NASA
National Aeronautics and
Space Administration

Budget Estimates

FISCAL YEAR 1985

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Volume I

Agency Summary

Research and Development

Space Flight, Control and Data Communications

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1985 ESTIMATES

VOLUME I

TABLE OF CONTENTS

AGENCY SUMMARY

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1985 ESTIMATES

GENERAL STATEMENT

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

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

-- Expand the practical applications of space technology;

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

-- Improve the civil and military usefulness of aeronautical vehicles;

-- Disseminate pertinent findings to potential users; and

-- Promote international cooperation in peaceful activities in space.

The NASA FY 1985 budget recommendation of $7,491.4 million provides for a program to achieve these objectives.

Space program elements in the budget provide for progress in (1) space transportation including expanded use of the Space Shuttle and initiation of major effort on a space station; (2) exploration of the solar system and expansion of our knowledge of the universe; (3) technology development for application of space capabilities to remote sensing of the surface and atmospheric conditions of the Earth and other planets, to materials processing, and to communications; and (4) advancing the research and technology necessary for United States leadership in space. Major areas of emphasis include:

o The space station, proposed in the FY 1985 budget, marks the formal initiation of this program and represents a commitment to continued United States leadership in space. Design and definition will proceed in FY 1985 with initial orbital activities planned for the early 1990's. The United States space station will provide space-based facilities to allow for enhancement of science and applications and for development of capabilities for further exploitation of space.

- Space transportation systems activities emphasize the expansion of the operational capabilities of the Space Shuttle, Spacelab, and upper stages to take advantage of this new form of space transportation. The FY 1985 program will provide for the procurement of the hardware, mission integration and training, ground processing and flight operations of the Space Shuttle in support of the NASA, Department of Defense, domestic commercial, and international users of the Space Transportation System. The present fleet of three orbiters will be expanded by the delivery of a fourth in late 1984, and final operational modifications to the initial orbiter will be undertaken during 1985. Additional Spacelab flights will capitalize on the success of the initial mission as this unique capability is exploited for space research and applications missions. Development of the Centaur upper stages for Department of Defense and NASA missions will proceed toward the first critical uses of the planetary version in 1986 for the Galileo and International Solar Polar Missions. The first set of lighter-weight filament wound case solid rocket boosters will be delivered in preparation for the late 1985 initial launch from the Vandenberg launch site. Work will continue on the modifications of the Space Shuttle main engine to ensure greater operating margins and lifetimes for the engine operations at full power levels.

- Space science and applications flight missions, research and analysis and ground-based activities are conducted (1) to expand human knowledge of the Earth's environment, the solar system and the universe; and (2) to develop the technology to use space capabilities to meet needs on Earth. Specifically, work will continue on the Galileo orbiter and probe mission to Jupiter as the next step after Voyager in exploration of the outer planets; on the Space Telescope to provide a quantum jump in our ability to observe the universe; on the Gamma Ray Observatory to study extremely high energy phenomena; and on the Venus Radar Mapper mission to obtain global imagery of Venus. The next Landsat spacecraft, which will be launched in early 1984, will continue work with Thematic Mapper data to improve the usefulness of Earth observations from space. Effort will also be continued on the Earth Radiation Budget Satellite data analysis (launched in mid 1984) and on the Search and Rescue locator system being flown on weather satellites. In addition, design and development activities will be initiated on the Upper Atmospheric Research Satellite to monitor the upper atmosphere; on the Mars Geoscience/Climatology Orbiter to map Mars; and on a Scatterometer to be flown on the Navy Remote Ocean Sensing System to acquire global ocean data. Materials processing experiment development will be continued to take advantage of the space environment, as well as the advanced communications satellite technology development and ground test program.

- Space research and technology activities emphasize the longer range aspects of generic research and technology development in transportation, spacecraft and platform systems which are crucial to future United States leadership in space.

Aeronautical research and technology involves an effective and productive program that contributes materially to the enduring preeminence of U.S. civil and military aviation. The objectives are achieved by conducting appropriate disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; maintaining the research centers in positions of excellence in facilities and technical staff; assuring timely transfer of research results to the U.S. aeronautical industry; assuring appropriate involvement of universities and industry; and providing aeronautical development support to other government agencies and U.S. industry. Conducted well in advance of, and independent of, specific applications, the aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced military and civil aircraft. Ongoing technology efforts will continue toward major improvements in subsonic aircraft, rotorcraft, high-performance aircraft, advanced propulsion and numerical aerodynamic simulation.

Resources Summary

The budget authority recommended for FY 1985 totals $7,491.4 million with estimated outlays of $7,370.0 million and civil service staffing level of 22,000 full-time equivalent workyears.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET **SUMMARY**
(Thousands of Dollars)

	Budget Plan 1983	1984	1985
RESEARCH AND)PMENT	1,902,500	2,028,200	2,400,100
;r Station a/	(4,000)a/	(14,000)a/	150,000
;r Transportation ır t	415,500	431,700	361,400
Space Science and cations	1,060,100	1,134,000	1,371,500
Techno Utilization	9,000	9,000	9,500
Aeronautical [illegible] and Technology	280,000	302,300	342,400
Space and l	124,500	137,000	150,000
and D dvance	13,400	14,200	15,300
SPACE FLIGHT, (AI ATA (b/	3,633,010	3,775,300	3,600,300
Shuttle Production and Operational Capability	1,725,810	1,649,300	1,465,600
Space Transportation Operations	1,421,700	1,452,000	1,339,000
Space & Ground Network, Comm. and Data Systems	485,500	674,000	795,700
CONSTRUCTION OF FACILITIES	103,530	155,500	160,000
RESEARCH AND PROGRAM MANAGEMENT	1,197,400	1,258,500	1,331,000
TOTAL	6,836,440	7,2 17,500	7,491,400
OUTLAYS	6,663,885	7,068,200	7,370,000

a/ In FY 1983, the Space Station Activity was included in Space Transportation Capability Development. In FY 1984, $6.0 million was included in Space Transportation Capability Development, $2.0 million in Space Science and Applications and $6.0 million in Space Research and Technology.

b/ Prior to FY 1984, these programs were included in the Research & Development appropriation.

NATIONAL AERONAUTICS *AND SPACE* ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE STATION

- o Establish a permanent human presence in space:
  - The next logical step in U.S. leadership in space
  - Built upon the operational capabilities of the Space Shuttle
  - Orbital activities begin in the early **1990's**
- o Develop a multi-purpose facility containing both manned and unmanned elements to perform:
  - Essential scientific and technical research
  - Unique commercial activities
  - Operational tasks in space more efficiently such as:
    - Satellite servicing
    - Construction and servicing of platforms
    - Placement of spacecraft into higher orbits
  - Extensive national and international user community participation through:
    - Simplified user interfaces
    - Capability for on-orbit crew maintenance
    - Operational autonomy to achieve effective long-term performance
  - Staging base for potential future national programs such as:
    - Manned missions to the Moon or planets
    - Unmanned scientific probes and sample returns
- o Perform a thoroughly detailed front-end definition including:
  - Engineering design by industrial contractors
  - Subsystem advanced development and tests in dedicated test beds
  - Early flight experiments on the Space Shuttle to prove system feasibility
  - Continued trade studies for system optimization

MAJOR FLIGHT ACTIVITY

	Fiscal Years			
	1985	1986	1987	1988
Flight Experiments on Space Shuttle................................		△		

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Utilization Requirements	1.3	2.9	14.1
Supporting Studies & Program Support	2.1	5.1	12.2
Focused Technology	---	2.5	34.2
Advanced Development	.6	3.5	20.2
Flight Experiments	---	---	11.0
Systems Definition/Integration	---	---	58.3
Total	4.0*	14.0**	150.0

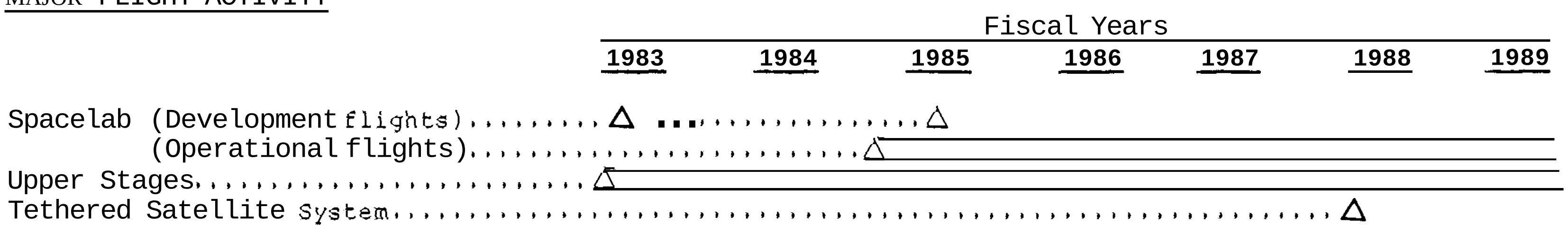
*Funded as part of Space Transportation Capability Development
Funded as part of Space Transportation Capability Development ($6.0), Space Research & Technology ($6.0), and Physics & Astronomy **($2.0)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

- o Proceed with development of the capabilities to enhance the space transporation system through pursuit of:
  - Manned orbital experiments using Shuttle and Spacelab
  - Development of upper stages to place payloads into deep space and in geosynchronous orbits;
  - Identification of future space programs and new technology to reduce program risks
  - Orbital placement, servicing and retrieval of automated satellites
- o Maintain engineering, scientific and technical support capability
- o Development of operational equipment to support payload pre- and post-launch processing and on-orbit operations
- o Development of United States-Italian Tethered Satellite System
- o Demonstration of Shuttle on-orbit retrieval and repair capability

MAJOR FLIGHT ACTIVITY



BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Space Transportation Capability Development (R&D)	415.5	431.7	361.4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE AND APPLICATIONS

- o Increase our understanding of the evolution and nature of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations;
- o Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields;
- o Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained; and
- o Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY

	Fiscal Years							
	1983	1984	1985	1986	1987	1988	1989	1990
Space telescope				△				
Gamma ray observatory						△		
Explorer launches	△	△ △		△	△ △	△		△
Shuttle/Spacelab payloads		△	—	—	—	—	—	—
Dedicated life sciences Spacelabs			△	—	—	—	—	—
Voyager-Uranus encounter				Ⓤ				
Galileo				△		Ⓙ		
International solar polar mission (ESA Spacecraft)				△				
Venus radar mapper mission						△ Ⓥ		
Mars Geoscience/Climatology Orbiter								△
Landsat-D'		△						
Search and rescue locator system on weather satellites	△	—	—	—	—	—	—	—
Earth radiation budget experiment		△	—	—	—	—	—	—
Upper atmospheric research satellite								△

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Physics and Astronomy	470.3	567.6	677.2
Life Sciences	55.7	58.0	63.3
Planetary Exploration	186.4	217.4	286.9
Solid Earth Observations	128.9	75.4	63.6
Environmental Observations	156.9	162.0	220.7
Materials Processing in Space	22.0	23.6	23.0
Communications	32.4	21.1	20.6
Information Systems	7.5	8.9	16.2
Total Space Science and Applications	1060.1	1134.0	1371.5
Technology Utilization	9.0	9.0	9.5

National Aeronautics and Space Administration

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide the Nation with the fundamental research and technology in the aeronautical disciplines and systems research applicable to general classes of advanced and civil military aircraft to:
  - Improve performance
  - Reduce costs
  - Increase safety
  - Reduce energy requirements
  - Decrease environmental effects

- Develop and sustain a strong Research and Technology Base in:
  - Fluid and thermal physics
  - Materials and structures
  - Controls and guidance
  - Human factors
  - Computer science and applications
  - Propulsion systems
  - Rotorcraft technology
  - General aviation/commuter technology
  - Subsonic aircraft technology
  - High-performance aircraft technology

- Conduct focused systems technology to evaluate the technical feasibility of advances or concepts:
  - Numerical aerodynamic simulation for complex aerospace computational problems
  - Advanced composite structures technology for transport aircraft design
  - Technology for next generation rotorcraft for X-Wing and advanced tilt-rotor technology
  - Turbine engine hot section technology for higher performance and longer lasting engines
  - High-performance flight research
  - Advanced rotorcraft technology and flight research
  - General aviation/commuter engine technology for better performance and efficiencies
  - Advanced turboprop systems for faster, more fuel-efficient transport and commuter aircraft

- Maintain expertise and operate significant national facilities to support research and technology:
  - Research and test facilities
  - Simulation facilities
  - Wind tunnels

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Aeronautical Research and Technology	280.0	302.3	342.4

NATIONAL **AERONAUTICS AND** *SPACE* ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

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

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

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

- Fluid and thermal physics
- Materials and structures
- Computer science and electronics
- Chemical propulsion
- Space energy conversion
- Controls and human factors
- Space data and communications
- Multidisciplinary research
- Spacecraft, transportation, and platform systems
- Component standardization

MAJOR FLIGHT ACTIVITY

	Fiscal Years 1983	1984	1985	1986	1987	1988	1989
Space technology Shuttle/Spacelab payloads...........Δ	———	———	———	———	———	———	———
Long duration exposure facility..............................		Δ					

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Space Research and Technology	124.5	137.0	150.0

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

- Continue with the operational establishment of a versatile and cost-effective space transportation system to provide for:
  - Establishment of a national fleet of four Space Shuttle orbiters including main engines
  - Ground support equipment, launch site equipment and manpower to support launch and landing operations
  - Provision of external tanks and solid rocket boosters and the manufacturing tooling/equipment supporting their production
  - Establish logistics support capability to provision spares, repair and overhaul flight hardware
  - Provision of capability for training astronauts, launch and flight operation personnel
- Eleven operational flight missions in FY 1985 building to a flight rate of 24 per year
- Continue with development of additional Shuttle performance capability
- Identification of improvements to make Space transportation more economical

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1983	1984	1985	1986	1987	1988	1989
Space Shuttle: Operational flights	4	7-8	11	16	21	23	24

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Shuttle Production and Operational Capability	1,725.8	1,649.3	1,465.6
Space Transportation Operations	1,421.7	1,452.0	1,339.0
Total*	3,147.5	3,101.3	2,804.6

* Prior to FY 1984, Shuttle Production and Operational Capability and Space Transportation Operations were included in the Research and Development appropriation; now contained in Space Flight, Control and Data Communications appropriation.

