Centers. With each Research Center being eligible for grants of $1-2 million, NASA will be enabling more institutional and infrastructure development among the selected HBCUs than would have been the case by only funding individual principal investigators. The primary goal of the Research Centers remains as it was for the Centers of Excellence; i.e., to commit substantial long-term resources (at least 5 years with expectations that relationships will extend 10 to 15 years) to upgrade the science and engineering infrastructure and curricula of a few of the most productive HBCUs; to enhance the number and quality of faculty (both teaching and research); to increase the number of minority students and faculty working on NASA's science and engineering activities; and to help these universities become renowned as major research producers. In FY 1992, NASA will continue the strategy and the process of fully establishing and funding the eight selected Research Centers.

BASIS OF FY 1992 ESTIMATE

It is projected that about one-third of the budget will be used for training grants; the other two-thirds will be available to the program offices and NASA field centers, and will be augmented by them, to help support HBCU research projects of their choice as well as continue funding for the eight HBCU Research Centers selected in FY 1991. A comprehensive annual evaluation will be conducted, and the results will be utilized for program modifications for subsequent funding periods or for decisions concerning further expansion.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Other minority universities...............	2,000	4,000	4,400	4,700

OBJECTIVES AND STATUS

NASA successfully established the OMU program in FY 1990 by developing and/or expanding its relationships with a limited number of universities with significant populations of minorities who are traditionally underrepresented in science and engineering. In FY 1991, NASA expanded the number of relationships with these institutions. These universities have been selected based on a combination of factors, such as science and engineering curricula and accreditation, research capabilities, and significant numbers of minority students and faculty underrepresented in science and engineering. A top priority continues to be the development of programmatic initiatives comparable to those for the HBCUs. The community of OMUs is becoming more identifiable. For example, there now exists a Hispanic Association of Colleges and Universities (HACUs) that number about 117; there are at least 20 OMUs with substantial American Indian student enrollments; and 7 OMUs that cater to students with disabilities. In expanding NASA's OMU efforts, care has been taken in selecting those institutions that have accredited programs in science and engineering, particularly those with graduate programs, and that have demonstrated the capability to effectively retain and graduate students underrepresented in science and engineering.

CHANGES FROM FY 1991 ESTIMATE

The increase of $400 thousand reflects additional funding appropriated for additional educational outreach programs at the pre-college levels and for teacher training programs.

BASIS FOR FY 1992 ESTIMATE

In FY 1992, funding will continue the current program. In previous years, some educational research and training grants were funded by the Research and Program Management appropriation. Funding for all educational research and training grants will be consolidated in Research and Development beginning in FY 1992.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers program (Underrepresented minority focus).......	2,200	2,200	2,200	3,300

OBJECTIVES AND STATUS

The objectives of this program are to enhance the development of underrepresented minority talent in an effective way so as to utilize the potential of this nation's diverse citizenry; and to increase the size of the resource pool of research skills that will be needed to meet aerospace and other technological objectives of the future. Principal investigators who have NASA research grants and a need for further student involvement will be encouraged to seek out talented underrepresented minority students and involve them in their NASA research projects. The underrepresented minorities who are the special focus of this program include Blacks, Hispanics, American Indians and Pacific Islanders. They must be enrolled in masters or doctoral programs in engineering, physics, mathematics, computer science, biology, or other disciplines of interest to NASA in aeronautics, space and life sciences. Data shows that almost 60 percent of the GSRP(UMF) students are in Ph.D. programs, and that Blacks and Hispanics make up about 90 percent of the program population. This is particularly encouraging since recent national scientific manpower data show Blacks and Hispanics making the least educational advancement of all target groups in science and engineering.

In FY 1990, the fourth year of the program, an additional 38 underrepresented minority students were selected for a total of 113 participants in the program. This total included 52 Blacks, 49 Hispanics, 4 American Indians and 8 Pacific Islanders.

BASIS OF FY 1992 ESTIMATE

Funding in FY 1992 will support an additional 45-50 students in this program. This increase is attributable to the tremendous growth in interest and competitiveness in the program.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Undergraduate student researchers program (Underrepresented minority focus)......	--	1,500	1,500	3,000

OBJECTIVES AND STATUS

This new program, begun in FY 1991, identified 80 high ability freshman level underrepresented minority students majoring in science and/or engineering and awarded them portable scholarships to selected universities with proven records of recruiting, retaining and graduating minority science and engineering students. With a projected success rate of at least 62 percent, this effort will grow to a level where at the fourth year, NASA expects to have about 200 students in the program. The pipeline of undergraduate minority students majoring in the physical and life sciences and engineering coming from this program impact substantially and positively NASA's freshout hiring needs, but even more important, these students are being targeted for advanced studies and research careers that will ultimately get them to the terminal degree levels. The USRP(UMF) may serve as a feeder to the Graduate Student Researchers Program (underrepresented Minority Focus). Identified students receive tuition support; are monitored, tutored and nurtured. By their junior year, they will be a part of NASA's Co-op program or become research assistants working with principals investigators at their universities on NASA sponsored research, or working at a NASA installation. The primary objective is to encourage talented underrepresented minorities to choose, as a career option, graduate level studies in science and engineering.

BASIS OF FY 1992 ESTIMATE

The funding level of the USRP(UMF) will approximate the funding level of the GSRP(UMF). Since the undergraduate component will serve as a feeder to the graduate component, the proposed budget structure for the undergraduate component represents a natural progression. NASA's goal is to have a continuous flow of minority undergraduate and graduate level students in science and engineering educational programs.

ACADEMIC PROGRAMS

NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIPS

SUMMAR OF RESOURCES REOUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space grant college and fellowship.......	6,797	10,000	12,100	15,000
Distribution of Proeram Amount by Installation				
Headquarters............................	6.797	10.000	12.100	15.000
Total................................	6,797	10,000	12.100	15.000

ACADEMIC PROGRAMS | **NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIPS**

OBJECTIVES AND JUSTIFICATION

As enacted in the NASA FY 1988 Authorization Act (P.L. 100-47), the National Space Grant College and Fellowship program is designed to broaden the base and enhance the capabilities of the university network capable of contributing, through research, education and public service, to the increased utilization of space and its resources.

The objectives of the program are to:

(1) Increase the understanding, assessment, development, and utilization of space resources by promoting a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques;

(2) Utilize the abilities and talents of the universities of the Nation to support and contribute to the exploration and development of the resources and opportunities afforded by the space environment;

(3) Encourage and support the existence of interdisciplinary and multidisciplinary programs of space research within the university community of the Nation, to engage in integrated activities of training, research and public service, to have cooperative programs with industry, and to be coordinated with the overall program of the National Aeronautics and Space Administration;

(4) Encourage and support the existence of consortia, made up of university and industry members, to advance the exploration and development of space resources in cases in which national objectives can be better fulfilled than through the program of single universities;

(5) Encourage and support Federal funding for graduate fellowships in fields related to space; and

(6) Support activities in colleges and universities generally for the purpose of creating and operating a network of institutional programs that will enhance achievements resulting from efforts under this title.

OBJECTIVES AND STATUS

The Space Grant College and Fellowship program is composed of three principal and interrelated elements: Designated Space Grant Colleges/Consortia; Space Grant Program Consortia; and Space Grant Capability Enhancement Consortia. Designated Space Grant Colleges/Consortia, of which 21 were selected in 1989 and 1990, are preeminent institutions which are substantially involved in a broad spectrum of NASA research, offer advanced study in aerospace fields, and are significantly involved in related public service. Designated Colleges/Consortia each received $75,000 in start-up funds in FY 1989 and from $250,000-$325,000 in FY 1990 and 1991, depending on consortium affiliations. In FY 1991, a new competition took place; consortia within states not represented by Designated Colleges/Consortia were invited to apply either for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs relate to current involvement in aerospace fields). At this time, 29 proposals have been received. The proposals are under review and selections will be announced in early 1991. It is expected that about 65 percent of the proposals will be funded, representing a substantial broadening of program representation. As with Designated Colleges/Consortia, program grantees and Capability Enhancement grantees will receive a substantial percentage of their grants in funds designated for fellowships.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $2.1 million reflects implementation of Congressional Appropriation direction. The increase will allow full funding of Phase II successful candidates including those which are specifically designed to focus on building aerospace capabilities in states identified in the National Science Foundation's Experimental program to Stimulate Competitive Research (EPSCOR).

BASIS OF FY 1992 ESTIMATE

In FY 1992, NASA must meet its continuing obligations to fund the original 21 consortia and to fully fund Phase II grantees, to be selected in 1991. We estimate making 16-20 selections of new State Space Grant Consortia, to be added to the original 21. Also, funds are needed to perform critical program evaluation which includes site visits to Space Grant College campuses and to convene the legislatively-mandated Space Grant Review Panel.

TRACKING AND DATA
ADVANCED SYSTEMS

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE OPERATIONS

!CRACKING AND DATA ADVANCED SYSTEMS

SUMMARY OF RESOURCES REOUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced systems........................	19,328	20,000	20,000	22,000	RD 17-2
Distribution of Proeram Amount bv Installation					
Goddard Space Flight Center..............	5,750	5,700	5,750	6,100	
Jet Propulsion Laboratory................	13,255	13,960	13,900	15,500	
Headquarters............................	323	340	350	400	
Total................................	19,328	20,000	20,000	22,000	

BASIS OF FY 1991 FUNDING REQUIREMENTS

ADVANCED SYSTEMS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced systems........................	19,328	20,000	20,000	22,000

OBJECTIVES AND STATUS

The objective of the Advanced Systems program is to achieve improved performance and reliability in the areas of tracking and data acquisition for future space missions. This program is a small but vital part of the overall program of the Office of Space Operations.

The program includes the study, evaluation, and development of new techniques and technologies in telecommunications, microelectronics, and computer sciences, for application to space operations. The work is carried to a stage where feasibility is firmly established and further development can be carried out under system implementation. Such effort is essential for the cost-effective introduction of new technology into the Space Network and the Deep Space Network, and for planning the future mission support capabilities. Primary effort in the current Advanced Systems program is in areas of data transfer, data processing, communications, orbit and position determination, and expert systems for mission operations.

BASIS FOR FY 1992 ESTIMATE

FY 1992 activities will include work on tracking techniques to determine the in-orbit position of a spacecraft with an accuracy of a few centimeters. Work will also focus on the development of very precise radiometric techniques which determine the angular direction of planetary mission spacecraft to an accuracy of five nano-radians. These improvements in spacecraft navigation will enable new highly accurate science experiments to be conducted. Work will also continue on ground based navigation strategies, analyses and demonstrations for Galileo, Ulysses, and Mars Observer.

Another area of activity will be the ground to spacecraft communications system, including the development of transmitters, receivers, and other components at Ka-band, operation of large antennas at millimeter frequencies, multifrequency feeds and reflectors, and a K-band terminal for a TDRSS user spacecraft. Optical communications will also be investigated for cost-performance advantages over microwave frequencies and for potential space data relay applications.

New techniques and technologies will be studied for the storage, processing and transmission of data at higher rates and in larger volumes, as required for high-resolution sensors and other instruments on future missions. This will include techniques for signal coding and decoding, communications network optimization, man-machine interfaces, and automatic processing and distribution of data.

Studies to develop more efficient mission operations control centers, and to provide real-time interaction between ground-based investigators and their spaceborne experiments will also be part of the program. Related work includes expert systems and artificial intelligence for mission scheduling and operations, possible use of distributed command centers, and onboard computation of spacecraft orbit and attitude parameters.

SPACE FLIGHT
CONTROL AND DATA
COMMUNICATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1992 ESTIMATES

GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of Space Flight, Control and Data Communications is to provide for the operational activities of the Space Transportation System and tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY: A program to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, spares inventory, production tooling, and related supporting activities. Included is the development of an Advanced Solid Rocket Motor (ASRM) to improve performance.