TRACKING AND DATA ACQUISITION

- o Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:
  - Shuttle operational flights
  - Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and Solar Mesosphere Explorer
  - Planetary missions - support will continue for Pioneers-10 and -11, Pioneer Venus, and Voyagers-1 and -2, as well as limited support for Helios and earlier Pioneer missions
  - Sounding rockets
  - Aeronautical flight research program
- o The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft was launched in April 1983 and the second is scheduled to be launched in late 1984. The TDRSS contract has been restructured to provide €or a dedicated Government system.

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1983	1984	1985	1986	1987	1988	1989
Tracking and Data Relay Satellite.................... (Backup satellites available)	Δ······	Δ	····Δ				

BUDGET PLAN (millions of dollars)	FY 1983	FY 1984	FY 1985
Space & Ground Network, Comm., and Data Systems *	485.5	674.0	795.7

* Prior the FY 1984, Space & Ground Network, Communications, and Data Systems was included in Research and Development appropriation; now included in Space Flight, Control and Data Communications. Advanced Systems portion still in Research and Development appropriation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1985 ESTIMATES

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

	Total	Research and Development	Space Flight, Control and Data Comm.	Construction of Facilities	Research and Program Management
Fiscal Year 1983					
Appropriation, PL 97-272...........	6,809,200	5,542,800	---	97,500	1,168,900
Transfer between accounts FY 1983..	---	-3,840	---	+3,840	---
Transfer from FY 1983 to FY 1982...	-1,260	---	---	-1,260	---
Supplemental Appropriation, PL 98-63........................	+28,500	---	---	---	+28,500
Transfer between accounts FY 1984.	---	-3,450	---	+3,450	---
Total Budget Plan................	6,836,440	5,535,510	---	103,530	1,197,400
Fiscal Year 1984					
Appropriation, PL 98-45............	7,177,500	2,011,900	3,791,600	135,500	1,238,500
Transfer between accounts..........	---	+16,300	-16,300	---	---
Supplemental Appropriation PL 98-181........................	+20,000	---	---	+20,000	---
Proposed Supplemental Appropriation	+20,000	---	---	---	+20,000
Total Budget Plan................	7,217,500	2,028,200	3,775,300	155,500	1,258,500
Fiscal Year 1985					
Appropriation request/budget plan..	7,491,400	2,400,100	3,600,300	160,000	1,331,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1985 ESTIMATES

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

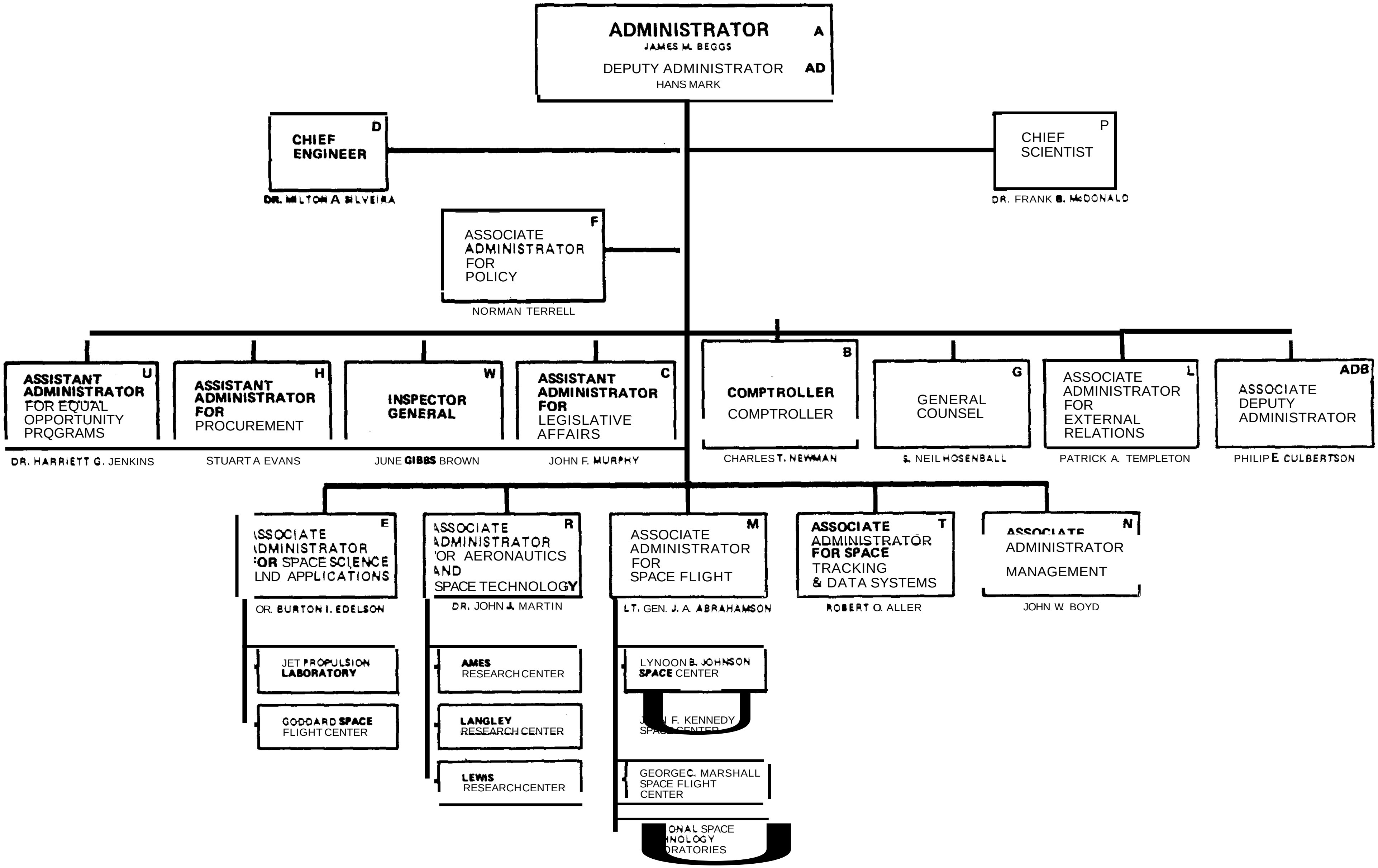
	Total			Space Pllght Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1983	1984	1985	1983	1984	1985	1983	1984	1985	1983	1984	1985	1983	1984	1985
Johnson Space Contar...............	1,745,163	1,613,373	1,437,916	1,398,890	1,230,700	1,041,200	151,056	174,991	173,411	---	2,300	3,200	195,217	205,382	214,105
Kennedy Space Contar...............	658,120	742,439	616,309	442,200	449,600	349,300	43,919	64,324	56,560	10,730	59,300	29,600	161.271	169,215	180,849
Marshall Space Flight Center........	1,826,344	1,903,560	1,926,489	1,189,900	1,270,500	1,271,500	434,333	432,398	452,125	11.845	11.700	1,600	184,266	188,962	195,264
National Space Technology Laboratories.....................	14,660	18,143	22,155	700	---	---	1,615	8,350	8,250	---	---	3,000	6,345	9,793	10,905
Goddard Space Flight Contar........	915,438	949,634	1,076,687	395,364	398,000	435,400	334,754	364,411	439,191	4,730	---	2,200	180,590	187,217	199,290
Jet Propulsion Laboratory...........	304,850	347,818	483,633	99,653	96,100	106,600	205,197	241.418	364,833	---	4,300	12,200	---	---	---
Ames Research Water...............	290,790	326,393	365,090	8,450	8,800	11,200	171,620	198,257	212.174	3,500	4.700	18,600	107,220	114,636	123,116
Langley Research Contar............	279,925	284,652	323,036	---	---	---	131,023	135,280	161,199	16,200	9,500	13,800	132,702	139,872	148,037
Lewis Research Center..............	403.772	358,773	355,763	---	---	---	281,088	217,760	215,260	3,915	10,600	---	118,169	130,413	140,503
Headquarters........................	387,518	662,415	858,522	91,853	321,600*	373,100*	141,895	185,005	316,491**	36,750	42,800	50,000	111,020	113,010	118,931
Undistributed Construtionn of Facilities:															
Various Locations...............	1,860	1,700	13,800	---	---	---	---	---	---	1,860	1,100	13,800	---	---	---
Facilities Planning and Design.....................	8.000	8,600	12,000	---	---	---	---	---	---	8,000	8,600	12,000	---	---	---
Total Budget Plan...............	6,836,440	7,217,500	7,491,400	3,633,010	3,175,300	3,600,300	1,902,500	2,028,200	2,400,100	103,530	155,500	160,000	1,191,400	1,258,500	1,331,000

*Includes payment on TDRSS loan.
**Includes total Space Station amount pending determination of canter assignments.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF PERMANENT POSITIONS BY INSTALLATION
FISCAL YEAR 1985 ESTIMATES
TOTAL NUMBER OF PERMANENT WORKYEARS
END OF YEAR

	FY 1983	FY 1984	FY 1985
Johnson Space Center	3.255	3.209	3.209
Kennedy Space Center	2.093	2.082	2.082
Marshall Space Flight Center	3.338	3.250	3.250
National Space Technology Laboratories	105	107	107
Goddard Space Flight Center	3.609	3.599	3.599
Ames Research Center	2.027	2.021	2.021
Langley Research Center	2.821	2.835	2.835
Lewis Research Center	2.520	2.591	2.591
Headquarters	1.434	1.423	1.423
Subtotal. Full-Time Permanent Civil Service	21.202	21.117	21.117
Other than full-time permanent	1.044	883	883
Total. Ceiling Controlled Civil Service	22.246	22.000	22.000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION CHART



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 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 define the systems and develop a United States space station which will allow for enhancement of the Nation's science and applications programs and for development of capabilities for further exploitation of space.

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 Spacelab, the upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, advanced programs study and evaluation efforts, and the development and first flight of the jointly developed U.S./Italy Tethered Satellite System.

SPACE SCIENCE AND APPLICATIONS: A program using space systems, supported by ground-based and airborne observations, 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 other stars of our galaxy and the universe; and 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 programs.

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.

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

STRUCTURE OF THE FY 1985 BUDGET
(RESEARCH AND DEVELOPMENT)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
SPACE STATION*	(4,000)	(14,000)	(14,000)	150,000
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	415,500	427,400	431.700	361,400
SPACE SCIENCE AND APPLICATIONS	1,060,100	1,068,000	1,134,000	1,371,500
Physics and astronomy..................	470,300	514,600	567,600	677,200
Life sciences..........................	55,700	59,000	58,000	63,300
Planetary exploration..................	186,400	205,400	217,400	286,900
Solid earth observations................	128,900	74,400	75,400	63,600
Environmental observations..............	156,900	163,000	162,000	220,700
Materials processing..................	22,000	21,600	23,600	23,000
Communications.........................	32,400	21,100	21,100	20,600
Information systems....................	7,500	8,900	8,900	16,200
TECHNOLOGY UTILIZATION	9,000	4,000	9,000	9.500
AERONAUTICS AND SPACE TECHNOLOGY	404,500	438,300	439,300	492,400
Aeronautical research and technology....	280,000	300,300	302,300	342,400
Space research and technology...........	124,500	138,000	137,000	150,000
TRACKING AND DATA ADVANCED SYSTEMS	13,400	14,200	14,200	15,300
TOTAL	1,902,500	1,951,900	2,028,200	2,400,100

* In FY 1983, the Space Station Activity was included in Space Transportation Capability Development. In FY 1984, $6.0 million was included in Space Transportation Capability Development, $2.0 million in Space Science and Application and $6.0 million in Space Research and Technology.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — **SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of	Dollars)		
Spacelab	121,200	119,600	112,500	69,300	RD 2-5
Upper stages	167,000	143,200	143,200	92,400	RD 2-8
Engineering and technical base	70,300	93,100	93,100	105,700	RD 2-11
Payload operations and support equipment	44,400	53,200	59,600	61,300	RD 2-14
Advanced programs	12,600	15,000	20,000	14,500	RD 2-16
Tethered satellite system	---	3,300	3, 300	18,200	RD 2-19
Total	415,500	427,400	431,700	361,400	

Distribution of Program Amounts By Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center	84,800	109,800	114,300	115,300
Kennedy Space Center	39,500	54,200	55,300	43,100
Marshall Space Flight Center	128,300	112,700	107,100	81,000
National Space Technology Laboratories	5,500	6,100	7,000	6,600
Goddard Space Flight Center	1,500	1,500	400	---
Jet Propulsion Laboratory	1,200	1,400	700	300
Langley Research Center	500	900	700	100
Lewis Research Center	144,900	112,200	98, 200	85,000
Headquarters	9,300	28,600	48,000	30,000
Total	415,500	427,400	431,700	361,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of	Dollars)		
Space telescope development..................	182,500	120,600	195,600	195,000	RD 3-4
Gamma ray observatory development...........	34,500	89,800	86,200	120,200	RD 3-6
Shuttle/Spacelab payload development and mission management.....................	81,000	92,900	80,900	105,400	RD 3-8
Explorer development........................	34,300	48,700	48,700	51,900	RD 3-10
Mission operations and data analysis..	61,400	79,500	68,100	109,100	RD 3-13
Research and analysis......................	28,500	29,800	35,800	36,900	RD 3-15
Suborbital program..........................	48,100	53,300	52,300	58,700	RD 3-18
Total.................................	470,300	514,600	567,600	677,200	

Distribution of Program Amount by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center...........,...........	8,850	8,650	10,548	4,500
Kennedy Space Center........................	2,955	7,100	6,904	11,000
Marshall Space Flight Center................	275,255	229,816	294,455	336,088
Goddard Space Flight Center.........,.......	116,688	194,523	186,549	232,521
Jet Propulsion Laboratory....................	17,866	20,554	17,624	26,308
Ames Research Center.......................	18,525	21,593	20,835	21,446
Langley Research Center.....................	238	18	1,091	2,183
Headquarters....	29,923	32,346	29,594	42,354
Total.....................,.........	470,300	514,600	567,600	677,200

PROGRAM OBJECTIVES AND JUSTIFICATION

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

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

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

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of scientific data; the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM) are still operating, and new scientific results are continually emerging from the analysis of the High Energy Astrophysics Observatories (HEAO) and Infrared Astronomical Satellite (IRAS) data sets.

Explorer satellites are relatively low cost but extremely effective missions which have been developed and launched since the beginning of our country's space program. Our most recent Explorer mission, the Infrared Astronomical Satellite (IRAS), developed in collaboration with the Netherlands and the United Kingdom, was launched in January 1983. In carrying out the first survey of the far infrared sky, IRAS made exciting discoveries and significant contributions to astronomical research as it observed the cool and obscured objects of the universe. These objects include cool matter around the stars, heretofore undetected comets, regions of star formation, and dust rings in our planetary system. A catalog will be published this year with many thousands of infrared sources identified.

In FY 1985, the development activities of the Space Telescope will be continued in preparation for launch in 1986. The major activity during FY 1985 will be the assembly and verification of the total Space Telescope system. The Gamma Ray Observatory system Critical Design Review will be held in FY 1985, and major fabrication efforts on spacecraft and instrument systems will be continued.

Two major Explorer missions are now under development: the Active Magnetospheric Particle Tracer Explorers (AMPTE) and the Cosmic Background Explorer (COBE). In addition, a U.S. X-ray high resolution imager is being developed for launch on the Roentgen Satellite (ROSAT), which is being developed by the Federal Republic of Germany. Development of the Extreme Ultraviolet Exlorer (EWE) which will be initiated in FY 1984, will allow a survey of the sky in the last unmapped spectral band by covering the portion of the electromagnetic spectrum between ultraviolet and X-rays.

The Spacelab 1 mission was successfully flown in late 1983, and provided exciting proof of the viability of conducting experiments on-board the Space Transportation System. The Materials Experiment Assembly instrumentation was also flown in late 1983 and good results were obtained. Effort is continuing on Spacelab 2, second of the two verification flights of the Spacelab. Spacelab 3, primarily a materials processing and life sciences mission, will be flown in late 1984, and will include the first flight of the Fluid Experiment System/Vapor Crystal Growth instrumentation. In addition, sounding-rocket-type of instrumentation will be developed to be flown on the Space Transportation System to allow longer flight times of these low-cost instruments.

Suborbital observations will continue to be conducted in FY 1985 from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere.

BASIS OF FY 1985 FUNDING REQUIREMENT

SPACE TELESCOPE DEVELOPMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft....	150,800	100,400	167,000	174,800
Experiments...	31,700	20,200	28,600	20,200
Total...	182,500	120,600	195,600	195,000
Mission operations and data analysis..	(31,900)	(51,500)	(41,500)	(74,700)
Space transportation system operations	(100)	(14,200)	(16,000)	(29,700)

OBJECTIVES AND STATUS

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

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make possible observations of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Space Telescope we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy; it may also be possible to determine whether some nearby stars have planetary systems.

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

During FY 1983, the Primary Mirror Assembly was completed and integration of the Optical Telescope Assembly began. Most of the Support System Module has been fabricated. All of the scientific instruments have been delivered to the Goddard Space Flight Center for verification and acceptance testing, which is now in progress.

In FY 1984, the Space Telescope system fabrication, integration and testing efforts will continue. In particular, the Optical Telescope Assembly (OTA) integration and testing activities will be continued, leading to delivery of the OTA to Lockheed in early FY 1985 for integration with the Support Systems Module.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The FY 1984 estimate reflects an increase of $75.0 million. This increase is the result of $45.0 million of additional appropriations over the budget request plus an addition of $30.0 million reallocation/reprogramming, and is required to solve some technical difficulties particularly with the Optical Telescope Assembly. The additional $30.0 million was made available by transferring $11.4 million from Physics and Astronomy Mission Operations and Data Analysis primarily from a reduction in ST Operations/ Refurbishment consistent with the delay of the ST launch from the first half of 1985 to the second half of 1986; $3.6 million from the Gamma Ray Observatory development due to a rephasing of the reserves; $12.0 million from Physics and Astronomy Spacelab Payload Development and Mission Management, comprised of a $10.0 million reduction in planned funding for the Solar Optical Telescope effort, which will be retained in the definition phase, and $2 million from Spacelab instrument and advanced planning; $1.0 million from Life Sciences Research and Analysis efforts, due to deferral of some planned research activities; and $2.0 million from Space Applications (Environmental Observations, Applied Research and Data Analysis), made available by deferring certain efforts within the upper atmosphere, oceanic and radiation/dynamics research activities.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding is required to complete the integration and testing of the Optical Telescope System and its subsequent delivery to Lockheed where it will be integrated with the Support Systems Module. In addition, the entire Space Telescope system integration and testing will be initiated leading to the launch of the ST in the second half of 1986 rather than the first half of 1985 due to technical problems encountered during FY 1983, particulary with the Optical Telescope Assembly.

LIFE

BASIS OF FY 1985 FUNDING REQUIREMENT

GAMMA RAY OBSERVATORY DEVELOPMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft..............................	16,900	70,900	66,200	101,700
Experiments and ground operations.......	17,600	18,900	20,000	18,500
Tbtal............................	34,500	89,800	86,200	120,200
Space transportation system operations..	(---)	(---)	(200)	(300)

OBJECTIVES AND STATUS

The objective of the Gamma Ray Observatory mission is to measure gamma radiation from the universe, and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Cosmic gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes.

The Gamma Ray observatory is scheduled for launch by the Space Shuttle in 1988. The spacecraft is being designed to accommodate four large gamma ray instruments, and will be designed to allow maintenance and retrieval by the Space Shuttle. The instruments will have their principal axis pointed in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods (hours to weeks).

In FY 1983, preliminary design reviews for the instruments were completed. Procurement of long-lead hardware for the spacecraft was initiated, as was detailed spacecraft design, including definition of interfaces with the Space Shuttle. In FY 1984, instrument critical design reviews will be held for the instruments, as will the preliminary design review for the spacecraft. In addition, fabrication of the spacecraft and instrument hardware will be initiated.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The reduction of $3.6 million was the result of a transfer of funds to Space Telescope development and was made available as a result of the rephasing of program reserves.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding is required for continuation of the major fabrication and assembly efforts on both the instruments and the spacecraft, and for completion of the total mission critical design review.

BASIS OF FY 1985 FUNDING REQUIREMENT

SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Payload development & mission management...	81,000	92,900	80,900	105,400

OBJECTIVES AND STATUS

The objectives of Spacelab payload development and mission management are to develop instruments in order to conduct experiments and acquire new knowledge in the disciplines of physics and astronomy, to develop experiment interface hardware for materials processing, to develop sounding rocket class payloads for flight on the Space Shuttle, and to manage the mission planning and execution of all NASA Spacelab payloads. This project supports the development of all physics and astronomy experiments; system management and engineering development of flight equipment and software; payload specialist training and support; physical integration of the payloads with the Spacelab system; operation of the payloads in flight; dissemination of data to experimenters; and analysis of physics and astronomy flight data. In addition, this project funds the mission management efforts for all NASA Spacelab payloads.

Instruments are currently under development for several Shuttle/Spacelab missions with primary emphasis on physics and astronomy. The Spacelab 2 mission, which is the second verification flight of the European-built Spacelab, is scheduled to fly in 1985. The objectives of Spacelab 2 are to verify the Spacelab pallet and igloo systems, and to obtain scientific data with emphasis on astrophysics and solar physics. The Instrument Pointing System, developed by the European Space Agency, will be flown for the first time on Spacelab 2.

Three ultraviolet telescopes are also currently in development leading to a launch in 1986 (Astro-1). This mission is designed to conduct investigations in ultraviolet imaging, spectrophotometry, and polarimetry at very high resolution. The Astro-1 mission will also carry two wide-field cameras, to conduct unique scientific observations of Halley's Comet in the near-earth environment. Astro-1, as well as reflights of this instrumentation, are designed to allow scientific investigations of a broad range of objects, from nearby comets and planets to the most distant quasars.

The Solar Optical Telescope (SOT) definition is being continued in FY 1984. The SOT will provide extremely high resolution images of the Sun's surface and atmosphere, permitting for the first time measurement matched to the spatial scale of fundamental solar phenomena.

Mission management activities are continuing on several space science and applications missions, for example, OSTA-3, several materials processing payloads, and the first dedicated Life Sciences mission (Spacelab 4).

The Spacelab 1 mission was successfully flown in early FY 1984, providing exciting proof of the viability of conducting experiments on-board the STS. The first flight of the Materials Experiment Assembly also took place. Spacelab 3, primarily a materials processing and life sciences mission, will be flown in early 1985. One of the major experiments which will be flown on Spacelab 3 is the Fluid Experiment System/Vapor Crystal Growth.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $12.0 million decrease is associated with to a $10.0 million reduction in the planned funding for the Solar Optical Telescope effort which will be retained in the definition phase, and a $2.0 million reduction in the Spacelab instrument and advanced planning activities. The $12.0 million has been reallocated to Space Telescope development to help solve ST technical problems.

BASIS OF FY 1985 ESTIMATE

In FY 1985, mission management of the ongoing Spacelab missions will be continued. Mission management for the non-physics and astronomy missions includes all Spacelab efforts except instrument development and data analysis on approximately eighteen different payloads. Definition of the Solar Optical Telescope will be continued in FY 1985, and development of the Space Plasma Lab will be continued. In addition, FY 1985 funding is required for the continuation of development and testing activities on the Spacelab 2 hardware, hardware for three ultraviolet telescopes which will be flown on ASTRO-1 in 1986, on OSS-2 which will be flown in 1987 and refurbishment of some hardware which were flown on Spacelabs 1 and 2. FY 1985 funding is also required for the development of low-cost sounding rocket class payloads which will be flown on the Space Shuttle to provide more flight opportunities to the science community at a relatively low cost.