SPACE TRANSPORTATION OPERATIONS: A program to provide the standard operational support services for the Space Shuttle and the procurement of expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS: A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects using ground-based and satellite (Tracking and Data Relay Satellite System) components.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1991 ESTIMATES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Millions of Dollars)			
Shuttle production and operational capability	1194.9	1302.0	1276.4	1288.9
Space transportation operations	2632.4	3118.6	3019.2	3365.5
Space and ground networks, communication and data systems	797.5	868.8	828.8	953.9
Total	4624.9	5289.4	5124.4	5608.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

For necessary expenses, not otherwise provided for, in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenana, repair, rehabilitation and modification of real and personal property; track-ing and data relay satellite services as authorized by law; purchase, hire, maintenana and operation of other than administrative air-craft; [$6,334,132,000] $5,608,272,796, to remain available until Sep-tember 30, [1992] 1993, of which [$1,209,732,000] $32,672,796 shall be used only for the purpose of payment, to the Federal Financing Bank, for the Tracking and Data Relay Satellite System (TDRSS) loan: Provided, That such payment shall constitute stetlement of all amounts owed on said loan: Provided further, That of the amounts provided herein for [development and production of the Advanced Solid Rocket Motor (ASRM), $15,000,000 shall be available without fiscal year limitation for the competitive award of a contract to develop either (1) a second domestic source for the development and production of the ASRM carbon/carbon integral throat entrance (ITE) or (2) a second domestic source for the production of the ASRM carbon/carbon ITE unless the Administrator of NASA certifies to the Congress by February 1,1991, that such application of funds is not in the best interst of the United States space program on the basis of cost, added assurance of reliable stupply, expanded technology base, and technical risk reduction] Space Shuttle operations, $50,000,000 shall not become available for obligation until September 1, 1992. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act of 1991; additional authorizing legislation to be Proposed.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

REIMBURSABLE SUMMARY
(In thousands of dollars)

	Budget Plan FY 1990	FY 1991	FY 1992
Shuttle production and capability development	81,449	31,379	16,100
Space transportation operations	88	32,900	106,600
Expendable launch vehicles	64,554	95,118	104,441
Tracking and data acquisition	43,173	67,050	69,300
Total	189,264	226,447	296,441

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1992 ESTIMATES
DISTRUBTION OF SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Transportation Sys	1990	3,827,349	1,129,200	857,300	1,628,300	26,900	80,700	3,900	6,400	3.800	55,600	35,249
	1991	4,295,600	1,188,200	939,600	1,868,800	25,100	109,700	1,800	5,800	0	116,600	40,000
	1992	4,654,400	1,323,900	1,022,600	1,845,700	33.000	109,500	0	6,400	0	223,000	90,300
Shuttle Production	1990	1,194,949	373,600	135,700	637,400	24,500	100	3.900	---	300	3,500	15,949
	1991	1,276,400	379,200	143,000	710,200	22,600	---	1.800	---	---	4,000	15,600
	1992	1,288,900	427,100	107,500	679,300	30,600	---	---	---	---	---	44,400
Space Transporation Ops	1990	2,632,400	755,600	721,600	990,900	2,400	80,600	---	6,400	3,500	52,100	19,300
	1991	3,019,200	809,000	796,600	1,158,600	2,500	109,700	---	5,800	---	112,600	24,400
	1992	3,365,500	896,800	915,100	1,166,400	2,400	109,500	---	6,400	---	223,000	45,900
Tracking And Data Acqui	1990	797,478	---	---	48,838	---	551,936	150,066	12,300	---	800	33,538
	1991	828,800	---	---	55,300	---	568,700	148,400	13,000	---	1,100	42,300
	1992	953,873	---	---	66,000	---	614,900	180,800	14,500	---	1,400	76,273
TOTAL BUDGET PUN	1990	4,624,827	1,129,200	857,300	1,677,138	26,900	632,636	153,966	18.700	3,800	56,400	68,787
	1991	5,124,400	1,188,200	939,600	1,924,100	25,100	678,400	150,200	18,800	0	117,700	82,300
	1992	5,608,273	1,323,900	1,022,600	1,911,700	33.000	724.400	180,800	20,900	0	224,400	166,573

SPACE
TRANSPORTATION
SYSTEMS

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — SPACE TRANSPORTATION SYSTEMS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Shuttle production and operations capability	1,194,949	1,302,000	1,276,400	1,288,900	SF 1-1
Space transportation operations	2,632,400	3,118,600	3,019,200	3,365,500	SF 2-1
Total	3,827,349	4,420,600	4,295,600	4,654,400	
Distribution of Program Amounts by Installation					
Johnson Space Center	1,129,200	1,134,600	1,188,200	1,323,900	
Kennedy Space Center	857,300	954,200	939,600	1,022,600	
Marshall Space Flight Center	1,628,300	2,018,900	1,868,800	1,845,700	
Stennis Space Center	26,900	24,400	25,100	33,000	
Goddard Space Flight Center	80,700	103,000	109,700	109,500	
Jet Propulsion Laboratory	3,900	2,900	1,800	--	
Langley Research Center	3,800	9,700	--	--	
Lewis Research Center	55,600	114,300	116,600	223,000	
Ames Research Center	6,400	6,100	5,800	6,400	
Headquarters	35,249	52,500	40,000	90,300	
Total	3,827,349	4,420,600	4,295,600	4,654,400	

OFFICE OF SPACE FLIGHT | SPACE TRANSPORTATION SYSTEMS PROGRAM

OBJECTIVES AND JUSTIFICATION

The primary program objective of the current activity in this area is to continue the buildup in launch activity and maintain the program focus on safety and mission success demonstrated since returning the Shuttle to flight. Space Transportation Systems includes development of capabilities and actual operation of the Space Shuttle and procurement of Expendable Launch Vehicles (ELV) in support of a wide variety of national and international users. The Space Shuttle is the key element because of its unique capabilities. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft scientific experiments, and national security payloads. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities that cannot be achieved with ELVs such as: retrieving payloads from orbit for reuse; servicing and repairing satellites in space; transporting humans to and returning them safely from space; operating and returning space laboratories. On the other hand, the ELVs offer different advantages for launching many spacecraft including reduced operational complexity, scheduling factors, and reducing pressures on the more precious manned launch system.

The Space Transportation System is funded under three budget line items: Shuttle Production and Operational Capability, Shuttle Operations, and Expendable Launch Vehicles. Shuttle Production and Operational Capability provides for investment in capabilities to effectively operate the national fleet of Shuttle orbiters, including the replacement orbiter which was fully funded in FY 1987. This budget element also provides for continued modification and improvement to the flight elements and ground facilities necessary to expand the Shuttle capabilities, increase the flight rate, and expand safety and operating margins. This line item contains the following major subdivisions: Orbiter Operational Capability, Propulsion, Launch and Mission Support, and Assured Shuttle Availability (ASA). Orbiter Operational Capability includes orbiter design modifications and system improvements, mission kits, procurement of a spares inventory for the operational orbiter fleet, necessary safety modifications, a structural spares project to maintain the capability to produce and repair orbiter vehicles, and continuation of work started in FY 1988 on an Extended Duration Orbiter capability (EDO). Propulsion Systems provides for continued development effort to expand safety margins in the Space Shuttle Main Engines and Solid Rocket Boosters. Also included is the development of an Advanced Solid Rocket Motor (ASRM). Launch and Mission Support provides for support capabilities at the Johnson Space Center (JSC) and launch site equipment provisioning for the ground facilities at the Kennedy Space Center (KSC). Assured Shuttle Availability provides the necessary investments required to extend the useful life of the Shuttle system into the next century by addressing the redesign requirements for systems which face obsolescence or will become increasingly difficult to maintain.

Space Transportation Operations provides the standard operational support services for Space Shuttle Operations and Expendable Launch Vehicles for NASA payload requirements. Within Shuttle Operations, funding is provided in three areas: flight operations, flight hardware, and launch and landing operations. Flight operations covers the manpower required, primarily at JSC, to conduct mission operations; flight hardware provides the necessary flight sets of external tanks, solid rocket motors, solid rocket boosters, and orbiter hardware support elements consistent with the manifest and Shuttle flight rate; and launch and landing operations covers the manpower and recurring activities, primarily at KSC, to checkout, modify, and conduct Shuttle launches and landings. The Shuttle Operations program provides for the launch of NASA missions, as well as missions for Department of Defense (DOD), other U.S. government agencies and certain commercial and international users on a reimbursable basis. The launch schedule calls for eight flights in FY 1991, nine flights in FY 1992, nine flights in FY 1993, and a revised steady-state flight rate of ten flights per year beginning in FY 1994. The Shuttle steady-state flight rate has been reduced from 12 per year to 10 per year consistent with the mixed fleet policy.

The Expendable Launch Vehicle program provides launch services for unmanned civil U.S. government spacecraft that do not require manned presence or the unique capabilities of the Shuttle. Initially, expendable launch vehicle services were procured sole source for a few selected near term and high-priority missions previously manifested on the Space Shuttle. The use of expendable launch services has expanded as NASA transitions to a balanced mixed fleet capability. Consistent with the President's Space Policy, Congressional direction, and the Competition in Contracting Act, expendable launch vehicle services are acquired competitively from the U.S. private sector whenever possible, and will generally be baselined for new spacecraft programs unless the unique capabilities of the Shuttle are required.

PRODUCTION AND OPERATIONAL CAPABILITY

BASIS OF FY 1992 FUNDING REQUIREMENTS

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Orbiter operational capability...........	238,100	213,600	275,600	273,800	SF 1-3
Propulsion systems......................	673,800	822,900	747,800	622,700	SF 1-5
Launch and mission support...............	283,049	265,500	253,000	270,100	SF 1-8
Assured shuttle availability (ASA).......	--	--	--	122,300	SF 1-10
Total................................	1,194,949	1,302,000	1,276,400	1,288,900	

Distribution of Program Amounts by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center....................	373,600	324,000	379,200	427,100
Kennedy Space Center....................	135,700	145,900	143,000	107,500
Marshall Space Flight Center.............	637,400	786,600	710,200	679,300
Stennis Space Center....................	24,500	21,900	22,600	30,600
Goddard Space Flight Center..............	100	--	--	--
Jet Propulsion Laboratory................	3,900	2,900	1,800	--
Langley Research Center..................	300	--	--	--
Lewis Research Center....................	3,500	4,000	4,000	--
Headquarters...........................	15,949	16,700	15,600	44,400
Total................................	1,194,949	1,302,000	1,276,400	1,288,900

OBJECTIVES AND STATUS

This program provides for necessary design modifications and safety improvements to support the Space Shuttle; needed capabilities at the launch site and for the flight operations process; continued development and testing of propulsion systems; and replacement of obsolete systems to ensure the long term viability of the Shuttle program.

With the loss of Challenger in January 1986, the orbiter fleet was reduced to three vehicles. The current orbiter fleet includes Columbia, the orbiter developed and flown on four test and evaluation flights, and two orbiters of a lighter-weight configuration, Discovery and Atlantis. A fourth orbiter is being manufactured and is to be delivered this year. The budget provides funding for necessary improvements, hardware fixes and mission kits for the orbiter fleet to satisfy flight requirements. In addition, the Kennedy Space Center is consolidating repair capabilities into a centralized repair depot. The Extended Duration Orbiter (EDO) development is also included to increase on-orbit stay time from 7-10 days to 14-16 days. This will improve the Shuttle capability to support an increased variety of payload requirements. The EDO development is being supported by private industry consistent with the Administration's effort to promote more industry investment in space operations. Also included is a set of structural spares to replace those used on the OV-105 vehicle.

Launch and Mission Support provides for the required investment in Launch Operations and Flight Operations capability to meet Shuttle program objectives, which include supporting a safe flight rate. At KSC, the second line of facilities allows simultaneous processing and checkout of orbiters and associated flight hardware from landing through launch. At JSC, mission support provides collateral hardware, principally the extra-vehicular mobility units (EMU), and provides for improvements in the flight support systems. The flight support systems funded by this budget include Shuttle training and carrier aircraft, additional landing aids at the contingency/abort landing sites, replacement/upgrade of equipment in the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and the Flight Analysis and Design System (FADS).

Propulsion systems provide for the production, continued development and extensive testing of the SSMEs, the development of capability enhancements to support operational requirements established for the SRB, and the development of the ASRM. The SSME program includes: production of new engines necessary to replace engines in the orbiter fleet and in test stands when life limits are reached as well as a spares inventory for the SSME test program, ground testing in support of engine development, product improvement, and advanced development efforts to improve operating margins. The SRB production and capability development activities include: static test firing of STS 51-L configuration solid rocket motors for reclamation of reusable hardware and obtain engineering evaluation data, certification efforts for booster hardware to a 20 flight life, hardware, procurement of manufacturing process control tooling and equipment to support the flight program, and selected studies to continue investigative and problem solving activities. The Lockheed contractor team continues to make progress on the ASRM development. The program will include the design, development, test, evaluation, and integration of the ASRM and the design and construction of production equipment for a new Government Owned-Contractor Operated (GOCO) production and test facility. The development schedule is currently under review.

Assured Shuttle Availability provides the necessary improvements and upgrades to maintain the long term viability of the Shuttle program. Items planned to be developed are the Hardware Interface Module (HIM) card replacements at KSC, the Multifunction Electronic Display (MEDS) upgrade to the orbiter cockpits, an Advanced Fabrication engine, and the continued development of the Alternate Turbopump.