BASIS OF FY 1985 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Infrared astronomical satellite..........	5,200	---	---	---
Active magnetospheric particle tracer explorer............................	11,700	4,300	6,500	---
Cosmic background explorer................	12,200	26,300	28,300	32,600
Roentgen satellite experiments..	2,800	2,000	2,300	1,100
Extreme ultraviolet explorer.............	---	11,000	8,000	15,000
Other explorers.........................	2,400	5,100	3,600	3,200
Total................................	34,300	48,700	48,700	51,900
Mission operations and data analysis.....	(13,700)	(14,600)	(13,200)	(20,400)
Space transportation system operations...	(6,400)	(100)	(200)	(6,000)

OBJECTIVES AND STATUS

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

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1984 include launch of the San Marco-D mission, and launch of the Active Magnetospheric Particle Tracer Explorer. The San Marco-D mission, a cooperative project with Italy, will include a group of U. S. experiments to study the relationship between solar activity and the Earth's meterological phenomena. The Active Magnetospheric Particle Tracer Explorer, a cooperative project with the Federal Republic of Germany, consists of two spacecraft, one built by the United States and one built by Germany. The mission will study the solar wind at the subsolar point and will identify particle entry windows, energization processes and transport processes into the magnetosphere.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, infrared, and low frequency radio regions of the electromagnetic spectrum. A prime example is the Infrared Asronomical Satellite, which has just completed a highly successful survey mission. In FY 1984, development will continue on the Cosmic Background Explorer (COBE), and on the x-ray imaging instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the infrared background radiation of the universe between the wavelengths of 1 micrometer and 9.6 millimeters. The detailed information which the COBE will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insight into the basic cosmological questions of the origin and evolution of the universe. ROSAT, a cooperative project between the Federal Republic of Germany and the United States, will perform high resolution imaging studies of the x-ray sky. The United States will provide a high resolution imaging instrument and launch services, and Germany will provide the spacecraft and other instrumentation.

Work is also continuing in FY 1984 on the Cosmic Ray Isotope Experiment (CRIE). The CRIE sensor, which will be launched in 1986 on a Department of Defense spacecraft, will study galactic cosmic rays and accelerated nuclei from solar flares. In addition, instrumentation development is being continued for the reflight of the Long Duration Explosure Facility to gather data on the relative energies and abundances of the rarer heavy cosmic ray nuclei. This spacecraft will be launched in 1986 by the Space Shuttle, with subsequent retrieval about two years later. In addition, funding in FY 1984 will support initiation of the Extreme Ultraviolet Explorer (EWE), which will carry out the first detailed all-sky survey of ultraviolet radiation between 100 and 900 angstroms--a hitherto unexplored portion of the electromagnetic spectrum.

FY 1984 funding is also supporting definition studies for future candidate explorer missions, including the X-ray Timing Explorer and the Far Ultraviolet Spectroscopy Explorer. Studies are also being conducted on potential alternate lower cost spacecraft concepts for future explorers.

CHANGES FROM FY 1984 BUDGET ESTIMATE

In total, the FY 1984 current estimate remains the same as the budget estimate. However, within the project, funding has been shifted to accommodate the increased cost projection of the remaining integration and test effort for AMPTE. The AMPTE mission is still scheduled for launch in 1984. In addition, COBE funding has been rephased to support a more efficient use of in-house resources which will lead to a launch in late 1987 or early 1988 rather than 1989 as previously planned.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required for continued development activity on the Cosmic Background Explorer, the Extreme Ultraviolet Explorer, the ROSAT instrument, the Cosmic Ray Isotope]Experiment, and the instrumentation for the reflight of the Long Duration Exposure Facility to obtain cosmic ray data. FY 1985 funding will also provide for definition studies of future potential explorer missions.

BASIS OF FY 1985 FUNDING REQUIREMENT

MISSION.OPERATIONS AND DATA ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
High energy astronomy observatory extended mission....................	3,500	5,000	5,000	5,000
Solar maximum mission extended mission............................	900	2,100	1,800	1,500
Solar maximum mission retrieval/ repair mission......................	11,000	6,300	6,600	7,500
Space telescope operations............	29,812	38,000	34,000	49,000
Space telescope maintenance and refurbishment.......................	2,088	13,500	7,500	25,700
Explorers............................	13,700	14,600	13,200	20,400
Orbiting astronomical observatory extended mission....................	400	---	---	---
Total...........................	61,400	79,500	68,100	109,100

OBJECTIVES AND STATUS

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

In addition to the normal support required for mission operations, the Space Telescope program encompasses several unique aspects which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, using the STS for in-orbit maintenance of the spacecraft and in-orbit changeout or repair of the scientific instruments. Also planned for the Telescope is periodic retrieval, return to Earth for complete refurbishment, and then relaunch by the Space Shuttle. During the period, the Space Telescope will be used primarily by observers selected on the basis of proposals submitted in reponse to periodic solicitations. Science operations will be carried out through an independent Space Telescope Science Institute. The Institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the Institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Space Telescope.

CHANGES FROM PY 1984 BUDGET ESTIMATE

The decrease of **$11.4** million is primarily from Space Telescope Operations/Maintenance and Refurbishment which is consistent with the Space Telescope launch slip from the first half of **1985** to the second half of **1986.**

BASIS OF FY 1985 ESTIMATE

FY 1985 funds will provide support for the basic mission operations and data analysis activities for the Active Magnetospheric Particle "racer Explorer, continued operation and data analysis activities for the International Ultraviolet Explorer, and continued analysis of the extensive data obtained by the Infrared Astronomical Satellite and the High Energy Astronomy Observatories. **FY 1985** funding will provide for the continued operation of the repaired Solar Maximum Mission, and preparation for the operation of the Space Telescope. In **FY 1985**, the development of mission operations procedures as well as development of the science operations ground system for the Space Telescope will be continued. The Space Telescope Science Institute activities will be continued leading to operational capability through the continued develoment of the Guide Star Selection System and Science Data Analysis Software. In **FY 1985**, maintenance and refurbishment planning activities such as the purchase of orbital replacement units and space support equipment will be continued to allow for the capability to service the Space Telescope in orbit.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology......	20,100	19,900	22,300	23,400
Advanced technology development.........	3,500	4,700	8,300	8,000
Data analysis...........................	4,900	5,200	5,200	5,500
Total............................	28,500	29,800	35,800	36,900

OBJECTIVES AND STATUS

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

o Supporting Research and Technology (SR&T): The objectives of supporting research and technology are to: **(1)** optimize the return expected from future missions by 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; and **(4)** strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to support our understanding of astrophysics and solar-terrestrial relationships.

Research is supported in the disciplines of astronomy, astrophysics, gravitational physics, and solar and heliospheric physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter, and cosmic rays. The work in solar and heliospheric physics involves the study of the solar atmosphere and the influence of the Sun on interplanetary phenomena. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SR&T program have a direct bearing on future flight programs. For example, the development of advanced X-ray and ultraviolet astronomy imaging devices under this program will enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit 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.

o Advanced Technological Development (ATD): The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. 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. Funding is applied to the definition and preliminary design for specific missions or subsystems and elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility (AXAF), the Solar Dynamics Observatory (SDO) and the Starprobe. The AXAF mission, which is the first priority mission recommendation of the National Academy of Sciences, will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's 1.2 meter class imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SDO will observe the oscillations visible on the Sun and use the data to investigate the dynamics of the Sun's interior in order to provide insight into solar and stellar interior structure. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within three solar radii of the Sun's surface.

Major Spacelab payloads being considered for future missions and requiring advanced technological development support include the following multi-user facilities: the Pinhole/Occulter Facility, a coded mask and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope, a meter-class ultraviolet/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space Telescope.

During FY 1984, major emphasis is being given to definition of the AXAF mission, while definition work is also continuing on Spacelab instruments and facilities, including detailed description of payload configurations and operational requirements.

o Data Analysis: The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data is correlated with other projects, when detailed cause-and-effect studied are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to extract a maximum amount of information from the data they obtained from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices now being ground tested for use on the Space Telescope.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $6.0 million increase reflects a general appropriation addition to the FY 1984 budget request. These funds will be used primarily to enhance research efforts in detector development activities in the areas of gamma ray spectroscopy, infrared astronomy, and solar physics.

BASIS OF FY 1985 ESTIMATE

During FY 1985, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detector development and on expansion of technology activities related to large x-ray mirrors, advanced x-ray detectors, gamma ray spectrometers and instrumentation. Emphasis will also be placed on the development of a large array multi-channel plate, and on intensified charge-coupled imagery devices. In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. Thrusts in the development of advanced generation instrument concepts will continue especially for the extreme ultraviolet and x-ray wavelengths, and for analyzing the structure and dynamics of the solar interior. FY 1985 funding will also support continued feasibility and definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics

FY 1985 funding will also support continued feasibility and definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility and the Solar Dynamics Observatory as well as the definition of new Spacelab payloads. In the data analysis activities to be carried out at universities and government research centers in FY 1985, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft and ground observatories).

BASIS OF FY 1985 FUNDING REQUIREMENT

SUBORBITAL PROGRAMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Sounding rockets	27,000	27,700	27,700	29,500
Airborne science and applications	17,600	18,900	18,900	22,000
Balloon program	3,500	6,700	5,700	7,200
Total	48,100	53,300	52,300	58,700

OBJECTIVES AND STATUS

The suborbital program uses balloons, aircraft, and sounding rockets to provide 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 domestic and an international cooperative basis.

o Sounding Rockets:

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

In FY 1983, 53 rockets were launched from five launch ranges located in the United States, Canada, and Peru. These rockets supported the research activities of about 26 groups from over 18 universities, NASA field centers, other government agencies and foreign research groups.

One highlight of the FY 1983 program was a highly successful international campaign with Peru to study the properties of the middle atmospheric electrodynamics and aeronomy in the equatorial region. This campaign included the launch of 18 major sounding rockets from Chilca, Peru. One of the significant findings from this campaign is that the electrical conductivity of the middle atmosphere increases in response to radiation received from the X-Ray star Sco-X-1.

In FY 1984, NASA will place emphasis on the transition from sounding rockets to the Shuttle of some of the sounding rocket class payloads in the disciplines of high energy astrophysics, solar physics, and ultraviolet astronomy. FY 1985 funds will provide for continuation of the sounding rocket program described above.

o Airborne Science and Applications:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. For astronomy research, the airborne science and applications program utilizes a C-141 instrumented with the 91-centimeter infrared telescope. The C-141A "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. This aircraft provides a large payload capacity and facilities for extending observations over any region of the Earth, and can operate at high altitudes (nearly 13 kilometers), in order to provide a cloud-free site for astronomical observations and auroral geophysics experiments. The possibility of conducting observations at this altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential to astronomy in opening the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1983, 72 flights were flown to make far-infrared observations, including an expedition to Australia to observe the center of our own galaxy. In FY 1984, approximately 64 flights of the C-141 will be made to continue exploration in the star-forming regions. Data gathered by the Infrared Astronomical Satellite will be used extensively to determine targets of observation. A complete overhaul of the C-141 will also be carried out in compliance with Federal Aviation Administration requirements.

This program also provides flight support to other major segments of the Space Science and Applications program, with an aircraft fleet currently consisting of two U-2C's, one ER-2, one C-130, one CV-990, and a Learjet. These aircraft serve as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites and the Spacelab. The data acquired during these flights are used to refine algorithms and develop ground data handling techniques. An example of such activities is flights in the ER-2/U-2C's to acquire simulated thematic mapper data. Another principal use of the ER-2/U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below orbiting satellites. This use is important in the study of stratospheric transport mechanisms.

In FY **1985,** the airborne science and applications funding will be used to continue operation of the Kuiper Airborne Observatory, to support astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy. Funding will also be used to fly the U-2C's, ER-2, Learjet, and **CV-990,** consistent with the approved aircraft flight program.

o Balloon Program:

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

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, and maintenance and operation of the National Science Balloon Facility (NSBF) at Palestine, Texas. This facility supports the launch of over **95** percent of NASA's balloon payloads, and it is the nation's primary means for carrying out large scientific balloon operations. NASA assumed total funding responsibility for the NSBF, including administrative costs, from the National Science Foundation at the beginning of FY **1984.** Funding for the experiments which are flown on balloons is provided from supporting research and technology programs.

In FY **1983, 44** balloons were flown from launch sites in the United States and Brazil. Over **95** percent of the flights originated in the United States. During FY **1983,** the development of a tethered balloon capability for investigating atmosphere electrodynamics was completed. Three missions were completed with the last one providing four days of flight data.

In FY **1984,** approximately 60 balloon flights are planned to continue scientific research in the areas of atmospheric chemistry, high energy astrophysics, galactic astronomy and solar studies.

The **$1.0** million decrease reflets a general appropriation reduction to the FY **1984** budget request.

The FY **1985** funding will provide for the continuation of the balloon program as well as management and operation of the NSBF. This funding is also required to continue definition activities on potential future long duration balloon flights.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

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

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Life sciences flight experiments..............	24,000	23,000	23,000	27,100	RD-4-4
Research and analysis....	31,700	36,000	35,000	36,200	RD 4-6
lbtal.................................	55,700	59,000	58,000	63,300	
Distribution of Program Amount by Installation					
Johnson Space Center.......................	21,166	20,032	20,728	23,736	
Kennedy Space Center.......................	1,176	1,550	990	1,600	
Marshall Space Flight Center.....,.........	247	267	---	---	
Goddard Space Flight Center................,	85	86	85	85	
Jet Propulsion Laboratory....................	494	1,102	1,363	1,700	
Ames Research Center.......................	22,615	23,128	21,346	24,364	
Langley Research Center....................	314	452	300	400	
Headquarters..............................	9,603	12,383	13,188	11,415	
Total.................................	55,700	59,000	58,000	63,300	

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND PLICATIONS — LIFE SCIENCES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding the response of biological systems to weightlessness; the design of the advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, its origin, evolution, and present state.

The Life Sciences program is the key to developing a capability to sustain a permanent manned presence in space and to utilize the space environment to study living systems. These activities include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes several major elements: operational medicine, which is focused on the health and well being of Space Shuttle crews; biomedical research, which is directed toward understanding and preventing any adverse physiological changes which occur in space flight; advanced life support systems, which is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time; gravitational biology, which consists of flight and ground-based experiments that focus on using microgravity as a biological research tool to understand its effect on plants and animals; exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and biospheric research, which is directed toward understanding the interaction between life on Earth and its physical and chemical environment.

The goals of the Operational Medicine and Biomedical Research programs are to assure astronaut and payload specialist health and ability to function effectively in the space environment. Eventually, experience gained from medical operations in space flight will allow a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is being placed on testing countermeasures designed to prevent physiological problems associated with exposure to the space environment. It is essential that long-term monitoring of spaceflight crews be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: vestibular dysfunction, cardiovascular deconditioning, bone and muscle loss, and radiation damage. This research concentrates on trying to define potential flight experiments and countermeasures, first as spaceflight experiments and ultimately on an operational basis.

The Advanced Life Support System program seeks ways of conducting research to develop technologies for more efficient space suits and life support systems for the astronauts and it also undertakes the scientific work in chemistry and biology necessary to understand how life can be maintained in closed systems which receive only energy from the external environment. All are aimed at potential future needs of long duration manned space flight.

The objective of the Gravitational Biology activities is to further our understanding of basic physiological mechanisms through the use of microgravity in the space environment. Plant and animal experiments have been flown on Soviet Cosmos satellites, on the Shuttle orbital test flight, and on STS missions to date. Experiments are also under development for all Shuttle flights up through the Spacelab 4 mission to explore the physiological effects of space flight on inner ear function, blood factors, bone formation, and plant growth and structure. This information should contribute to the solution of biological and medical problems on Earth as well as contribute to man's effective functioning in space. The unique properties of space (e.g., microgravity) provide an opportunity to explore significant problems in biology under controlled conditions that cannot be duplicated in laboratories on Earth.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sound hypotheses which could lead to discovering the relationships which may link the formation of the solar system and the origin of life. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with the results of planetary flight experiments, are clarifying the mechanisms and environments responsible for the chemical evolution leading to life's origin. Studies of life's origin and evolution will be extended to enhance our understanding of the interaction of the biota with the Earth's present environment, and thereby provide a more comprehensive picture of life--its past, present, and future.

BASIS OF FY 1985 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT EXPERIMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Life sciences flight experiments.....	24,000	23,000	23,000	27,100

OBJECTIVES AND STATUS

The objective of the Life Sciences Flight Experiments program is to assimilate information and scientific questions from the various life sciences disciplines and translate them into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting of medical and biological investigations. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth; however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these changes may prove irreversible. Early Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early response to weightlessness, which will improve the management of several existing problems (e.g., space adaptation syndrome) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities involve the development of life sciences flight experiments to be flown on Spacelabs 2, 3 and 4 and the German-Dl mission (Spacelab-D1). Most of the experiments onboard the early Shuttle flights will serve as pathfinding activities for Spacelab-4, the first Spacelab mission dedicated entirely to life sciences investigations. Hardware and experimental protocols for flights through Spacelab-3 are well developed. Activities on Spacelab-3 will involve evaluation of functional performance and compatibility of hardware that is essential to human and animal investigations which will be conducted on Spacelab-4. Hardware development and mission planning activities are proceeding on schedule for the United States vestibular experiment which will be flown on the German-Dl mission; these are follow-up investigations to those conducted on Spacelab-1.

Twenty-four investigations have been tentatively selected for flight on Spacelab 4. The definition phase activities have been completed and the design and development of the flight hardware is well underway. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight through the use of both human and animal subjects, and key scientific investigations in gravitational biology. Teams of prinicipal investigators will examine cardiovascular adaptation, space adaptation syndrome, muscle atrophy, demineralization of bone, the early anemia of weightlessness, and the effects of weightlessness on plant and animal development. These missions will be unique in several respects: they will be the first Shuttle/Spacelab missions dedicated entirely to life sciences; they will involve highly skilled scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space; and the experiments will employ complementary human and animal investigations in order to validate models for human physiology.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required for the continuing definition and development of hardware which will be flown on future Spacelab missions, i.e., Spacelab-3, D1, 4 and the second dedicated life sciences mission, yet to be designated. Flight hardware integration and experiment development associated with Spacelab-2, 3, and D1 will be completed in preparation for launches in 1984 and 1985. We are now in the process of final experiment selection of investigations for the first life sciences dedicated mission (Spacelab-4). In addition, the selection process for experiments for the follow-on dedicated Spacelab life sciences missions has been initiated through the recent release of a new flight Announcement of Opportunity (AO).

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Life sciences research and analysis.......	31,700	36,000	35,000	36,200

OBJECTIVES AND STATUS

The research and analysis activity of the Life Sciences program is concerned, in part, with ground-based research in basic biology and in those medical problem areas that affect manned spaceflight. The program is comprised of six elements: (1) operational medicine; (2) biomedical research; (3) advanced life support systems research; (4) gravitational biology; (5) exobiology; and (6) biospheric research.

The Life Sciences Operational Medicine program is responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. The program provides the means for assuring the physical welfare, performance, and adequate treatment of in-flight illnesses or injuries. Such conditions as spatial disorientation and fluid and endocrine shifts which can decrease performance, cardiovascular tolerance, and possibly aggravate latent diseases, will be carefully monitored to determine preventive measures. To this end, careful medical selection, periodic evaluation of health status, and in-flight monitoring of the time required for adaptation to the space environment will be continually undertaken.

The Biomedical Research program seeks to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, each designed to rectify a particular physiological problem known or expected to affect the human organism in space. Such problems as motion sickness, bone loss, and electrolyte imbalances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventive measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space.

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

The Gravitational Biology program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal behavior, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth as well as long-term survival and reproduction of life in space.

The Exobiology program is directed toward furthering our understanding of the origin and evolution of life, and life-related molecules, on Earth and elsewhere in the universe. Research, in general, builds on data acquired by missions in planetary exploration and astrophysics to uncover the relationship between the origin and evolution of the solar system and life itself. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on the primitive Earth as related to early chemical and biological evolution.

The Biospheric Research program explores the interaction between the biota and the contemporary environment to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes in global dynamics. Biospheric modelling efforts are focused on integrating biology with atmospheric, climatic, oceanic, terrestrial, and bio-geochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The decrease of $1.0M million in Research and Analysis is the result of a reallocation to Space Telescope development to help solve ST technical problems; this reduction was made possible by the deferral of some planned research activities.

BASIS OF FY 1985 ESTIMATE

In FY 1985, the Operational Medicine program will collect information on occupational exposures in zero-gravity on each Shuttle flight; conduct inflight clinical testing of countermeasures especially in the areas of cardiovascular deconditioning and vestibular problems, and develop health care procedures compatible with the space environment. Medical data will be evaluated in order to better define responses of different population groups to space flight.

In FY 1985, the Biomedical Research program will focus primarily on problems related to vestibular dysfunction because of the high incidence of space adaptation syndrome in Shuttle operations. Psychology, human factors, and the enhancement of performance and efficiency among flight crews are all receiving increased emphasis. Studies of bone loss and of electrolyte imbalance will also be pursued so that potential countermeasures can be devised. Increased exposure to, and awareness and understanding of, the potential radiation hazard from space flight has resulted in more emphasis being placed on the precise measurement of radiation doses, the specific biological effects of cosmic rays, and the identification of possible radiation shielding.

In FY 1985, the Advanced Life Support Systems program will continue to investigate basic biological processes and physical methods to recycle air, water, food and biological waste; and continue definition of concepts for improved space suits and portable life support systems.

In FY 1985, the Gravitational Biology program will focus on continuation of research directed at understanding animal and plant equilibrium, gravity perception, and biotransduction mechanisms, as well as gravity's effect on plant and animal development, structure, and behavior. Increased emphasis will be placed on research that will lead to the development of hypotheses, and provide baseline data for future Shuttle/Spacelab flight experiments.

In FY 1985, the Exobiology program emphasis will be placed on the continuation of such efforts as expanding our knowledge of non-biological mechanisms for synthesis of biologically significant molecules both in space and on the Earth. This research is crucial for gaining further insight into the origin of life, assessing the possibility of these processes occurring elsewhere in the universe, and preparing for future flight experiments.

In FY 1985, the Biospheric Research program will place emphasis on improving our estimating techniques for determining the size and distribution of the terrestrial biomass by combining ground-based measurements with remote sensing data. Additional emphasis will be placed on characterizing biogenic gas fluxes of key atmospheric constituents. This information is required for the development of a better understanding of global bio-geochemical cycles.

In FY 1985, emphasis will also be placed on the formulation of improved approaches to the operational management of space adaptation syndrome. In-flight evaluation of these approaches will be conducted to provide the basis for the development of more effective countermeasures. An interdisciplinary approach to determining how to enhance the capabilities, performance and efficiency of spaceflight crews will also be undertaken. The object of this effort will be to allow humans, to the fullest extent possible, the opportunity to explore and work in space by improving the working environment and by facilitation of the human interaction with the automated devices that can be placed at their disposal.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Galileo development..........................	91,600	79,500	79,500	56,100	RD 5-4
Venus radar mapper mission..................	---	29,000	29,000	92,500	RD 5-6
International solar polar mission...........	6,000	8,000	6,000	9,000	RD 5-8
Mars Geoscience/Climatology Orbiter (MGCO)..................................	---	---	---	16,000	RD 5-10
Mission operations and data analysis..........	38,500	43,400	43,400	58,800	RD 5-11
Research and analysis........................	50,300	45,500	59,500	54,500	RD 5-13
Total..................................	186,400	205,400	217,400	286,900	
Distribution of Program Amount by Installation					
Johnson Space Center........................	7,980	6,800	9,050	8,150	
Goddard Space Flight Center.................	4,073	4,336	3,842	3,357	
Jet Propulsion Laboratory.....................	111,370	139,040	144,474	234,283	
Ames Research Center........................	20,920	12,253	16,623	12,074	
Langley Research Center.....................	2	---	5	---	
Headquarters.................................	42,055	42,971	43,406	29,036	
Tbtal..................................	186,400	205,400	217,400	286,900	

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

The exploration of the giant outer planets began relatively recently. The Pioneer-10 and 11 flybys of Jupiter in 1973 and 1974 were followed by the Voyager-1 and 2 spacecraft. Voyager-1 encountered Jupiter in March 1979 and Saturn in November 1980. Voyager-2 flew by Jupiter in July 1979 and Saturn in August 1981. New data on these planets, their satellites and rings have revolutionized our concepts of the formation and evolution of the solar system. The Voyager-2 spacecraft is headed for an encounter with Uranus in 1986 that will provide our first look at this giant outer planet. Its trajectory will carry the spacecraft on to Neptune in 1989. The Pioneer-10 and 11 and Voyager-1 spacecraft are on trajectories leading out of the solar system, and they continue to return scientific data on the outer reaches of the solar system.