BASIS OF FY 1992 FUNDING REQUIREMENT

ORBITER OPERATIONAL CAPABILITY

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Orbiter	148,300	113,400	144,900	143,300
Extended duration orbiter	23,700	15,000	25,000	18,500
Structural spares	22,900	52,400	71,000	78,300
Systems integration	15,000	11,100	11,400	19,900
Orbiter spares	28,200	21,700	23,300	13,800
Total	238,100	213,600	275,600	273,800

OBJECTIVES AND STATUS

Orbiter production activities include safety modifications and capability improvements and the development and installation of necessary hardware, software, and procedural modifications to safely fly the orbiters. Work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements. These improvements include upgrading the general purpose computers (GPC), inertial measurement units (IMU), and auxiliary power units (APU). The brake and the nose wheel steering systems are undergoing modifications to improve landing performance. In addition to these system changes, there are procurements of selected orbiter hardware improvements and associated engineering analysis tasks. Production, engineering and logistics of the Remote Manipulator System (RMS) are included, as is the work necessary to continue development of the Extended Duration Orbiter (EDO).

The structural spares program initiated in FY 1983 provided the foundation for the production of a replacement orbiter (OV-105). The continuation of this structural spares effort is providing an extra set of structural assemblies. Structural assemblies include the wings, aft thrust structure, engine compartment, crew module (including the nose and cockpit), mid and aft fuselage sections, payload bay doors, vertical tail, and the orbital maneuvering system pods.

The procurement and fabrication of the orbiter spares inventory is ongoing. A concerted effort has been made to better define the spares requirements and production capability at various vendors. A logistics depot has been established near KSC for repair and maintenance of orbiter spare parts. The depot is reducing logistics program costs and shortening turnaround time. The depot is currently repairing, maintaining and manufacturing minor line replaceable units (LRU) and shop replaceable units (SRU). When the repair capability for major LRUs is completed in FY 1994, the depot will be fully operational.

CHANGES FROM FY 1991 BUDGET

FY 1991 funding for orbiter operational capability activities has increased by $62.0 million. Orbiter increased by $31.5 million as a result of required vehicle modifications on Columbia which will be performed during its maintenance down period at Palmdale this summer. Additional funding is also needed to cover anticipated modifications on the orbiter fleet which have been definitized over the past year. In addition, the structural spares program was increased $18.6 million in order to maintain the contract schedule. Increased funding of $10.0 million is added to the 16 day EDO program to ensure successful development of this extended capability. Orbiter spares increased by $1.6 million due to more high value spares being procured than earlier planned.

BASIS OF FY 1992 ESTIMATE

Orbiter funds provide for the continuation of necessary flight and safety modifications on the orbiter vehicles particularly as they enter their maintenance down periods, the engineering analysis and integration capabilities needed to support the flight program, orbiter support activities such as the remote manipulator system, and verification and validation of the avionics system interface. The structural spares activity will continue at essentially the same level in FY 1991. This will ensure maintenance of production capability for the long-lead components. In FY 1992, work on the Extended Duration Orbiter (EDO) will continue with the cryogenic kit being developed under a commercial agreement with Rockwell International. Orbiter funding also covers systems integration of all redevelopment analyses and hardware changes, and continued development of the Systems Integrity Assurance program to monitor systems performance and trends. The orbiter logistics program in FY 1992 is concluding the lay-in of LRU's, SRU's, and repair parts to support the initial inventory. The funding covers flight hardware spares, ground equipment spares, scheduling, provisioning, and documentation. In addition, funding is included to provide maintenance test equipment and special test equipment for the centralized depot and selected vendor repair sites.

BASIS OF FY 1992 FUNDING REQUIREMENT

PROPULSION SYSTEMS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Main engine	438,200	430,900	388,300	374,100
Solid rocket booster	72,500	82,900	50,400	48,600
External tank	2,700	--	--	--
Advanced solid rocket motor	160.400	309.100	309.100	200.000
Total	673.800	822.900	747.800	622.700

OBJECTIVES AND STATUS

The Propulsion Systems budget provides for the production of the SSMEs, the development of the safety, reliability and producibility enhancements needed to support operational requirements for the SSME, SRB capability developments, and the development of the ASRM. The SSME program includes: the procurement of spare engines to replace those reaching their life limits; ground testing operations; and development and certification activities to improve operating margins, safety, reliability and durability, as well as to make the engine easier to produce and maintain. The SRB program includes the static test firing of Technical Evaluation Motors (TEMs) produced prior to the Challenger accident to reclaim reusable hardware and to provide data for engineering evaluation and analysis. Engineering analysis and modifications of booster hardware for certification of a twenty flight use capability will continue in FY 1992. The ASRM design and development is underway and will employ changes in configuration, design details, and materials to meet more stringent design requirements and to enhance safety margins.

The SSME program has been restructured to improve the visibility and management of hardware costs within the program. The new structure splits the production line into SSME prime contract, project support, and other center support. The SSME prime funding will be subdivided into hardware and non-hardware activities. SSME hardware activities include: new engines to replace those reaching the end of their useful life; ground support equipment; test hardware to support development, certification and flight certification extension of improved components; and initial production of improved components for fleet implementation. Non-hardware activities include the labor and functional materials used for program support, test support, development, certification and flight certification test analysis, and engineering improvements to components and manufacturing processes. Among the improved components currently in development are a redesigned hot-gas manifold and single coil heat exchanger, which are expected to substantially increase SSME safety, reliability, and durability. The technology test bed program, conducted with the Office of Aeronautics, Exploration and Technology (OAET), is also included in the non-hardware activities because it uses unique engine components. The technology test bed provides an independent means to evaluate technical advances arising from the SSME development engineering efforts, as well as from the OAET research and technology program. SSME project support provides funds for engineering and support efforts at MSFC and the Stennis Space Center (SSC) as well as propellants used in engine tests. Other support funds studies and analysis at the Slidell Computer Complex, at JPL, and the Lewis Research Center. These efforts provide the technical base for improving the safety, reliability, and durability of the SSME while reducing development and production costs.

The SSME experience involving full-up engine systems now exceeds 1700 tests, totalling approximately 460,000 seconds of test and flight time. This experience includes tests, exceeding 84,700 seconds of test operation, at the full power level (FPL) of 109 percent. In light of the Challenger accident, the SSME has delayed all activities associated with the operational use of FPL. However, single engine testing at these levels has continued to demonstrate margin and safety for the life certification extension test program. In addition, testing is required to demonstrate capability to support extreme abort modes which require operation at FPL.

The redesign of the SRB to resolve deficiencies in the previous design was completed in FY 1988. Assessment of flight data, including inspection of recovered hardware, will be continuing through FY 1992 and there will be a continuing activity to improve tooling and procedures to enhance process control and product quality. Reclamation of reusable SRM hardware contained in solid rocket motors produced prior to the Challenger accident will also be accomplished through static firing and refurbishment.

The ASRM project is intended to enhance the flight safety, reliability and performance of the Space Shuttle fleet. The ASRM will employ changes in configuration, design details, and materials to meet more stringent design requirements and enhance safety margins. Production processes will use the latest applicable technology and process automation to enhance reproducibility and reliability. The ASRM production facility under construction will be a modern, automated production facility which will maximize material and process controls for enhanced reliability. An additional objective of the ASRM is to achieve increased payload capability. The design and development requirements state that there will be no compromise to flight safety and reliability, and that the impact to other Shuttle elements be held to an absolute minimum. An asbestos-free insulation development program is incorporated into the scope of ASRM development. This requirement is driven by environmental and production safety concerns rather than by technical or performance issues. Costly duplications of qualification tests can be avoided by incorporating this effort into the overall ASRM effort. A significant amount of activity has been underway since the signing of the ASRM prime contract in May 1990. All major subcontracts are under letter agreements. Ground clearing is underway at Iuka, Mississippi in preparation for facility construction planned for the spring of 1991. Design specifications for the construction of facilities and plant equipment are nearing completion. The ASRM schedule for first flight is under review.

CHANGES FROM FY 1991 BUDGET

FY 1991 funding requirements in Propulsion decreased $75.1 million. The $42.6 million decrease in the main engine program is attributed to a decrease in propellant costs due to favorable prices, reduced funding for product improvement items, deletion of the external heat exchanger implementation, and a transfer of anomaly resolution activities to Shuttle operations where they will be more appropriately funded. Solid Rocket Booster requirements decreased $32.5 million because of a reassessment of the cost threats associated with completion of the development activities.

BASIS OF FY 1992 ESTIMATE

Funding for the FY 1992 budget supports the development of the ASRM program and the continued development of the production capability of the other propulsion elements (SSME and SRB). The SSME program will continue production of flight hardware and the development programs including necessary improvements to the current configuration. The continued development of the Alternate Turbopump has been included under Assured Shuttle Availability (ASA). The SRB FY 1992 funding will primarily focus upon continued evaluation and analysis of flight data to thoroughly assess the redesign. Modification of booster hardware necessary to obtain 20 flight use capability will continue as well. The ASRM development program will proceed with development and test of the new design, and production of verification units.

BASIS OF FY 1992 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Launch site equipment..................	105,700	114,900	110,400	79,400
Mission support capability..............	177,349	150,600	142,600	190,700
Total................................	283,049	265,500	253,000	270,100

OBJECTIVES AND STATUS

This activity supports the development of launch and mission support capabilities, principally at JSC and KSC. The major operational Space Shuttle facilities at KSC include two Orbiter Processing Facilities, two launch pads, the Vehicle Assembly Building, the Launch Control Center (LCC), and three mobile launch platforms. These facilities and the orbiter modification and refurbishment facility (OMRF) support processing and checkout of up to three orbiters in flow. The OMRF is being upgraded to a full up Orbiter Processing Facility (OPF) in order to accommodate the delivery of the new orbiter in FY 1991 and the increase in flight rate. Funding is also included to develop new supporting capabilities, such as an automated data management system to control the launch processing flow, an upgraded Checkout, Control, and Monitoring Subsystem (CCMS) of the launch processing system and a Launch Team Training System.

The major mission support capabilities at JSC include the Mission Control Center, the flight and ground support training capabilities, the flight design systems, and development and procurement of crew equipment such as the extravehicular mobility units. Improvements are being made in simulation training including new host computers, interface hardware and simulator subsystem replacement in the Shuttle Mission Simulator as well as in the Mission Control Center with host computer replacements and console upgrades. Critical improvements in simulation fidelity will be accommodated with the expanded capacity of the new hardware. Reliability required for the longer integrated simulations, and associated maintenance cost, will also be substantially improved with these replacements. Other activities include implementing required modifications and upgrades on the T-38 proficiency aircraft. A second Shuttle Carrier Aircraft will be operational this year; the fourth Shuttle Training Aircraft (STA-4) will be brought into fleet operations this year. Support of extravehicular mobility units and associated improvements are also included. Funding has been included for upgrading landing aids for end of mission and contingency/abort landing sites. Capability improvements have been added for weather prediction and information handling to improve system monitoring, notably for anomaly tracking. Funding for a preflight adaptor trainer is included to help prepare the crews for a weightless environment.

CHANGES FROM FY 1991 BUDGET

The Launch and Mission Support total has decreased $12.5 million. The launch site equipment decrease of $4.5 million reflects a deferral of selected items of launch site equipment. Mission support capability decreased by $8.0 million due to favorable negotiations on the modifications required on the Second Carrier Aircraft (SCA-2) as well as some economies and deferrals of equipment upgrade programs at JSC.

BASIS OF FY 1992 ESTIMATE

In FY 1992, Launch Site Equipment includes activities to improve the capability and processing efficiency to support the flight rate requirements at KSC. These include the Shuttle processing data management system, a digital internal communications system with associated fiber optics cabling, upgrade of the orbiter modification and refurbishment facility to an orbiter processing facility, replacement equipment for the launch processing system, development of the upgraded CCMS II; enhancement of equipment at contingency landing sites and development of a launch team training system (LTTS) for launch crew training and proficiency.

Mission support capability requirements continue to establish an inventory of crew equipment, principally extravehicular mobility units (EMU), to support the flight rate. STS operations effectiveness work and other support functions continue to support program-wide requirements including flight safety, mission success, and flight rate capability. Funding in FY 1992 provides for replacement of ADP and other hardware in the Mission Control Center and the Shuttle Mission Training Facility. Continuing projects include development of the Flight Analysis and Design System (FADS), as well as improvements to weather prediction, information handling, mission control systems, and contingency landing sites.