The Galileo mission will be launched to Jupiter in 1986 by the Space Shuttle/Centaur Upper Stage. The comprehensive science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the Voyager and Pioneer missions. During twenty months of operation in the Jovian system, Galileo will have the capability to provide as many as eleven targeted encounters with the Galilean satellites, and an instrumented probe will be injected into Jupiter's atmosphere.

The International Solar Polar Mission (ISPM) is a joint NASA and European Space Agency endeavor that will fly a package of experiments to investigate the Sun at high solar latitudes that cannot be studied from the Earth's position in the ecliptic. The ISPM spacecraft will be launched in 1986 on the Shuttle/Centaur Upper Stage.

The Venus Radar Mapper (VRM) mission, initiated in FY 1984, will provide a global map of the cloud-shrouded surface of Venus. The VRM, using a synthetic aperture radar, will achieve a resolution sufficient to address fundamental questions regarding the origin and evolution of the planet, and will obtain altimetric and gravity data to determine accurately the gravity field, internal stresses, and density variations of the planet's interior. These data will be analyzed so that the evolutionary history of Venus can be compared with the Earth's. The VRM is scheduled for launch in 1988 on the Shuttle/Centaur Upper Stage.

A major new flight program element is a FY 1985 new initiative in response to the Solar System Exploration Committee's recommendations. The Mars Geochemical/Climatology Orbiter (MGCO) will follow-up on the discoveries of Mariner 9 and Viking with emphasis on the geologic and climatic evolution of this complex planet. The MGCO mission will be a relatively low-cost mission due to the use of a modified Earth-orbiting spacecraft, thereby benefitting from industry's investment in development.

The Planetary Exploration program is founded on a coordinated research and analysis program. Research and analysis activities will continue to maximize the scientific return from ongoing and future missions, and from lunar sample and meteorite analysis, ground-based telescope observations, theoretical and laboratory studies, and instrument definition. This program strives for interdisciplinary coordination among various research groups to widely disseminate scientific results. A close coupling is maintained between the research programs and the planning activities that are undertaken to define the scientific rationale and technology needed for potential future missions.

BASIS OF FY 1985 FUNDING REQUIREMENT

GALILEO DEVELOPMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Spacecraft........................	67,524	48,800	55,400	26,300
Experiments........................	8,612	4,500	6,700	8,100
Ground Operations..................	15,464	26,200	17,400	21,700
Total........................	91,600	79,500	79,500	56,100
Space transportation system operations	(12,600)	(35,300)	(37,600)	(35,900)

OBJECTIVES AND STATUS

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and ~~in situ~~ measurements by an atmospheric probe. The scientific objectives of the mission are based on recommendations by the National Academy of Sciences to provide continuity, balance, and orderly progression of the exploration of the solar system.

The 'Orbiter and Probe will be launched together in 1986 as a single combined payload using the Shuttle/Centaur Upper Stage. Arrival at Jupiter will be in late 1988 when the Orbiter will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. Twenty months of orbital operations will follow in which both Jupiter's surface and the dynamic magnetosphere will be comprehensively mapped. Eleven close flybys of Jupiter's major satellites are targeted.

The Galileo flight system will be powered by two general purpose heat-source radioisotope thermoelectric generators (RTG's) being developed by the Department of Energy. The Orbiter will carry approximately 100 kg of scientific instruments and the Probe will carry approximately 25 kg of scientific instruments.

During FY 1984, major activities of the Galileo program will involve completion of the Orbiter subsystems integration and testing, and the flight probe will be integrated with the Orbiter leading to environmental testing in FY 1985.

CHANGES FROM FY 1984 BUDGET ESTIMATE

In total, the FY 1984 estimate remains unchanged from the budget estimate. However, reallocation of funds within the project is required to meet the scheduled milestones in the most efficient manner.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding will provide for completion of the environmental testing of the entire Galileo system; final subsystem and instrument calibration verification will be initiated; and development of the ground systems and the associated software required to support operation of the spacecraft will be continued. The FY 1985 funding is also required for hardware changes necessitated by recent information regarding the Jovian radiation and its potential effect on the Galileo spacecraft as currently designed; based on analysis of Voyager and Pioneer spacecraft data, heavy ion flux in the vicinity of the satellite Io may be more severe than previously assumed. In addition, FY 1985 funds are required to reimburse the Department of Energy for the continued development of the radioisotope thermoelectric power generators for the Galileo mission.

BASIS OF FY 1985 FUNDING REQUIREMENTS

VENUS RADAR MAPPER MISSION

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	---	14,200	15,900	65,800
Experiments	---	11,600	12,600	24,500
Ground Operations	---	3,200	500	2,200
Total	---	29,000	29,000	92,500
Space transportation system operations	(---)	(---)	(500)	(12,300)

OBJECTIVES AND STATUS

The Venus Radar Mapper (VRM) project was initiated at the beginning of FY 1984. The mission objective is to address fundamental questions regarding the origin and evolution of Venus by obtaining global radar imagery of the planet. VRM will also obtain altimetric and gravity data to accurately determine the gravity field, internal stresses, and density variations of the planet's interior. The detailed surface morphology of Venus will be analyzed to compare the evolutionary history of Venus with that of the Earth.

The VRM spacecraft will carry a single major scientific instrument, a synthetic aperture radar, which will be used to obtain high resolution (0.5 to 1.0 km) images and altimetric data of the planetary surface. Gravity data will be obtained by processing radio signals from the spacecraft. The spacecraft will be developed by making extensive use of existing designs, technology, and residual hardware; for example, the spacecraft will use a bus structure, large antenna, and propulsion components from the Voyager program. Spare computers and other equipment will be obtained if available from the Galileo program after the Galileo launch in 1986.

In April 1988, the VRM spacecraft will be launched by the Shuttle/Centaur Upper Stage on a direct trajectory to Venus. Arriving at Venus in July 1988, the spacecraft will perform a retro-propulsive maneuver and enter a near-polar elliptical orbit; after an initial checkout period, the spacecraft will map the planet over a 243 day period (one Venus year).

During FY 1984, major effort on the Venus Radar Mapper program includes the initiation of the design and development activities on both the spacecraft and radar including and initiation of long-lead procurement items.

CHANGES FROM FY 1984 BUDGET ESTIMATE

In total, the FY 1984 estimate remains unchanged from the budget estimate; however, reallocation of the funds within the project has been made based on the contractor development schedule.

BASIS OF FY 1985 ESTIMATE

FY 1985 funds are required to complete the preliminary design reviews for the spacecraft and radar systems, to initiate fabrication of the subsystems, to initiate development of the mission software, and to complete the radar development model.

BASIS OF FY 1985 FUNDING REQUIREMENT

INTERNATIONAL SOLAR POLAR MISSION

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Spacecraft.................,..........	100	3,000	2,200	4,000
Experiments............................	2,300	3,300	1,500	2,100
Ground Operations.......................	3,600	1,700	2,300	2,900
Total............................	6,000	8,000	6,000	9,000
Space transportation system operations...	(12,200)	(35,200)	(36,900)	(37,400)

OBJECTIVES AND STATUS

The International Solar Polar Mission (ISPM) is a joint NASA and European Space Agency (ESA) program wherein ESA will provide the spacecraft and some scientific instrumentation, and the U.S. will provide the remaining scientific instrumentation, the launch, tracking support, and the radioisotope thermoelectric power generators. The mission is designed to obtain the first view of the solar system from outside 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. The ISPM will be launched in 1986 on the Shuttle/Centaur Upper Stage.

The ISPM 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 developing five of the nine principal investigator instruments, and three of the four European investigations have U.S. co-investigators. During FY 1983, the U.S. flight instruments were delivered to the ESA spacecraft developer for integration and system testing. All spacecraft testing has been completed and the spacecraft is being partially disassembled €or storage until launch.

CHANGES FROM FY 1984 ESTIMATE

The decrease of $2.0 million in the FY 1984 estimate is a part of Congressional general reduction; this reduction can be made due to the early delivery of the U.S. instrumentation and because the transition from the Inertial Upper Stage to the Centaur is not expected to be as complex as was previously envisioned.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding is required to support U.S. principal investigators in their mission planning, and retrofitting of the U.S. instruments with the spacecraft prior to shipment to the Kennedy Space Center. In addition, FY 1985 funds are required to complete the ground system development activities and to reimburse DOE for the continued development of the radiosotope thermoelectric power generators.

BASIS OF FY 1985 FUNDING REQUIREMENT

MARS GEOSCIENCE/CLIMATOLOGY ORBITER

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft..........................	---	---	---	6,000
Experiments..........................	---	---	---	5,000
Ground operations....................	---	---	---	5,000
Total...........................	---	---	---	16,000
Space transportation systems operations	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS

The Mars Geoscience/Climatology Orbiter (MGCO) mission is a relatively low-cost inner solar system mission which will utilize a high-inheritance, modified production line Earth-orbital spacecraft, and will have a well defined and focused science objective. The objective of the MGCO mission is to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, topography, figure, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and characterize their interaction with the Martian environment.

The MGCO mission, which is a FY 1985 new initiative, will be launched in 1990 with the Space Shuttle, and be inserted into Martian orbit in 1991, to perform geochemical, geophysical, and climatological mapping of the planet over a period of two years. The planning estimate for total cost of the development and mission operations is in the $300-375 million range. The project will be supported by approximately 48 direct personnel in FY 1985 and a total of 487 man-years over the life of the development activities.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funds are required to initiate the Mars Geoscience/Climatology Orbiter spacecraft design and development activities. An existing Earth-orbital spacecraft derivative will be selected for the MGCO mission based on the recommendation of the Solar System Exploration Committee to identify lower-cost Planetary Exploration missions. The scientific instruments will be selected based on a very focused scientific objective. The MGCO mission is the highest priority planetary exploration mission recommended by the Solar System Exploration Committee.

BASIS Of FY 1985 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Voyager Extended Mission..........	17,400	19,100	19,100	29,400
Pioneer Programs....................	5,100	6,400	6,400	7,000
Planetary Flight Support...........	16,000	17,900	17,900	22,400
Total.........................	38,500	43,400	43,400	58,800

OBJECTIVES AND STATUS

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating--the Pioneer and the Voyager spacecraft. 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 for all planetary spacecraft.

Voyager 1 is now on a trajectory which will take it out of the solar system on a steep angle to the plane of the ecliptic; it will continue to collect data on the outer solar system environment while it also serves as a test bed for sequences and maneuvers to be used by Voyager 2 at Uranus and possibly Neptune. Voyager 2 is proceeding toward a January 1986 encounter with the planet Uranus. Unlike the other planets, the rotation axis of Uranus lies almost in the ecliptic so that its north pole now points at the Sun.

Operation of the Pioneer Venus and the Pioneer 6-11 spacecraft is continuing. The Pioneer Venus orbiter is measuring the dynamic character of the upper Venus ionosphere and its solar wind interaction which resembles that of a comet. The Pioneer 6-9 spacecraft are orbiting the Sun, and data is being acquired when unusual solar phenomena occur. The Pioneer 10 and 11 spacecraft are on a course that will take them out of the solar system in opposite directions while collecting data on the behavior of the diminishing solar wind. The search for gravitational evidence of a tenth planet will also be continued with these spacecraft.

Analysis of data from these missions continues to be rewarding. For example, analysis of the Voyager-1 data has led to the discovery of an oxygen-bearing molecule in the atmosphere of Saturn's satellite Titan, forcing a significant revision in photochemical models. Measurements made by the Mutch Memorial Station (Viking Lander-I) on Mars have provided new insight into the frequency of major dust storms and the transportation of fine soil particles around the landing site.

The planetary flight support activities include design, development and operation of the ground-based planetary navigation system, the ground command and control system, the image processing system, and the ground data handling systems. In addition, the planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory.

BASIS OF FY 1985 ESTIMATE

During FY 1985, the operation and data analysis activities for the Voyager and Pioneer spacecraft will be continued. The FY 1985 planetary flight support funding is required for the continued preparation for the Galileo and ISPM missions and the Voyager-2 encounter with Uranus. The development of the multi-mission space flight operations center at the Jet Propulsion Laboratory will be continued in FY 1985 leading to a versatile control complex that will provide multi-mission data acquisition, telemetry and image processing, and commanding support capabilities for solar system exploration missions including Voyager, Galileo, ISPM, Venus Radar Mapper, MGCO, etc.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND YSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology.....	35,300	34,500	40,900	37,900
Advanced programs.....................	8,500	7,300	9,800	9,000
Mars data Analysis....................	4,300	1,500	5,500	4,300
Halley's comet co-investigations and watch...........................	2,200	2,200	3,300	3,300
Total...........................	50,300	45,500	59,500	54,500

OBJECTIVES AND STATUS

The research and analysis program consists of four elements required to: assure that data and samples returned from flight missions are fully exploited; undertake complementary laboratory and theoretical efforts; define science rationale and develop required technology to undertake future planetary missions; and coordinate an International Halley's Comet Watch and provide co-investigator support to the European Space Agency's Giotto mission to Halley's Comet.