BASIS OF FY 1992 FUNDING REQUIREMENT

ASSURED SHUTTLE AVAILABILITY (ASA)

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Assured shuttle availability (ASA).......	--	--	--	122,300

OBJECTIVES AND STATUS

In order to assure that a viable manned transportation capability is maintained, specific program investments must begin in FY 1992. These investments are required to extend the useful life of the Shuttle system into the next century. The ASA program will address obsolete systems that will become increasingly expensive to operate and maintain. Additional benefits include improving safety and reliability, improving the flight turnaround time, and reducing operational costs. In the past, these kinds of improvements have been added incrementally as individual items of hardware experienced problems or vendors could no longer supply the older models. It is apparent that these types of requirements will increase as the Shuttle system matures. The approval process in ASA will ensure that improvements are evaluated and approved on a priority basis across the entire Shuttle program. The ASA will enable the life of the current Shuttle fleet to be extended for the foreseeable future. The orbiter vehicle, associated elements of flight hardware, ground processing facilities and other supporting systems, will be considered in the implementation of this program. The schedule for development and installation of orbiter related improvements is designed to take advantage of the planned intervals when orbiters are scheduled to be taken out of service for structural inspections and modifications. This plan provides for an orderly development and implementation program and minimizes interruption of the flight rate capability.

BASIS FY 1992 ESTIMATE

Planned development activities in FY 1992 include: (1) the replacement of the Hardware Interface Module (HIM) cards at KSC, (2) development of a Multifunction Electronic Display System (MEDS) in the orbiter cockpit, and (3) Advanced Fabrication of selected main engine components such as the ducts and throat to eliminate uninspectable welds. Funds will also be utilized to perform vulnerability assessments across the entire Shuttle system to identify and prioritize future candidates for inclusion into ASA. Beginning in FY 1992, the funds for continuing the development of the Alternate Turbopump will be included under ASA.

OPERATIONS

BASIS OF FY 1992 FUNDING REQUIREMENTS

SPACE TRANSPORTATION OPERATIONS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
	(Thousands of Dollars)				
Flight operations....................	750,700	815,600	801,500	912,500	SF 2-4
Flight hardware......................	1,201,000	1,467,200	1,393,300	1,417,000	SF 2-6
Launch and landing operations..........	541.000	606.600	595.200	694.100	SF 2-8
Shuttle operations...................	2.492.700	2.889.400	2.790.000	3.023.600	
Expendable launch vehicles and services.......................	139.700	229.200	229.200	341.900	SF 2-10
Total..............................	2.632.400	3.118.600	3.019.200	3.365.500	

Distribution of Program Amounts by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Johnson Space Center...	755,600	810,600	809,000	896,800
Kennedy Space Center...	721,600	808,300	796,600	915,100
Marshall Space Flight Center..	990,900	1,232,300	1,158,600	1,166,400
Stennis Space Center..................	2,400	2,500	2,500	2,400
Goddard Space Flight Center............	80,600	103,000	109,700	109,500
Langley Research Center................	3,500	9,700	--	--
Lewis Research Center...	52,100	110,300	112,600	223,000
Ames Research Center..................	6,400	6,100	5,800	6,400
Headquarters.........................	19.300	35.800	24.400	45.900
Total..............................	2.632.400	3.118.600	3.019.200	3.365.500

i

OBJECTIVES AND STATUS

Space Transportation Operations provides launch services to NASA payloads using a mixed fleet approach of both the Shuttle and Expendable Launch Vehicles (ELV). Launch services are also provided, on a reimbursable basis, to the Department of Defense, other civil agencies, and certain commercial and international users. The Shuttle program launch schedule is based on eight flights in FY 1991, nine in FY 1992 and nine in FY 1993. The flight rate in 1994 and succeeding years is now planned to be ten flights per year; this reflects a reduction from the previous plan of twelve flights per year. The ELV program launch schedule is based on a mix of launch services in four performance classes: small, medium, intermediate and large.

The Space Shuttle has demonstrated a broad range of capabilities including deployment of spacecraft and their upper stages, satellite repairs, satellite retrieval, operations using the remote manipulator, integral scientific experimentation using Shuttle and Spacelab systems, and extravehicular activity operations. These capabilities provide a unique opportunity to enhance the scientific reward of many payloads so the Shuttle will remain the mainstay of NASA's launch capability. The major program elements of Shuttle Operations are Flight Operations, Flight Hardware, and Launch and Landing Operations. These elements provide for the standard service operation of the Shuttle including preflight preparation activities, procurement and refurbishment of flight hardware, and maintenance and operation of equipment and facilities necessary to support all phases of the Shuttle flight process.

The Flight Operations activity is divided into three major elements: mission operations, integration, and support. Mission operations includes training, flight operations activities, and a wide variety of planning activities ranging from operational concepts and techniques development to detailed systems operational procedures and checklists. Integration includes production of flight software, launch support services and sustaining engineering for orbiter systems, cargo analytical integration, and systems integration. The support element includes systems support activity at JSC such as aircraft operations, engineering support, and support to the Space Shuttle program office. Shuttle system support for program and integration activities at Headquarters, the Marshall Space Flight Center, Kennedy Space Center, and the Stennis Space Center are also included.

The Flight Hardware program element provides for: the procurement of external tanks (ETs) and solid rocket booster (SRB) elements including motors, booster hardware, and propellants; orbiter logistics support; replenishment of spare parts inventory for the orbiter; SSME component repairs and overhauls; SSME anomaly resolution activities; orbiter and crew equipment; ET disconnects; maintenance and operations of flight crew equipment. Included in the funding request for tanks and boosters are the long-lead time raw materials, subassemblies, subsystems and additional ground testing of the Redesigned Solid Rocket Motor (RSRM) needed to sustain and verify the production of elements in a manner consistent with flight rate requirements.

Launch and Landing Operations provides for the prelaunch preparation, liquid propellants and gases, launch and landing operations of the Shuttle and its cargo.

A Mixed Fleet plan was initiated after the Challenger accident as a result of an assessment of NASA's space transportation requirements. This assessment showed that several U.S. Civil Government spacecraft should be launched on Expendable Launch Vehicles (ELVs) in order to provide increased access to space, to assure continuity of space operations, and to enhance mission flexibility. In 1989, NASA established a payload Flight Assignment Board (FAB) whereby each civil government primary payload is reviewed for assignment to launch on either the Shuttle or an ELV. The FAB criteria states that a payload will be assigned to an ELV unless: it requires manned presence, it requires the unique capabilities of the Shuttle, or other compelling circumstances exist.

BASIS OF FY 1992 FUNDING REQUIREMENT

FI OPERATIONS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Mission operations......................	252,600	280,500	276,500	318,800
Integration.............................	303,200	335,600	319,900	342,300
Support.................................	194.900	199.500	205.100	251.400
Total.................................	750,700	815.600	801.500	912.500

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission operations, integration, and support. Mission operations includes a wide variety of preflight planning, crew training, and operations control activities. The planning activities range from the development of operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include flight planning, preparation of systems and software handbooks, flight rules, detailed crew activity plans and procedures, development and implementation of the Mission Control Center (MCC) and network system requirements for each flight, and operations input to the planning for the selection and operation of Shuttle payloads. Specific flight planning activity encompasses the flight design, flight analysis, and software activities. Flight design products include conceptual flight profiles and operational flight profiles, which are issued for each flight, as well as support to the crew training simulations and flight techniques. In addition, the flight-dependent data located in the erasable memory (mission-to-mission changes) is developed in the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems. Also included are the maintenance and operation of critical mission support facilities including the Mission Control Center, flight simulators, crew training, and flight software reconfiguration and recertification facilities.

Integration includes orbiter sustaining engineering, payload integration into the Shuttle, system integration of the flight hardware elements, orbiter launch support services to the launch site and flight development and verification software. The orbiter sustaining engineering provides all prime contractor engineering activities necessary to re-qualify the orbiter for flight including Failure Modes Effects Analysis/Critical Item List (FMEA/CIL), design changes and certification reviews. The software activities include the development, formulation, and verification support of the guidance, targeting, and navigation systems software requirements in the orbiter.

Support includes base operations support to Shuttle operations and systems level support at the manned space flight centers. Base operations support provides for operation and maintenance of aircraft for flight training, crew proficiency and orbiter ferry requirements; engineering and supporting activities for the orbiter, crew equipment, and flight operations systems; and support to the Space Shuttle Program Office.

991 BUDGET

FY 1991 funding for the Flight Operations budget decreased $14.1 million. Mission operations decreased $4.0 million due to flight savings based on the new manifest. Integration decreased $15.7 million due to reduced estimates for sustaining engineering levels as well as flight savings. The support category increased $5.6 million due to increased charges for Defense Contract Administration Services (DCAS) for safety and quality inspections on NASA hardware as well as support to Shuttle Operations.

BASIS OF FY 1992 ESTIMATE

The Flight Operations portion of the Shuttle Operations budget continues to support that activity predominately associated with the effort at JSC to plan for and conduct STS missions from launch to landing. The functions are essentially the same as in the past: to maintain and operate all the ground facilities necessary for flight preparation and execution, and to instruct the flight and ground controller crews; to maintain and operate aircraft for proficiency, training and orbiter ferry requirements; and to perform analyses of and conduct the mission planning necessary for each mission. The nine missions to be flown in FY 1992 and initial efforts for flights in FY 1993 and FY 1994 will be supported. In addition, because the DOD has initiated a plan to incrementally remove their requirements for secure operations support, some support costs will be incurred in Flight Operations that had previously been funded separately by the DOD. It also includes the sustaining engineering required to integrate all flight and ground elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and certification of interfaces; and support of crew operations and training programs. Orbiter engineering manpower continues the required support of procedure and hardware modifications resulting from the FMEA/CIL reviews, in addition to the sustaining engineering activities that ensure maintainability, reliability, and anomaly resolution during operations. Support functions will also be continued including aircraft operations and JSC engineering support to the Shuttle. Support operations will increase in FY 1992 with the activation of a Second Carrier Aircraft (SCA-2) and a fourth Shuttle Training Aircraft (STA-4), landing site support, support for Shutte operations, and DCAS inspections.

BASIS OF FY 1992 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Orbiter..............................	397,800	397,800	442,900	441,700
Solid rocket booster..	458,600	691,300	572,900	592,400
External tank..........................	344.600	378.100	377.500	382.900
Total..............................	1.201.000	1.467.200	1.393.300	1.417.000

OBJECTIVES AND STATUS

The Flight Hardware program element provides for the procurement of External Tanks (ET), the manufacturing and refurbishment of Solid Rocket Booster (SRB) hardware and motors; and operational support to the Orbiter including Orbiter spares, ET disconnects, spare components, flight support and anomaly resolution for the Space Shuttle Main Engines (SSME) along with maintenance and refurbishment of flight crew equipment. Included in the funding request for tanks and boosters are the long-lead raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a manner consistent with the increasing flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain a smooth and efficient buildup of the production capability. An RSRM Flight Support Motor (FSM) was tested in FY 1990 to qualify a new source of ammonium perchlorate used in propellant production. The FSM's being manufactured in FY 1991 will be used to verify production consistency and qualify improved tooling, processes, and design features to include the qualification of a new source of rayon necessitated by the loss of Avtex. In the ET, production continues at the minimum level of activity necessary to retain manufacturing capability. The Orbiter line element includes Orbiter spares for replenishment of line and shop replaceable units, the manpower for supporting the logistics operation, and the repair capability for flight hardware. The SSME includes component and engine overhauls, procurement of replacement spare parts, flight support, and anomaly resolution. Also included in flight hardware are replaceable spares, field support, and maintenance of crew-related equipment. Some examples of orbiter spare equipment are fuel cells, tiles for thermal protection, tape recorders, leading edge support structures, wheels, brakes and pyrotechnics. The crew-related equipment activities include support to preflight training and flight usage of the extravehicular mobility unit, emergency portable oxygen systems, radiation instrumentation, survival radios, closed-circuit television cameras, medical support, and food and other galley-related items.

CHANGES FROM FY 1991 BUDGET

Overall, Flight Hardware funding has decreased $73.9 million. The Orbiter Flight Hardware element has increased $45.1 million because of the transfer of SSME Anomaly Resolution activities from Shuttle Production coupled with increased SSME component recycles. These increases in orbiter flight hardware were partially offset by flight savings due to the reduced manifest. The SRB requirements have decreased by $118.4 million due to flight savings based on the flight manifest as well as reduced estimates on attrition hardware, material costs, and Ammonimum Perchlorate surcharges. Flight savings on the ET were a modest $0.6 million since this project is already at minimum production while the backlog of tanks continues to be flown off.

BASIS OF FY 1992 ESTIMATE

Requirements for orbiter flight spares, crew equipment spares, and logistics are based on projected flight rates, maintenance schedules, operational usage, repair times, and lead times to procure or repair flight hardware. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity for the orbiter, extravehicular maneuvering unit and other crew equipment. The flight equipment processing contract (FEPC) is continuing its buildup to full capability to support the projected flight rates. Main engine hardware provides for manufacturing and delivery of overhauled engines, engine component spares, flight support and anomaly resolution. Flight hardware requirements activity for the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown during FY 1992, as well as the support of the production of units which will be flown thereafter. Additionally, manufacture of flight support motors, for static firing to monitor the consistency of production characteristics and qualify process and design changes, will continue in FY 1992.

BASIS OF FY 1992 FUNDING REQUIREMENT

LAUNCH AND LANDING OPERATIONS

	1990 Actual	1991 Budget Estimate	1991 Current	1992 Budget Estimate
	(Thousands of Dollars)			
Launch operations.......................	484,000	546,400	537,500	629,300
Payload and launch support...............	57.000	60.200	57.700	64.800
Total.................................	541.000	606.600	595.200	694.100

OBJECTIVES AND STATUS

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at KSC. Standard service processing and preparation of payloads as they are integrated into the orbiter are also funded by this category as is procurement of liquid propellants and gases for launch and base support. Support to landing operations at KSC, Edwards Air Force Base (EAFB) and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at KSC includes refurbishing the orbiter, stacking, and mating of the flight hardware elements into a launch vehicle configuration, verification of the launch configuration, and operation of the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, and inventory management.

Other launch support services included in this budget are maintenance and repair of the central data subsystem, which supports Shuttle processing as an on-line element of the launch processing system; Shuttle related data management functions such as work control and test procedures; purchase of equipment, supplies and services; and operations support functions such as processing propellants, life support systems, railroad maintenance, pressure vessel certification, Shuttle landing facility, and equipment modifications.

Payload and launch support funding provides propellants for payload launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers, verifying cargo-to-orbiter interface, and providing operations maintenance and logistic support to cargo support equipment (such as cargo integration test equipment and multimission payload support equipment) and to the payload support areas including the Vertical Processing Facility, Operations and Checkout building, and cargo hazardous servicing facilities. Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Funding requirements for Launch and Landing Operations reflect a decrease of $11.4 million. This is due to flight savings and reduced allowances for potential growth based on prior performance.

BASIS OF FY 1992 BUDGET

Launch operations funding in FY 1992 provides for manpower and support services necessary for processing launches from KSC. This includes manpower to assemble the SRB's, mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRB's and tank, process and checkout integrated flight elements through launch, retrieve and disassemble the SRB's for refurbishment, and support landing of the Orbiter either at KSC, EAFB or at a contingency landing site when required. Funding also supports the manpower required for sustaining engineering, provisioning, logistics, launch processing system operation and maintenance, and maintenance/modification of all other Shuttle-related ground support equipment and facilities. Flight safety will continue to be emphasized through testing, engineering and quality control.

The increase in FY 1992 funding required over FY 1991 levels is due to: (1) additional manpower for the third orbiter processing facility, (2) the increasing flight rate, (3) the inclusion of Shuttle range support previously funded by DOD under the quid pro quo, and (4) the impact of DOD withdrawing their requirement and funding for secure missions resulting in increased funding required by NASA.

BASIS OF FY 1992 FUNDING REQUIREMENT

EXPENDABLE LAUNCH VEHICLES AND SERVICES

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Small class	11,900	15,000	14,800	33,700
Medium class	75,400	102,900	98,700	81,500
Intermediate class	49,600	101,100	106,000	156,500
Large class	2,800	10,200	9,700	70,200
Total	139,700	229,200	229,200	341,900

OBJECTIVES AND STATUS

The Expendable Launch Vehicles (ELV) program provides a mixed fleet capability, which in conjunction with the Space Shuttle satisfies NASA payload requirements. Payloads are assigned for launch on ELVs consistent with Shuttle use criteria established in NASA's FY 1991 Authorization Act. As part of NASA's launch recovery strategy following the Challenger accident, four scientific spacecraft configured for launch on the Shuttle were transitioned to ELVs. The ELVs for these missions were selected non-competitively. Two of these missions were launched successfully in 1990: the NASA/German cooperative Roentgen Satellite (ROSAT) in June on an USAF procured Delta II; and the NASA/USAF Combined Release and Radiation Effects Satellite (CRRES) on the first commercial Atlas I, procured through an exchange of residual NASA assets for the launch service. Funding in FY 1991 will continue the procurement of a Delta II vehicle and launch services through the DOD (under the Quid Pro Quo arrangement) for the Extreme Ultraviolet Explorer (EWE) mission in December 1991 and a Titan III commercial launch service to support the Mars Observer spacecraft in September 1992.

All subsequent ELV launch services are being acquired by NASA competitively from the private sector, whenever available, to launch civil government payloads in three performance classes: (a) small class capable of launching payloads up to 1,000 lbs. in low Earth orbit, (b) medium class capable of launching payloads up to 10,000 lbs., and (c) intermediate class capable of launching payloads up to 30,000 lbs. Large class mission with payloads up to 40,000 lbs. to low Earth orbit must be acquired through the DOD since no commercial launch services are currently available for this size payload.

CHANGES FROM FY 1991 BUDGET ESTIMATE

Funding for ELVs remains unchanged with the exception of the Mobile Satellite (MSAT) mission which now requires an intermediate class vehicle instead of a medium (Delta II class) vehicle. This was due to an increase in the projected weight of the spacecraft. There were also some minor funding adjustments between vehicle classes.

BASIS OF FY 1992 ESTIMATES

Continued funding will be required to support the procurement of commercial launch services for small, medium, and intermediate class vehicles. In FY 1992, increased funding is required for the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) to be launched on a Scout vehicle in FY 1992 and for the Total Ozone Mapping Spectrometer (TOMS) mission to be launched on a Small Expendable Launch Vehicle (SELV) in FY 1993. Funding for the Fast Auroral Snapshot Explorer (FAST) on an SELV is also included. A series of medium class ELV missions will also be funded in FY 1992 as part of the Global Geospace Science project including the Geotail, Wind, and Polar missions. The Radarsat mission, scheduled for launch in June 1994 on a Delta vehicle will begin to require significant funding in FY 1992.

For intermediate class ELVs, the acquisition of the Titan III commercial launch services will be concluded in FY 1992 for the Mars Observer mission scheduled for launch in September 1992. Both NASA and American Mobile Satellite Corporation (AMSC) will share in the procurement of an intermediate ELV for the MSAT mission scheduled for launch in FY 1994. In return for NASA launch services, AMSC is participating with NASA in mobile communications experiments. An Atlas-IIAS vehicle is continuing to be procured for the Solar and Heliospheric Observatory (SOHO) mission to be launched in FY 1995. In support of the Advanced TDRS series with the first launch planned in FY 1997, procurement will be initiated on an intermediate ELV in FY 1992. The TDRS-G spacecraft originally manifested on the Shuttle will now be launched on an intermediate class launch vehicle consistent with the FY 1991 legislation and recommendations of the Report of the Advisory Committee on the Future of the U.S. Space Program.

With regard to large ELVs, the procurement of a Titan IV launch vehicle for the Cassini mission will continue in FY 1992. The procurement of a Titan IV for the Comet Rendezvous Asteroid Flyby (CRAF) mission has been deferred pending a determination of a revised launch date for CRAF. The plan to procure Titan IV launches through the DOD on the QPQ payment arrangement has been revised to provide for hardware funding on an earlier schedule. The previous arrangement for hardware payments assumed payment in the fiscal year prior to the year of launch. In addition, NASA will now have to pay for propellants, aerospace integration, and range costs for these vehicles.

TRACKING AND DATA
ACQUISITION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1992 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE OPERAT

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space network	321,135	331,200	310,100	347,973	SF 3-4
Ground networks	251,476	267,800	260,700	291,700	SF 3-11
Communications and data systems	224,867	269,800	258,000	314,200	SF 3-20
Total	797,478	868,800	828,800	953,873	

Distribution of Proeram Amount by Installation

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
Marshall Space Flight Center	48,838	56,800	55,300	66,000
Goddard Space Flight Center	551,936	598,562	568,700	614,900
Jet Propulsion Laboratory	150,066	159,600	148,400	180,800
Ames Research Center!	12,300	15,800	13,000	14,500
Headquarters	33,538	37,938	42,300	76,273
Lewis Research Center	800	100	1,100	1,400
Total	797,478	868,800	828,804	953,873

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1992 ESTIMATES

OFFICE OF SPACE OPERATIONS

SPACE AND GROUND NETWORKS. COMMUNICATIONS AND DATA SYSTEMS

OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide the vital tracking, telemetry, command, data acquisition, communications, and data processing required by all NASA flight projects. In addition to NASA flight projects, some of these capabilities are provided on a reimbursable basis to projects of other Government agencies, commercial firms, and international organizations.

Support is provided for Earth orbital, planetary and solar system exploration spacecraft missions, launch vehicles, research aircraft, sounding rockets and balloons. Included in the Earth orbital activities are the Space Shuttle, Spacelabs, and scientific and applications missions. The various type of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of science and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmission of commands from ground facilities to the spacecraft; (f) voice communications with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. These capabilities are essential for operating and maintaining U.S. space assets to achieve the scientific objectives of all flight missions and for executing the critical decisions necessary to the success of these missions.

NASA has three separate tracking networks to meet the requirements of all classes of NASA flight missions. These are: the Spaceflight Tracking and Data Network (STDN), for high Earth orbital missions and Shuttle launch and landing operations; the Deep Space Network (DSN), for planetary and interplanetary flight missions; and the Space Network, which includes the Tracking and Data Relay Satellite System (TDRSS), required by most low Earth orbital missions. The Space Network and STDN are managed by the Goddard Space Flight Center (GSFC). The DSN is managed by the Jet Propulsion Laboratory (JPL).

NASA has two communications networks: NASCOM, which is managed by the GSFC; and a Program Support Communications Network (PSCN), which is managed by the Marshall Space Flight Center (MSFC). The NASCOM interconnects the tracking networks with the spacecraft control centers and data processing facilities associated with each mission. This network provides three classes of service: a relatively low data rate system for the launch and landing facilities at the Kennedy Space Center (KSC) and the Dryden Flight Research Facility (DFRF); a medium rate system for the Deep Space Network; and a high rate system for the Space Network. The PSCN provides telecommunications among all NASA Centers and NASA contractors. These include telephone service between Centers, high speed digital data, facsimile, and video teleconferencing capabilities.

Highly specialized computation facilities provide real-time information for mission control and data processing of the scientific, applications, and engineering data which flow from flight projects. In addition, instrumentation facilities provide support for sounding rocket and balloon launchings and flight testing of aeronautical research aircraft.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The current estimate of $828.8 million for FY 1991 is $40 million below the budget request and is consistent with Congressional action. This reduction is being accommodated through a TDRS contract restructuring and a rephasing of some activities. Some work on TDRS-6 has been moved to FY 1992, and upgrading of the Spacelab Data Processing Facility has been delayed. Additional changes are described in subsequent sections.

BASIS OF FY 1992 ESTIMATE

The FY 1992 budget reflects the increasing activity level of flight programs plus the development and implementation activities to meet future mission requirements. FY 1992 is characterized by the substantial increase in the number of operational spacecraft to be supported. Among these missions are Galileo, Magellan, Hubble Space Telescope (HST), Ulysses, the Cosmic Background Explorer (COBE), the Gamma Ray Observatory (GRO), Pioneer spacecraft, Voyager spacecraft and the Shuttle missions. In addition, the Spacelab, planetary, and other missions currently under development and scheduled for operation before the middle of this decade, raise the communications, mission operations, and data processing requirements significantly in FY 1992. The Second TDRSS Ground Terminal (STGT) development activities continue, and TDRS Replacement Spacecraft activities include assembly, test and launch preparation. Development activities will be scheduled for the Customer Data Operations System (CDOS) and the Advanced TDRSS in late FY 1992. Both of these are needed to meet the requirements in the later half of this decade.

BASIS OF FY 1992 FUNDING REOUIREMENT

SPACE NETWORK

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)...............................	43,325	77,200	62,900	82,773
Space network operations.................	33,320	41,600	39,000	46,500
Systems engineering and support..........	26,511	34,000	35,400	51,700
TDRS replacement spacecraft..............	89,629	50,200	54,600	34,200
Second TDRSS ground terminal.............	126,200	100,000	92,800	118,000
Advanced TDRSS..........................	2.150	28.200	25.400	14.800
Total................................	321.135	331,200	310,100	347.973

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellites (TDRS) and the associated ground elements necessary to meet the requirements of Earth orbital spacecraft missions. The Space Network is now operating with a three TDRS constellation in geostationary orbit. One is fully functional; the other two, which are each partially degraded, provide the equivalent of one full TDRS. The TDRSS ground facilities are located at White Sands, New Mexico. Satellite and ground communication links interconnect the White Sands facilities with the Network Control Center (NCC) at the GSFC and other spacecraft mission facilities.