The supporting research and technology program element includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, and instrument definition.

The planetary astronomy activity includes all observations made by ground-based telescopes of solar system objects 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 and Saturn, 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 Venus Radar Mapper mission will be 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 the planetary materials/geochemical funding.

The instrument development and 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 is 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. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been developed by the Solar System Exploration Committee (SSEC), an advisory group, which has recommended a program of "low-cost" but scientifically important potential future missions.

The Mars Data Analysis activity continues to ensure that we capitalize on the wealth of data provided by Viking and earlier missions and that we are scientifically prepared for the next phase of Mars exploration, more specifically, the Mars Geoscience/Climatology Orbiter mission. While continuing to support a variety of scientific investigations, the major emphasis of this program will address the origin and evolution of Martian volatiles.

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

CHANGES FROM FY 1984 ESTIMATE

The increase of **$14.0** million in the **FY 1984** estimate is the result of Congressional appropriations over the **FY 1984** budget request. These funds will be used to continue, at an enhanced level, all of the Research and Analysis programs.

BASIS OF FY 1985 ESTIMATE

During **FY 1985**, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and in the development of required technology to undertake future missions. Telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. 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, in FY **1985**, 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 and Saturnian satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in **FY 1985** to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition for potential future missions will also be continued.

The **FY 1985** Halley's Comet Co-Investigations and Watch funding is required to support U.S. co-investigators involved in the European Space Agency's Giotto mission, and to provide support for a Jet Propulsion Laboratory managment team and several scientists at other institutions, who are establishing a worldwide network for the astronomical study of Halley's Comet.

In addition, the **FY 1985** funding is required to continue to operate both the Infrared Telescope Facility and the Lunar Curatorial Facility.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

SOLID EARTH OBSERVATIONS PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Landsat-4	58,400	15,800	16,800	---	RD 6-4
Extended mission operation	1,100	1,000	---	---	RD 6-6
Shuttle/Spacelab payloads	14,500	15,000	16,000	18,100	RD 6-7
Geodynamics	28,100	28,000	28,000	29,900	RD 6-9
AgRISTARS	15,000	---	---	---	---
Research and analysis	11,800	14,600	14,600	15,600	RD 6-11
Tbtal	128,900	74,400	75,400	63,600	

Distribution of Program Amount by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center	14,425	2,319	3,730	3,300
Marshall Space Flight Center	275	214	300	400
Goddard Space Flight Center	91,496	50,478	53,733	40,600
Jet Propulsion Laboratory	12,084	14,069	13,986	15,300
Ames Research Center	800	638	500	600
National Space Technology Laboratories	2,095	1,081	1,300	1,400
Headquarters	7,725	5,601	1,851	2,000
Tbtal	128,900	74,400	75,400	63,600

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Solid Earth Observations program are to develop space observations and experimentation techniques to further the understanding of the global, physical, chemical, and biological processes involving the land areas of the earth and interactions of the land areas with the earth's oceans and atmosphere; to improve our ability to systematically evaluate the composition and geometry of the Earth's mineral and energy resources; and to increase our understanding of the Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and mechanisms associated with the occurrence of earthquakes.

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

Another important aspect of the Solid Earth Observations program is the research associated with understanding the physical relationship of electromagnetically sensed phenomena to the radiation emitted or reflected by various types of surface features of the Earth; the development of models to increase our understanding of global processes; and the evaluation of the use of space-derived data along with other data sources in meeting the research needs of the scientific community.

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information which is needed to: understand the processes leading to the release of crustal strain in the form of earthquakes; improve our understanding of the formation of mineral deposits; contribute to long-term weather and climate forecasting; and better understand the Earth as a planet. Space techniques such as laser ranging to satellites and the Moon, and very long baseline interferometry using radio stars or satellites, are the only methods which can provide the precise measurements needed for these studies.

Landsat-4, launched on July 16, 1982, has continued to provide Multispectral Scanner and Thematic Mapper images for many applications in civil remote sensing. NOAA assumed operational responsibility for the Landsat-4 spacecraft and the Multispectral Scanner in January 1983. NASA will retain responsibility for the Thematic Mapper operations and data processing through FY 1984. The Landsat-D prime spacecraft has been removed from storage and modified to correct for anomalies developed in orbit with Landsat-4, in preparation for launch in March 1985.

The objective of the Shuttle/Spacelab payload development project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid earth observations research. Both the Shuttle Imaging Radar, which was flown on the Shuttle orbital test flight in November 1981 to evaluate the utility of spaceborne imaging radar for geologic exploration, and the Shuttle Multispectral Infrared Radiometer which was used to determine the optimum spectral bands for surface materials classification, operated successfully. The Large Format Camera, required for high resolution mapping applications, is being prepared for launch on the Shuttle in 1984. The next generation Shuttle Imaging Radar is also under development leading to a 1984 Shuttle launch.

The Multispectral Linear Array (MLA) advanced technology development activities are being focused on the development of a future high performance MLA instrument which can be used as a diagnostic tool for fundamental research in remote sensing. The MLA solid-state sensor has a number of significant features such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research on the linear array instrument and the Shuttle Imaging Spectrometer is being continued in FY 1985.

Along with the Environmental Observations program, the Solid Earth Observations activities compose an integral part of NASA's total Earth sciences and applications effort with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

BASIS OF FY 1985 FUNDING REQUIREMENT

LANDSAT-4

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft systems and sensors..........	17,000	1,300	1,000	---
Ground systems..........................	21,000	2,500	3,600	---
Ground operations.......................	13,600	9,600	4,600	---
Investigations..........................	6,800	2,400	7,600	---
Total..............................	58,400	15,800	16,800	---
Delta (expendable launch vehicles programs)............................	(6,300)	(2,600)	(2,600)	(---)

OBJECTIVES AND STATUS

The objective of the Landsat-4 program was to develop, launch, and operate an advanced land observing system, and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental Thematic Mapper (TM) and the flight-proven Multispectral Scanner (MSS). Landsat-4 was successfully launched in July 1982. The Landsat-4 backup spacecraft (Landsat-D prime) will be launched in 1984. The major technical focus of the Landsat-4 program involved a test of the Thematic Mapper's capabilities and an improved ground data handling system. The Thematic Mapper offers higher resolving power and greater spectral coverage than previous instruments. These advantages promise to open up a significant number of new uses of Landsat data and enhance many current uses.

The National Oceanic and Atmospheric Administration (NOAA) assumed control of Landsat-4 operations in January 1983. NASA will retain responsibility for operation of the TM and associated data processing until it becomes fully operational in January 1985. The Landsat-D prime spacecraft has been removed from storage and modified to correct anomalies developed in-orbit with Landsat-4 in preparation for launch in March 1984. NASA is currently conducting a study to determine if the Landsat-4 spacecraft should be placed into a lower orbit after Landsat-D prime becomes operational so that it may be available for a possible future retrieval by the Space Shuttle.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase in the FY 1984 estimate is the result of the transfer of $1.0 million from Extended Mission Operations, as operation of the Landsat 3 spacecraft has been terminated, The additional funds will be used to enhance the Thematic Mapper data processing activities.

BASIS OF FY 1985 ESTIMATE

There is no requirement for FY 1985 funds.

BASIS OF FY 1985 FUNDING REQUIREMENT

EXTENDED MISSION OPERATIONS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousand of Dollars)		
Landsat-2 and 3......................	1,000	1,000	---	---
Magsat.......	100	---	---	---
lbtal........................	1,100	1,000	---	---

OBJECTIVES AND STATUS

The objective of extended mission operations was to capitalize on the continued performance of Solid Earth Observations program satellites beyond the initial planned mission duration. Data products from these missions are being used to support research and operational activities in agriculture, water resources, geology, and land use. In the case of Landsat, some operational requirements of federal and state agencies, plus many private interests will continue to be satified.

Completion of Magsat data analysis was accomplished in 1983. Landsat 3 operations have been terminated.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The decrease of $1.0 million in FY 1984 is the result of the termination of the Landsat-3 operations. These funds were transferred to Landsat-4 to be used for the Thematic Mapper data processing.

BASIS OF FY 1985 ESTIMATE

There is no requirement for FY 1985 funds.

BASIS OF FY 1985 FUNDING REQUIREMENT

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of	Dollars)	
Payload development................	3,800	5,000	5,400	5,900
Large format camera...............	1,100	700	600	200
Multispectral linear array.........	9,600	9,300	10,000	12,000
Total........................	14,500	15,000	16,000	18,100

OBJECTIVES AND STATUS

The objective of this project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research.

In FY 1984, preparations are continuing for the flights of the Large Format Camera (LFC) and the Shuttle Imaging Radar-B (SIR-B). The Large Format Camera is required for high resolution mapping applications. The new attitude reference system for the LFC has been completed, and the launch of the LFC is scheduled for 1984. The SIR-B will obtain a quantitative assessment of the effect of various radar viewing geometries on the mapping of surface texture and topographic features. The SIR-B instrumentation is based on an upgraded SIR-A instrument including the addition of a variable look angle antenna, digital data handling, and increased bandwidth and resolution. Data will be recorded on board and transmitted via the Tracking and Data Relay Satellite System (TDRSS).

The focus of the Multispectral Linear Array (MLA) technology development is on a future high performance MLA instrument for use as a diagnostic tool utilizing the Space Shuttle for fundamental research in remote sensing and the development of advanced spectrometer technology. The MLA class of solid state sensors has a number of significant features, such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase in the FY 1984 estimate is the result of additional appropriations over the FY 1984 budget request. The additional funding has been applied to development of the MLA Shuttle experiment, which will be the first spaceborne test of the MLA technology and will be flown in 1987, and to the Shuttle Imaging Radar development and data analysis activities.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required for operation of the Large Format Camera and the Shuttle Imaging Radar-B (SIR-B) plus data analysis. FY 1985 funding is also required for continued development of the Multispectral Linear Array experimental instrument.

BASIS OF FY 1985 FUNDING REQUIREMENT

GEODYNAMICS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Crystal dynamics project..................	18,400	17,500	17,500	18,700
Laser network operations..................	7,000	7,500	7,500	8,000
Research and technique development....	2,700	3,000	3,000	3,200
Total..............................	28,100	28,000	28,000	29,900

OBJECTIVES AND STATUS

The objective of the Geodynamics program is to increase our understanding of the solid Earth by studying the movement and deformation of its tectonic plates; its rotational dynamics, and its internal dynamics and structure. The program uses space techniques for precise positioning to determine how the plates are moving; how crustal strain is accumulated and released at plate boundaries; and how the Earth's polar motion and rotational rate interact with variations of mass distributions in the Earth's atmosphere, oceans, core and mantle. Models of the Earth's global gravity and magnetic fields are developed in order to improve our understanding of the structure and dynamics of the Earth and to aid in studies of large scale ocean circulation. Over the long term, geodynamics research will also contribute to our understanding of earthquake mechanisms, the geophysical processes associated with the formation of petroleum and mineral deposits, and help to gain a clearer understanding of the form and extent of mantle convection and the origin of the Earth's magnetic field.

BASIS OF FY 1985 ESTIMATE

The plate motion and regional crustal deformation measurements (in the western U.S, Alaska, Mexico, and South America) will be continued in FY 1985. The Pacific Plate motion experiments with Japan will be repeated and studies will be initiated in the Mediterranean with some European countries. Operation of the Laser Network will also be continued in FY 1985. In addition, theoretical studies of crustal motion and internal core dynamics, and modeling and interpretation of geopotential fields will be continued in FY 1985.

In FY 1985, the Crustal Dynamics Project will continue the development of laser ranging and microwave interferometric systems and, in cooperation with 16 other countries, will be acquiring data on the contemporary movement of most of the major tectonic plates.