The FY 1992 request includes funding for: maintenance and operations of the White Sands complex; the NCC; systems engineering, documentation, and mission planning; equipment modification and replacement; competitive design studies for the next generation of relay satellites (Advanced TDRS); development of the replacement spacecraft; the continued development of the second ground terminal at White Sands; and the modernization of the current ground terminal.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)........................	43,325	77,200	62,900	50,100
Federal Finance Bank Payment.............	--	(1.209.732)	(1.209.732)	32.673
Total................................	43.325	77.200	62.900	82.773

OBJECTIVES AND STATUS

The TDRSS serves as the communication link between the spacecraft operating in Earth orbit and ground facilities. The TDRS provides space-to-space communications with the orbiting spacecraft and relays data to the White Sands ground facilities which are interconnected with control centers and other facilities. From geostationary orbit, TDRS provides a sixfold increase in orbital coverage over the ground tracking stations it replaced and accommodates data rates up to 300 megabits per second.

Through FY 1992, the Space Network will have provided data communications to the Shuttle missions, including Spacelabs, and orbiting satellite missions such as the Solar Maximum Mission (SMM), the Earth Radiation Budget Satellite (ERBS), the Solar Mesospheric Explorer (SME), Landsat, the Cosmic Background Explorer (COBE), the Hubble Space Telescope (HST), the Gamma Ray Observatory (GRO) and the Upper Atmosphere Research Satellite (UARS).

With the successful launch of TDRS-4 in March 1989, an operational constellation of three satellites was established. The TDRS-1 has been repositioned within three degrees of TDRS-3 to compensate for a subsystem failure in TDRS-3. These two partially operating satellites provide the equivalent capability available from a single, healthy satellite. The TDRS-5 is being prepared for launch in late FY 1991, which is a delay of 6 months due to a manifest change. Assembly and test activities continue on TDRS-6. Both TDRS-5 and TDRS-6 will be launched on the Shuttle.

In FY 1991, the outstanding debt to the Federal Financing Bank was paid off. The FY 1992 funding will repay the outstanding accrued interest and premiums related to the early payoff of the loan.

CHANGES FROM FY 1991 BUDGET ESTIMATES

The decrease of $14.3 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. This was accomplished by TDRSS contract restructuring, staffing reductions at the White Sands complex, reduced logistics expenditures, and moving some work on TDRS-6 into FY 1992.

BASIS OF FY 1992 ESTIMATE

During FY 1992, TDRS-6 will be in storage until the assembly and test activities begin in preparation for launch in FY 1993. Operations and maintenance activities will continue at the White Sands complex.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Space network operations.................	33,320	41,600	39,000	46,500

OBJECTIVES AND STATUS

The primary objectives of Space Network Operations are to provide for the operation and maintenance of the ground systems and facilities required to schedule, control and operate the network system. This integrated network operations system provides continuous feedback to the planning, training, staffing, and preparations for upcoming missions necessary to assure the operational network capability required by the expanding workload.

The NASA Ground Terminal (NGT) at White Sands monitors TDRSS performance, provides fault isolation monitoring for the network, and serves as the communications interface with all other facilities. The Network Control Center (NCC) at GSFC manages and schedules TDRSS services for all user spacecraft.

Funds are also provided for the Flight Dynamics Facility (FDF). It provides orbit and attitude determination, trajectory analysis, and position location for most space missions.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $2.6 million reflects the program adjustments that are being made to accommodate a portion of the general reductions specified by Congress. This was accomplished through reductions to support contract staffing in the FDF, the NGT and NCC software maintenance.

BASIS OF FY 1992 ESTIMATE

The requested funding provides for the operation of space network facilities 24 hours per day, seven days per week, and for related hardware and software maintenance. Funding is also provided for a variety of support activities such as operational analysis, mission planning, simulations, user compatibility testing, and documentation.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Systems engineering and support..........	26,511	34,000	35,400	51,700

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services, and the hardware and software development required to sustain and modify the space network elements. Systems engineering is supplied primarily through support service contracts. These contracts provide for equipment design and replacement, logistics support, and specialized maintenance and operations support activities including configuration management and procedure development. Ongoing activities include network integration and test; systems reliability analyses; test equipment procurement; and software modifications required for reliable spacecraft operations and to meet the requirements of new missions such as the Extreme Ultraviolet Explorer (EWE), the Upper Atmospheric Research Satellite (UARS), the Ocean Topographic Experiment (TOPEX), and the Gamma Ray Observatory (GRO).

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $1.4 million reflects a program adjustment needed for a software augmentation to the NCC required to interface with the Second TDRSS Ground Terminal (STGT).

BASIS OF FY 1992 ESTIMATE

Funds are requested to provide systems engineering, hardware and software maintenance, sustaining engineering support, test equipment, and vendor support for specialized equipment and space network subsystems. Increased funding is needed for the Network Control Center (NCC) software and hardware development and implementation required for the new interface with the Second TDRS Ground Terminal (STGT), scheduled for initial operations in FY 1993.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
TDRS replacement spacecraft..............	89,629	50,200	54,600	34,200

OBJECTIVES AND STATUS

The objective of this program is to provide the replacement spacecraft to maintain the required TDRS constellation. This spacecraft is functionally identical to the previous six satellites. Design changes have been made to improve reliability and to accommodate subsystems and parts that are no longer being produced. Previously, NASA planned to exercise an option to procure an eighth TDRS spacecraft from the contractor (TRW). With changes in support requirements, driven largely by the Space Station restructuring, the schedule for increasing the TDRS constellation from three to four spacecraft has slipped. It now appears that the TDRS-8 spacecraft procurement is not needed to fill service requirements prior to the availability of the Advanced TDRS.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $4.4 million reflects the latest set of unexpected development problems with new power amplifiers for TDRS-7. New amplifiers were required due to obsolescence concerns with the parametric amplifiers used in the previous TDRS.

BASIS OF FY 1992 ESTIMATE

The requested funds will continue spacecraft and payload subsystem integration and test activities scheduled to be completed in late FY 1992. TDRS-7, which will be available for launch in the first quarter of FY 1993, is now planned for launch on an ELV rather than the Space Shuttle, as previously planned. In FY 1992, funding is required to perform loads analyses, prepare mod kits, and analyze spacecraft-to-launch vehicle integration requirements.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Second TDRSS ground terminal (STGT)......	126,200	100,000	92,800	118,000

OBJECTIVES AND STATUS

The construction of the STGT was approved to: (1) eliminate the Space Network's critical single point of failure at the existing ground terminal at White Sands, New Mexico, which could result in a complete loss of communications; (2) upgrade the existing ground terminal without major disruptions to operating Earth orbiting missions; and (3) provide the capability to use the two TDRS spacecraft with partial failures to meet full service requirements.

The upgrade of the existing ground terminal provides a twofold benefit. First, the aging, error prone and difficult to maintain architecture of the existing ground terminal will be replaced with updated technology and an inherently more reliable architecture of the STGT. Second, the commonality of hardware and software systems will allow greatly reduced operational staffing through shared hardware and software maintenance, logistics, and personnel for management and engineering support.

The implementation contract was definitized in July 1989 and the Critical Design Review (CDR) was completed in June 1990. Design and development of most ground communications equipment is complete. Manufacturing of first articles is in progress. Software design is complete and coding is fifty per cent complete. Hardware and software integration testing will be initiated in the third quarter of FY 1991. The STGT building has been completed. Construction of three new 19 meter antennas is underway.

CHANGES FROM FY 1991 ESTIMATE

The decrease of $7.2 million reflects a slightly slower than planned buildup of manpower and materials. Workarounds have been developed in order to maintain the overall schedule.

BASIS OF FY 1992 ESTIMATE

The requested funding provides for the continued manufacturing, assembly, and integration testing of the Space to Ground Link Terminals (SGLTs) and antenna systems. Software and hardware integration and unit testing will continue. The STGT operations personnel will participate in validating man-machine interfaces, systems operability and maintainability through a unique in-plant validation program prior to the shipment of the systems to White Sands. The SGLTs for the modernization of the existing White Sands Terminal will begin hardware buildup and integration testing. Antenna designs for modernization of the existing antennas will be completed, and fabrication and test activities will begin during FY 1992.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Advanced tracking and data relay satellites (ATDRS)....................	2,150	28,200	25,400	14,800

IVES AND STATUS

The objective of the program is to design, develop, and competitively procure technologically advanced relay satellites required for continuity of space network operations. By the mid-1990's, the initial block of TDRS satellites will be exhausted. Maintaining the ATDRS delivery schedule will assure the continuity of space network operations capability for Earth orbiting satellites.

The ATDRS will enable space network capability to continue into the 21st century. Definition studies are to be completed by the end of FY 1991.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $2.8 million is due to a reduction of the number of Phase B design study contractors from four to three, along with a reallocation of funds.

BASIS OF FY 1992 ESTIMATE

The requested funding will support continuing technical definition activities and in-house engineering analyses prior to a contractor selection in FY 1993.

BASIS OF FY 1992 FUNDING REQUIREMENTS

GROUND NETWORKS

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) systems implementation..........	6,400	3,200	2,800	3,600
Spaceflight tracking and data network (STDN) operations.....................	55,083	55,200	55,600	58,700
Deep space network (DSN) systems implementation........................	62,650	60,700	61,900	82,400
Deep space network operations............	98,553	108,900	105,200	109,700
Aeronautics, balloons, and sounding rocket support systems implementation..	10,400	18,400	14,600	14,700
Aeronautics, balloons, and sounding rocket support operations..............	18,390	21,400	20,600	22,600
Total................................	251,476	267,800	260,700	291,700

OBJECTIVES AND STATUS

Three broad categories of missions depend on the ground networks: (1) Earth orbital; (2) planetary and solar system exploration; and (3) sub-orbital Aeronautics, Balloons and Sounding Rockets (AB&SR). The Deep Space Network (DSN) is required by the planetary and solar system exploration missions, as well as Earth orbital missions not compatible with Tracking and Data Relay Satellite System (TDRSS). Aeronautical, balloon and sounding rocket (AB&SR) research requires specially instrumented ranges as well as mobile systems. The Spacecraft Tracking and Data Network (STDN) stations at Merritt Island, Florida; Bermuda; and Dakar, Senegal are required during the launch phase of Space Transportation System (STS) missions. Range safety functions are provided via Bermuda and Wallops. Some emergency orbital telemetry and spacecraft control is provided to scientific satellites by the STDN. Shuttle landings at the Dryden Flight Research Facility are facilitated by the Goldstone 26-meter station of the DSN and a local facility. The Wallops Flight Facility fulfills a broad role within the Ground Networks by supporting orbital scientific spacecraft, the Shuttle, and routine AB&SR activities.

The Ground Networks funding provides for the operation and maintenance of the worldwide tracking facilities, engineering, and the procurement of hardware and software to sustain and modify network capabilities as required for new missions. The workload in FY 1992 will include the Space Shuttle, Magellan, Galileo, Ulysses, the Pioneers, International Cometary Explorer (ICE) and the Voyager missions. Preparations are underway for the Mars Observer mission, the International Solar Terrestrial Physics (ISTP) series, the Ocean Topography Experiment (TOPEX), CRAF/Cassini, Small Class Explorer (SMEX), and Search for Extraterrestrial Intelligence (SETI) missions.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) systems implementation..........	6,400	3,200	2,800	3,600

OBJECTIVES AND STATUS

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement of hardware and engineering services to sustain, modify, and replace existing network capabilities to ensure reliable tracking, command and data acquisition required by NASA's spaceflight missions.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $400 thousand reflects program adjustments that were made to accommodate a portion of the general reduction specified by Congress. This will delay the replacement of the intra-site communication systems at Bermuda and Merritt Island.

BASIS OF FY 1992 ESTIMATE

The FY 1992 request provides funds to upgrade equipment and subsystems required for Shuttle operations at the Merritt Island, Florida, and Bermuda STDN tracking stations. It also includes funding for the replacement of obsolete, difficult-to-maintain equipment at these tracking stations.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) operations.....................	55,083	55,200	55,600	58,700

OBJECTIVES AND STATUS

The primary function of the STDN is to provide launch, prelaunch, and landing communications required by the Space Transportation System (STS). In addition, this network provides an emergency backup for orbiting spacecraft in the event that they are unable to communicate through the TDRSS/Space Network. The network also provides support on a reimbursable basis to spaceflight missions of other United States government agencies, private industry, and international organizations.

The STDN consists of three ground stations located at Bermuda; Merritt Island, Florida; and Dakar, Senegal.

Each station is capable of tracking spacecraft, transmitting commands for spacecraft and experiment control, and receiving engineering and scientific data from the spacecraft. They also provide backup voice communications for Shuttle operations and range safety functions of Eastern Test Range operations.

CHANGES FROM FY 1991 Budget estimate

The increase of $400 thousand reflects program adjustments necessary to accommodate final closure of the Ascension Island station. Although actual operations ceased in FY 1990, cleanup activity will continue until April 1991, which is when the site is expected to be restored to its original condition.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding provides for the operation and maintenance of the three ground stations as well as a centralized logistics support operation. This logistics operation includes a central supply depot, a magnetic tape purchasing and certification facility, and centralized equipment repair and shipping facility. The depot is operated as a centralized facility, and supports the Communications and Data Processing program, the Deep Space Network, the Space Network, the Aeronautics, Balloons and Sounding Rocket program, and the STDN. It is managed by the Goddard Space Flight Center (GSFC).

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Deep space network (DSN) systems implementation........................	62,650	60,700	61,900	82,400

OBJECTIVES AND STATUS

The primary role of the Deep Space Network (DSN) is to provide communication between interplanetary spacecraft and the Earth. The DSN receives science and engineering telemetry, and transmits command, control and navigation signals to a variety of spacecraft, ranging from hundreds to billions of kilometers from Earth.

The systems and facilities required by spacecraft at the limits of the solar system are highly specialized and include large aperture antennas which can receive extremely weak radio signals. These antennas use ultrasensitive receivers and powerful transmitters. Extremely stable time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the Network Operations Control Center located at the Jet Propulsion Laboratory (JPL) and the DSN complexes. New systems implementation is required to support. the Mars Observer launch; the International Solar Terrestrial Program (ISTP) series, which includes the Global Geospace Science (GGS) and the Collaborating Solar-Terrestrial Research (COSTR) missions; the Very Long Baseline Interferometry (VLBI) Space Observatory (VSOP); and the Comet Rendezvous Asteroid Flyby (CRAF)/Cassini missions.

The major objectives of the DSN are: (1) to provide communications with scientific spacecraft at ever greater distances and to increase the capability to receive images from the far reaches of the solar system; (2) to meet the requirements of Earth orbiting spacecraft which are non-TDRSS compatible; (3) to provide the navigation capabilities for precision spacecraft targeting and probe delivery; and (4) to provide the increasing network frequency range and data rate capabilities required by new deep space missions.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $1.2 million reflects program adjustments that were made to modify the 70-meter antennas to permit rapid access for repair. Without these modifications, certain types of 70-meter antenna failures could require extensive downtime to repair.

BASIS FOR FY 1992 ESTIMATE

The FY 1992 funding provides for sustaining activities to keep the Deep Space Network functioning in a highly reliable manner. The increase in the requested funding level from FY 1991 to FY 1992 is required to implement a new DSN subnet of 10-meter antennas and to renovate the Greenbank Radio Observatory 14-meter antenna for use in the Orbiting Very Long Baseline Interferometry (OVLBI) cooperative missions with NASA's Japanese and Soviet partners. In addition, implementation activities are increasing for TOPEX, CRAF/Cassini, and SETI.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
	(Thousands of Dollars)			
Deep space network (DSN) operations......	98,553	108,900	105,200	109,700

OBJECTIVES AND TUS

The three Deep Space Network (DSN) complex locations--Goldstone, California; Canberra, Australia; and Madrid, Spain--are approximately 120 degrees apart in longitude to permit continuous viewing of planetary spacecraft. Each complex has four antennas--one 70-meter, two 34-meter, and one 26-meter. The 26-meter antennas are required by some Earth orbiting spacecraft, such as Nimbus-7 and for emergency backup functions. The complexes are staffed for round-the-clock operations. A central network control center is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Other DSN facilities include a spacecraft compatibility test area at JPL and a launch operations and compatibility facility at the Merritt Island Spaceflight Tracking and Data Network (STDN) site.

Two planetary spacecraft which require DSN support were launched in 1989 - Magellan and Galileo. In 1990, Magellan began mapping the planet Venus. Galileo has recently received the first of two gravity assists from Earth flyby before the spacecraft begins its journey to Jupiter. Ulysses, launched this past October, is also enroute to Jupiter where it will receive a gravity assist to deflect it on a trajectory to the Sun's polar regions.

The DSN also provides communications for the Voyagers, the Pioneers, and International Cometary Explorer (ICE) spacecraft, as well as for several cooperative and reimbursable programs.

One planetary spacecraft--Pioneer 6, which the DSN tracks occasionally--had its twenty-fifth anniversary this past December.

The DSN facilities are also used for ground-based measurements in solar system radar and radio astronomy observations. The network's ultrasensitive antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. The solar system radar is useful in understanding surface characteristics of asteroids, comets, moons, and ring systems.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $3.7 million reflects slowdown of several network enhancement activities and a reduction in technical support to accommodate a portion of the general funding reduction specified by Congress.

BASIS OF FY 1992 ESTIMATES

The DSN operations funding provides for the maintenance and operation of network facilities and the support and engineering required for continuing operation of the network. The expected DSN workload in FY 1992 includes Magellan, Galileo, and Ulysses (including a Jupiter gravity assist maneuver), as well as a variety of other missions. These include Pioneers 10 and 11; Pioneer-Venus; Voyagers 1 and 2; International Cometary Explorer (ICE); Nimbus-7; and the Space Shuttle landing. The Pioneer-Venus spacecraft is expected to be destroyed after entering the Venusian atmosphere near the end of FY 1992. The DSN will also provide emergency and backup communications for the TDRSS/Space Network which provides primary support to Space Shuttle, Hubble Space Telescope, Gamma Ray Observatory, and Cosmic Background Explorer (COBE).

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket support systems implementation..	10,400	18,400	14,600	14,700

OBJECTIVES AND STATUS

The Aeronautics, Balloons and Sounding Rocket (AB&SR) systems implementation program is directed primarily at the systematic replacement of obsolete systems and the upgrade of facilities to assure reliable support to NASA's research programs.

The facilities provide the ground capabilities required to capture the scientific and engineering data from aircraft, balloons, sounding rockets and some Earth-orbiting spacecraft engaged in scientific research. The primary fixed facilities are located at the Wallops Flight Facility (WFF), the Moffett Field Flight Complex (MFFC), and the Dryden Flight Research Facility (DFRF).

The WFF, under the management of Goddard Space Flight Center (GSFC), operates a range at Wallops Island, Virginia, which supports aeronautics research as well as sounding rocket and small meteorological balloon launches. The WFF also manages the operation of off-site ranges located at the White Sands Missile Range, New Mexico; Poker Flat Research Range, Alaska; and the National Scientific Balloon Facility, at Palestine, Texas. Mobile campaigns for balloon and sounding rocket launches are conducted at various sites, as required, throughout the world.

The ranges at Moffett Field, Crows Landing and the Dryden Flight Research Facility (DFRF) are under the management of Ames Research Center (ARC) and are configured to support aeronautics research. The DFRF has the additional responsibility of supporting Shuttle landings.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $3.8 million reflects program adjustments made to accommodate a portion of the general reduction specified by Congress. This decrease will be accommodated by deferring the replacement of aging radar systems at Dryden and WFF.

BASIS OF FY 1992 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons require fixed and mobile instrumentation systems. These include radar, telemetry, optical, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, test and calibration equipment routinely replaced, and equipment refurbished or modified to assure reliable support. Funds are also included for acquisition of a new mobile tracking system to support NASA's Small Explorer program.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons, and sounding rocket support operations	18,390	21,400	20,600	22,600

OBJECTIVE AND STATUS

The operations element of the AB&SR program includes the operations and maintenance of ground-based tracking instrumentation systems, both fixed and mobile, under the management of the Ames Research Center (ARC) and the Goddard Space Flight Center (GSFC). These facilities support NASA aeronautics, sub-orbital, and a limited number of Earth-orbiting research programs. Funding provides for services and consumable supplies required to operate and maintain the tracking radar, telemetry, data acquisition, data processing, data display, communications and special purpose optical equipment essential for these research programs.

The Western Aeronautical Test Range (WATR), composed of Dryden Flight Research Facility (DFRF) and the Moffett Field Flight Complex (MFFC), maintains an aggressive schedule of aeronautics research operations. During FY 1990, 1,594 missions were conducted at DFRF and MFFC. The trend continues upward in FY 1991 with approximately 1,700 aeronautical missions. Programs supported by these ranges included high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies. Shuttle tracking and telemetry landing operations are coordinated through Dryden.

The Wallops Flight Facility provides tracking, telemetry, and command functions for NASA's aeronautics, sounding rocket, balloon and some Earth orbiting satellite programs. During FY 1990, approximately 150 aeronautics missions were conducted. These were related to such programs as automatic landing operations using Global Positioning Satellite inputs, aircraft performance using vortex flap technology, radar surveillance technology support, runway friction testing, and cooperative programs with DOD in support of low cost launch vehicle operations.

In FY 1990, Wallops highly specialized mobile tracking systems supported 30 major sounding rocket missions in world wide campaigns. Approximately 34 sounding rocket missions are planned in FY 1991. In addition, WFF routinely launches smaller meteorological and special purpose rockets in support of specialized research programs. The Wallops Flight Facility (WFF) is also the center for a scientific balloon operations program. In FY 1990, WFF mobile tracking and telemetry systems launched 27 large balloons of the million cubic foot class for major scientific payloads, and in FY 1991, 45 large balloon launches will be supported.

The Wallops Orbital Tracking station provides 24 hour space tracking operations for missions such as Cosmic Background Explorer, International Ultraviolet Explorer, Interplanetary Monitoring Platform-8, Nimbus-7, Dynamics Explorer-1, Meteosat and Landsat.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $800 thousand reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. This will reduce the level of tracking, telemetry communications available for AB&SR programs. In turn, these programs will reduce their planned level of operations.

BASIS OF FY 1992 ESTIMATE

The funding for AB&SR program operations includes support services contractor operations and maintenance personnel, logistical support, and technical services for the ground-based fixed and mobile instrumentation systems supporting the ongoing sounding rocket, balloon, Earth orbiting satellite and aeronautical research programs. The increased funding levels are commensurate with the increased mission workload.

COMMUNICATIONS AND DATA SYSTEMS

	1990 Actual	1991 Budget	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation....	9,535	13,500	11,600	10,300
Communications operations................	106,054	120,300	118,200	129,600
Mission facilities......................	10,220	11,100	9,000	22,000
Mission operations......................	27,200	40,800	41,400	44,900
Data processing systems implementation...	18,391	22,800	22,000	39,800
Data processing operations...............	53.467	61.300	55.800	67.600
Total................................	224.867	269.800	258.000	314.200

OBJECTIVES AND STATUS

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems that are required for data transmission, mission control and data processing for space flight missions. The requirements for these functions are increasing sharply as new flight missions are overlaid on the continuing operations of older spacecraft. During the past year, two new spacecraft control and data processing facilities have been completed, Hubble Space Telescope (HST) and the Gamma Ray Observatory (GRO).

Communications circuits and services provide for the transmission of data between and among the remote tracking stations, the TDRSS Ground Terminal, launch areas, the mission control centers, and data processing facilities. Real-time information is crucial to determine the condition of the spacecraft and payloads and for the generation of spacecraft and payload control commands. Data received from the various spacecraft must be transformed into a usable form for spacecraft monitoring in the control centers and for experimenter analysis.

Major activities underway include: operation of the Hubble Space Telescope (HST), preparations for missions such as Gamma Ray Observatory (GRO), Spacelabs, Upper Atmosphere Research Satellite (UARS), Global Geospace Science (GGS), Collaborative Solar Terrestrial Research (COSTR), Small Explorers (SMEX), and Advanced X-ray Astrophysics Facility (AXAF). In addition, a system architecture has been developed for the Customer Data and Operations System (CDOS) and NASCOM II from the efforts of two independent contractors and the CDOS staff. These systems, as are most of the planned science spacecraft, will incorporate the new internationally accepted digital communications protocols. The CDOS and NASCOM II are systems that will provide the two orders of magnitude increase in data processing capacity required in the late 1990's. These systems are required by the Space Station Freedom (SSF), the Earth Observation System (EOS), the Tropical Rainfall Measurement Mission (TRMM), and the Advanced X-ray Astrophysics Facility (AXAF).

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation....	9,535	13,500	11,600	10,300

STA US

The objective of the Communications Systems Implementation program is to provide the necessary capability in NASA's Global Communications Network (NASCOM) to meet new flight program requirements, to increase the efficiency of the network, and to maintain a high level of reliability for the transmission of data and commands between U.S. assets in space and their respective control centers.

A major implementation' activity is the planning, engineering, and equipment acquisition required to tie together the existing TDRSS ground terminal with the Second TDRSS Ground Terminal (STGT) at White Sands, New Mexico. This requires an integrated communications capability for the control and transfer of data between the two facilities. Another significant effort under way is the equipment acquisition to replace the Deep Space Network's ground communications and data handling systems with higher capacity systems. These systems will be installed at Madrid, Spain; Goldstone, California; Tidbinbilla, Australia; and the Jet Propulsion Laboratory. These higher capacity systems are required to support spacecraft under development such as Mars Observer and Global Geospace Science (GGS) missions.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $1.9 million reflects program adjustments that are being made to accommodate a portion of the general reductions specified by Congress. As a result, the planned replacement of the Shuttle video system will be cancelled.

BASIS OF FY 1992 ESTIMATE

The FY 1992 funding will provide the equipment and modifications to the NASCOH network and the engineering and equipment acquisition required for the STGT at White Sands. Funding will also provide the ground communications data systems in the Deep Space Network required by the combined data rates of the Magellan, Galileo, Ulysses, Mars Observer, and the International Solar Terrestrial Program (ISTP) missions. New multiplex/demultiplex equipment will be acquired for the Goddard Space Flight Center (GSFC) and the Johnson Space Center (JSC) to functionally match the equipment installed at the STGT and the upgraded current ground terminal at White Sands.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Communications operations................	106,054	120,300	118,200	129,600

OBJECTIVES AND STATUS

NASA's NASCOM interconnects the tracking and data acquisition facilities for all flight projects, by means of leased voice, data, and wideband circuits. Also, NASCOM links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at JPL and Madrid. The NASA flight projects require the transfer of data between the mission control centers and the sites because of the need for real-time control of spacecraft and on-board experiments.

NASA's Program Support Communications Network (PSCN) interconnects the NASA Centers, Headquarters, and major contractor locations through leased voice, data, and wideband circuits for the transfer of programmatic and scientific data. Video teleconferencing capability and other administrative telecommunications services are also provided. The Marshall Space Flight Center (MSFC) operates the PSCN and serves as its major switching control point.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $2.1 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. The adjustments include delaying implementation of new capabilities in requirements on the PSCN and NASCOM by time-sharing existing circuitry.

BASIS OF FY 1992 ESTIMATE

The requested FY 1992 funding for the communications operations program provides the circuits and capability required to operate and maintain the network for the increasing number of scheduled missions. International communications satellites and cables will continue to provide digital wideband required by all the overseas tracking stations. Domestic satellite systems and terrestrial networks will continue to service the continental United States locations. The funding to provide the Deep Space Network with wideband data links with Spain and Australia, deferred from FY 1991, must be implemented in FY 1992, to meet the operational requirements of the Mars Observer and International Solar Terrestrial Program (ISTP) programs.

The Program Support Communications Network (PSCN) provides for the circuits and facilities for programmatic operations such as data transmission and computer-to-computer data sharing for NASA Centers and Headquarters. In FY 1992, funds are required to operate and maintain the PSCN hardware and wideband satellite and terrestrial circuits at all NASA locations and selected contractor sites. The network supports all NASA programs and projects.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Mission facilities......................	10,220	11,100	9,000	22,000

OBJECTIVES AND STATUS

The Mission Facilities implementation program provides the capabilities needed for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control of the spacecraft and on-board experiments are carried out via the Payload Operations Control Centers (POCC's) and related mission support systems.

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the generation of commands. Four POCC's currently monitor and control numerous spacecraft. In FY 1990, a major new dedicated control center was completed for control of the Hubble Space Telescope. Related mission support systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC Interface Facility (SPIF) and a Mission Planning/Command Management System to schedule spacecraft support and generate command sequences for transmission by the POCC's to the spacecraft.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $2.1 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. The reduction results in a delay in the development of the AXAF, the Small Explorers, Fast Auroral Snapshot Explorer (FAST), and the Submillimeter Wave Astronomy Satellite spacecraft control centers, and deferral of planned replacements of some aging control center equipment.

BASIS OF FY 1992 ESTIMATE

The FY 1992 budget request includes funds for continued implementation of mission control capabilities at GSFC for the Small Explorers missions and at MSFC for AXAF. Also in FY 1992, funds are included for mission unique modifications to the existing Multi-Satellite Operations Control Center (MSOCC) at GSFC for control of the Total Ozone Monitoring Spectrometer (TOMS), Tropical Rainfall Measuring Mission (TRMM), X-ray Timing Explorer (XTE), GGS, COSTR, and various Shuttle attached payloads. The increase from FY 1991 to FY 1992 reflects the deferral of work from FY 1991, plus the implementation activities required by the increasing queue of scheduled new missions.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Mission operations......................	27,200	40,800	41,400	44,900

OBJECTIVES AND STATUS

The Mission Operations program provides for the operation of the mission control centers and the related software and support services necessary for the monitoring and control of in-orbit spacecraft and prelaunch preparations for new spacecraft.

Control facilities for spacecraft/payload operations have the capability for receiving, processing, and displaying spacecraft engineering and telemetry data and for generating commands. Commands are generated in response to emergencies or preplanned in sequences to carry out the mission objectives. Each facility is operated 24 hours per day, 7 days per week for mission support. For Shuttle missions with attached payloads operated by GSFC, a specialized system processes and displays Shuttle-unique data that is needed for payload control.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The increase of $600 thousand is required for a further increase in the number of operating personnel required for new missions---the Gamma Ray Observatory (GRO), the Upper Atmosphere Research Satellite (UARS), and the Extreme Ultraviolet Explorer (EWE)--that become operational in FY 1991 and early FY 1992.

BASIS OF FY 1992 ESTIMATE

The FY 1992 budget request includes funds to operate the control centers and supporting facilities for control of the fifteen on-orbit missions scheduled for FY 1992 operations, and to develop the control center capabilities required for upcoming missions being developed. The funds will also support development of improvements to the planning and scheduling systems for the flight missions; control facilities for spacecraft with higher data rates; and to the interface with the JSC Shuttle control center. These enhancements are required to operate the increased number of spacecraft being controlled, to accommodate the higher data rates and the sophistication of the new spacecraft. New missions being planned or developed include the Total Ozone Mapper Spectrometer (TOMS), the Tropical Rainfall Measurement Mission (TRMM), the X-ray Timing Explorer (XTE), the Global Geospace Satellite (GGS) and the Collaborative Solar Terrestrial Research (COSTR) Spacecraft.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation...	18,391	22,800	22,000	39,800

OBJECTIVES AND STATUS

The Data Processing Systems Implementation program provides for the procurement of equipment and related services for the large data processing and computation systems at the Goddard Space Flight Center which are required by the broad spectrum of operational missions. These systems determine spacecraft attitude and orbit, and generate commands for the spacecraft operations. These systems also process the large volume of data produced by the many missions prior to the final analysis by the individual mission research projects.

Major computation capabilities include the Flight Dynamics Facility, which performs the real-time attitude, orbit computation, and flight maneuver control functions, and the Mission Operations and Data Systems Information Network (MODSIN). Also included are testbed facilities used for prototyping, testing, and evaluating maturing technologies. Using these facilities, promising technologies in the areas of remote payload operation and control, expert systems, high speed data processing, high level languages, and very large scale integration (VLSI) will be further developed and tested. In addition, there are four major systems for processing payload data: (1) the Generic Time Division Multiplexer (GTDM) Facility, which processes data from all TDM satellites; (2) the Packet Processor (PACOR), which processes data from satellites which employ the new packet technology and protocols; (3) the Hubble Space Telescope Data Capture Facility (HSTDCF), which captures, processes, and forwards the packetized telemetry from the

Hubble Space Telescope to the Science Institute Facility; and, (4) the Spacelab Data Processing Facility (SLDPF), which performs the data processing required by Spacelab missions. The final success of the many missions depend on these data systems being viable and responsive to project requirements.

Definition studies and preliminary design for the Customer Data and Operations System (CDOS) were completed in June 1990 by two independent contractors. These studies provide the basis for a preliminary system architecture. The CDOS will employ the new and efficient internationally accepted digital communications protocols which are also planned for the newer spacecraft. The CDOS will incorporate state-of-the-art systems that will provide the two orders of magnitude increase in data processing capacity needed by NASA in the mid 1990's. The CDOS is required by SSF, EOS, TRMM, AXAF and all other future missions of the late 1990's and beyond.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $0.8 million reflects program adjustments made to accommodate a portion of the general reduction specified by Congress. The reductions will delay the planned Spacelab data processing hardware replacement.

BASIS OF FY 1992 ESTIMATE

The FY 1992 budget request will provide continued funding for improvements in the existing computation capabilities at GSFC that provide real-time support to NASA spacecraft. The budget request also includes funds to complete development of the GTDM data processing system, for first use by UARS. The UARS data handling will serve as a pathfinder for other users and provide the basis for conducting trade-off analyses between development costs and operating efficiencies for future mission applications. Funds are also requested for upgrading the data processing capabilities at GSFC to facilitate the exchange of data within the data processing complex and to other mission support facilities. Significant effort will be expended on developing CDOS testbeds and prototype systems to provide proof of concept before full system implementation.

Requested funding provides unique spare parts for maintenance of electronic systems, test equipment, and minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

	1990 Actual	1991 Budget Estimate	1991 Current Estimate	1992 Budget Estimate
		(Thousands of Dollars)		
Data processing operations...............	***53,467***	***61,300***	***55,800***	***67,600***

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to the experimenters for analysis. This transformation is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to more complex imaging satellites.

Telemetry data is the primary product of spacecraft, and it is through analysis of this data by the investigators that the mission objectives are achieved. Data are processed to separate the information obtained from various scientific experiments aboard the spacecraft, to consolidate information for each experimenter, to determine spacecraft attitude, and to correlate these measurements with time and spacecraft position data. Four facilities, the GTDM, the PACOR, the SLDPF, and the HSTDCF facilities preprocess different types of raw mission data.

The GTDM will handle satellite data that is received in a time division multiplexed digital form from ground telemetry facilities via NASCOM. It is capable of electronically storing large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. The PACOR facility processes packet telemetry satellite data. The SLDPF processes Spacelab telemetry data and the HSTDCF provides the processing for Hubble Space Telescope data. In addition to telemetry data processing, new projects require extensive prelaunch mission planning and analyses. Spacecraft position and attitude predictions analyses are also required to develop operational sequences and procedures. Benefits from these analyses include optimization of systems resources such as ensuring spacecraft safety while maximizing science data return during spacecraft operation. These analyses result in the generation of flight dynamics requirements, and lead to the visual displays of attitude and simulation systems.

Facility management, maintenance and operations, and software development support for the data processing facilities are provided for in this request. Also included is the software development and maintenance required for attitude determination, flight maneuvers, and mission simulations for upcoming flight programs.

CHANGES FROM FY 1991 BUDGET ESTIMATE

The decrease of $5.5 million reflects program adjustments to accommodate a portion of the general reduction specified by Congress. Reductions were made in data systems, computer operations, and maintenance; and will result in the delayed delivery of some mission data.

BASIS OF FY 1992 ESTIMATE

The FY 1992 budget request provides for operation of the various computation and data processing facilities including the SLDPF, which provides unique hardware and software support to Spacelab and Dedicated Discipline Laboratory (DDL) missions. Pre-mission, mission, and post-mission activities for FY 1992 launches of the International Microgravity Laboratory (IML)-1, United States Microgravity Laboratory (USML)-1, United States Microgravity Payload (USMP), Diffuse X-ray Spectrometer (DXS), Attached Shuttle Payloads (ASP), Atlas-1, and Spacelab-J missions are required. In addition, preparation for future missions such as USMP-2, Spacelab D2, Atlas-2, Hitchhiker payloads, and Spacelab Life Science (SLS) -2 will be continued. Ongoing spacecraft support for HST, International Cometary Explorer (ICE), Earth Radiation Budget Satellite (ERBS), Interplanetary Monitoring Platform (IMP), Cosmic Background Explorer (COBE), and GRO includes the software and maintenance enhancements necessary to perform spacecraft attitude control, maneuver operations, and data processing. Funding will support the Space Station Freedom flight dynamics analysis.

Application software development, prototyping, and system testing are continuing for upcoming science and applications missions such as International Solar Terrestrial Program (ISTP) Wind, ISTP-Polar, ISTP-Geotail, X-ray Timing Explorer (XTE), ISTP-Solar Heliospheric Observatory (SOHO), and Attached Shuttle Payloads.