Acquisition and processing of laser data for sites in the United States, the Pacific, South America, and Australia will be continued in FY 1985. In addition, the Laser Geodyamics Satellite (LAGEOS) will continue to be used for studies of plate motion. This data is being used to improve gravity field models and has recently detected changes in the Earth's gravity field. Under a tentative agreement with Italy, a joint program is being planned for a second LAGEOS mission wherein the mission will be developed by Italy and launched by the U.S.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Fundamental research..............	2,800	3,500	3,500	3,600
Geological processes..............	4,500	5,600	5,600	5,500
Land processes....................	4,500	5,500	5,500	5,500
Remote sensing....	---	---	---	1,000
Total........................	11,800	14,600	14,600	15,600

OBJECTIVES AND STATUS

The major objectives of the Solid Earth Observations Research and Analysis program are to develop remote sensing technology and to apply such technology to the study of the Earth's land surface.

Sensor system technology currently under development is needed to obtain measurements of Earth radiation in various portions of the electromagnetic spectrum. Typical questions encountered in this type of research concern the precision that can be achieved with specific techniques and tradeoffs involved when using specific sensor systems. Research is also conducted to develop procedures for extracting information about the Earth's surface from remotely sensed data. This type of research is concerned with such topics as pattern recognition; image segmentation and classification; modeling of scene components; atmospheric effects in remotely sensed imagery; data base manipulation and merging; etc. This wide range of technique development activities is designed to provide a new set of unique tools for Earth related research of both a basic and applied nature.

The Research and Analysis program also involves the application of remote sensing methods to the study of the Earth. Research is typically conducted within specific disciplinary fields to determine the various types of ecological, geological, and hydrological information that can potentially be inferred from remotely sensed data. Global Earth phenomena currently under study includes the influence of vegetation upon the global carbon dioxide budget and other biogeochemical cycles, and rock weathering in arid regions. A wide range of topical problems have tentatively been identified as likely candidates for future research studies of an interdisciplinary nature.

In ecology and gy the focus is on understanding how d processes, most of which are mediated by vegetation, interact with global processes relating to climate, the hydrological cycle, and the various biogeochemical cycles. The principal satellite sensors employed are the Thematic Mapper, the Landsat Multispectral Scanner, and the Advanced Very High Resolution Radiometer; but significant inputs are also expected from other sensors such as the Shuttle Imaging Radar. In geology, research is underway to evaluate the utility of different remote sensing techniques for geological mapping, and to apply techniques of proven utility to the study of the Earth's crust. These basic crustal studies are expected to lead to an improved understanding of the physical processes responsible for the concentration of geological resources within the Earth's crust.

In addition, feasibility and conceptual design studies of future sensors and missions are being conducted to ensure future capabilities in remote sensing of Earth resources.

Select remote sensing projects are jointly conducted with outside cooperating organizations to apply remote sensing technology in a problem oriented setting. Joint research projects will continue to be carried out with public and private sector organizations involving predictive permafrost modeling in the Alaskan Arctic biomes; wetlands stratification for biogeochemical cycle modeling; assessment of vegetative stress from acid rain; crop condition assessment and monitoring; cropland conversion; timber resource inventory; facility site selection and waste disposal impact assessment; and land capability analysis. In addition, nine multi-disciplinary, university-based remote sensing centers will be maintained for the purpose of research, test, and evaluation of emerging remote sensing techniques.

BASIS OF FY 1985 ESTIMATE

During FY 1985, the research and analysis disciplines will make use of the data from Landsat-4 Thematic Mapper. New radar data from the SIR-B will also be used to conduct further research. The FY 1985 Research and Analysis program will focus on the analysis of this new data to improve our understandings of long-term land processes, and develop some techniques for merging multisensor/multispectral data sets. Fundamental remote sensing science research on scene radiation and atmospheric effects will be continued, as will pattern recognition and image analysis. Advanced mission studies will be continued with emphasis on Shuttle-borne sensor feasibility and space platform payloads.

Investigations are being conducted in FY 1985 to extend our basic understanding of sensor-target relationships in the optical, thermal, and microwave portions of the spectrum. Results to date indicate microwave measurements can be used to model vegetation canopies according to leaf, branch, and trunk components. This research also supports generic technique development to extract the full potential of information found in the image data; results to date include a technique which can be used to identify spatially-related spectral patterns in image data which improves discrimination, for instance, between forested and agricultural fields, as well as between different densities of forest canopy.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

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

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Upper atmosphere research and analysis.......	27,700	29,600	28,500	31,000	RD 7-6
Atmospheric dynamics and radiation research and analysis.....................	26,500	28,400	27,500	28,500	RD 7-8
Oceanic processes research and analysis......	17,000	18,200	18,200	19,400	RD 7-10
Space physics/research and analysis......	15,200	15,700	16,700	16,700	RD 7-12
Shuttle/Spacelab payload development.........	3,700	7,600	7,600	7,800	RD 7-14
Operational satellite improvement program....	6,000	600	600	---	RD 7-16
Earth radiation budget experiment............	24,000	15,500	15,500	8,100	RD 7-17
Extended mission operations..................	22,800	27,400	27,400	29,500	RD 7-19
Interdisciplinary research and analysis......	---	---	---	1,000	RD 7-21
Tethered satellite payloads..................	---	---	---	3,000	RD 7-22
Scatterometer.............................	---	---	---	15,000	RD 7-23
Upper atmosphere research satellite mission..	14,000	20,000	20,000	60,700	RD 7-24
Tbtal.,................................	156,900	163,000	162,000	220,700	

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center	175	170	200	800
Marshall Space Flight Center	4.368	6.830	5.200	9.046
Goddard Space Flight Center	100.032	93.939	96.615	133.136
Jet Propulsion Laboratory	19.947	24.091	21.950	38,973
Ames Research Center	4.136	3.614	4.335	4.650
Langley Research Center	7.368	8.716	9.203	7,856
Lewis Research Center	100	---	---	---
Headquarters	20.774	25.640	24.497	26.239
Total	156.900	163.000	162.000	220.700

OFFICE OF SPACE SCIENCE AND APPLICATIONS — ENVIRONMENTAL OBSERVATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Environmental Observations program are to improve our understanding of the processes in the magnetosphere, atmosphere, and the oceans; to provide space observations of parameters involved in these processes; and to extend 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 solely, observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, plasma acceleration, and dynamic processes occurring in the magnetosphere, atmosphere, and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimization of the use of space-derived measurements in understanding large scale weather patterns; advances in our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; an improved knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction; and a comprehensive understanding of solar terrestrial processes and a detailed determination of the physics and coupling between the solar wind, magnetosphere, and ionosphere.

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 and dedicated spacecraft, 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 to collect appropriate data, through remote and in situ means, which will address specific program objectives.

Studies of the upper atmosphere have led to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone, and a report is being forwarded to the Congress in January 1984. The revised assessment of the predicted impact is somewhat less severe; this assessment is the result of improved precision in our continuing program of laboratory chemical kinetics measurements.

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

The Upper Atmospheric Research Satellite (UARS) will place a set of instruments in Earth orbit which will make a comprehensive measurement of the state of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which are presently unattainable. Detailed definition studies of the instruments have been completed, and the design and development activities have begun. In FY 1985, design and development activities will be initiated on the UARS observatory.

The development of the Earth Radiation Budget Experiment (ERBE) and the Solar Backscatter Ultraviolet instrument development is proceeding on schedule toward a 1984 launch. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOAA) by managing the implementation of the NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis. Preparations are proceeding to launch NOAA-F in 1984.

Design and development activities will be initiated on a Scatterometer, which will be flown on the Navy Remote Ocean Sensing System (N-ROSS), in late 1988 to acquire global ocean data.

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

Virtually all of the data from the Seasat mission has been archived and much of the Nimbus-7 ocean data has been analyzed. This information is being used to define potential low cost approaches to the use of demonstrated ocean observing techniques to address a variety of ocean research challenges.

The Nimbus spacecraft continue to collect unique data sets to aid in the study of long term trends of the Earth's atmosphere, oceans and polar ice. The Solar Mesosphere Explorer (SME) data collection over the last year has made a major contribution to the study of the El Chichon volcano. The Dynamics Explorer-1 continues to collect valuable data on magnetosphere-ionosphere coupling processes. In addition, the ISEE-3 spacecraft, renamed International Cometary Explorer, has completed an exploration of the Earth's geomagnetic tail and is being redirected toward a the planned encounter in 1985 with the comet Giacobini-Zinner.

Along with the Solid Earth Observations program, the Environmental Observations activities compose an integral part of NASA's total Earth sciences and applications effort with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

BASIS *OF* FY 1985 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Upper atmospheric research.............	16,500	17,650	17,000	18,700
Stratospheric air quality research......	6,000	6,400	6,150	6,400
Tropospheric air quality.....	5,200	5,550	5,350	5,900
Total............................	27,700	29,600	28,500	31,000

OBJECTIVES AND STATUS

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric air quality research and tropospheric air quality research.

In particular, the goal of the upper atmosphere research program is to understand the physics, chemistry and transport processes in the atmosphere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities. In order to accomplish this, efforts are underway to: (1) improve upper atmosphere and global troposphere models, validate them, and assess their uncertainties; (2) measure important trace chemical constituents, temperature, and radiation fields throughout the atmosphere; (3) develop sensors capable of making chemical and physical measurements of the upper atmosphere and the global troposphere both directly and remotely from space; (4) assemble and maintain the existing long-term data base of stratospheric and tropospheric ozone measurements to aid in the detection of long-timescale natural variations and man-made ozone changes; (5) determine the effects of global tropospheric chemistry on the atmosphere; (6) conduct theoretical and field studies of tropospheric/stratospheric exchange; and (7) carry out laboratory kinetics and spectroscopy investigations to support these activities.

A variety of ~~in situ~~ and remote sensing techniques are needed to meet the objectives of determining and understanding the distribution of ozone and other trace species in the atmosphere. Data sets from satellites are now generally available to the scientific community including a record of the global distribution of ozone extending back over a decade, and simultaneous observations of a number of trace constituents for the winter of 1978-79. This data is being exploited to determine if trends in the ozone amount has been detected and to understand those processes which are directly involved with these trends. A new assessment of the state of the upper atmosphere and its susceptibility to change has been prepared for delivery to Congress and the Environmental Protection Agency in January 1984. This assessment predicts smaller changes in the future level of ozone due to emissions of chlorofluorcarbons.

CHANGES FROM PY 1984 ESTIMATE

The decrease of $1.1 million in FY 1984 is the result of a transfer of funding to Space Telescope development to help solve technical problems being encountered; this decrease is being made available through the deferral of selected activities.

BASIS OF FY 1985 ESTIMATE

The most recent assessment of changes in the ozone layer has uncovered more diversity in the model predictions than expected, plus the combined effect caused by the addition of several gases to the atmosphere; thus additional study is required. During FY 1985 model calculations and interpretation of satellite data will be used to try to resolve as many of these questions as possible. The development of more realistic two- and three- dimensional models will be continued. The global data sets from past and current satellites will be further analyzed to help understand large-scale processes at work in the upper atmosphere and the distribution of tropospheric carbon monoxide.

The intercomparison of balloon, aircraft, and ground-based measurements will be continued to ensure the validity of the different techniques that have been developed and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere; they also help to validate satellite observations. Studies of potential new instruments for use on future satellites and suborbital measurement platforms will be conducted to ensure that new technologies are put to use in improving the capability and cost efficiency of tropospheric composition and upper atmosphere measurements.

BASIS OF FY 1985 FUNDING REQUIREMENT

ATMOSPHERIC DYNAMICS AND RADIATION RESEARCH AND ANALYSI

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Global-Scale Processes Research and Analysis	12,500	13,400	12,900	13,400
Mesoscale Processes Research and Analysis	7,000	7,500	7,300	7,550
Climate Research and Analysis	7,000	7,500	7,300	7,550
Total	26,500	28,400	27,500	28,500

OBJECTIVES AND STATUS

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program's three main thrusts are in the areas of global-scale processes research, mesoscale processes research and climate research.

The objectives of the global scale research program are to improve our understanding of large-scale atmospheric behavior and to develop improved capability to observe the atmosphere from space; the program involves the development of advanced remote sensing instrumentation to observe the atmosphere, the development of advanced analysis techniques to better utilize existing meteorological satellite data, and development of advanced numerical models which use satellite observations to describe the state of the atmosphere both diagnostically and predictively. Recent accomplishments include the development of techniques which utilized passive multispectral data from the NOAA operational satellites to provide global maps of a number of key atmospheric and surface parameters. In addition, special attention has Seen devoted to developing active lidar techniques to provide detailed profiles of atmospheric temperature, pressure, and moisture data from spaceborne platforms. Simulations of these advanced techniques indicate a great potential in meteorological prediction capability.

The objectives of the mesoscale processes research program are to improve our understanding of the behavior of the atmosphere on short (minutes to hours) time scales and over local to regional size scales (severe weather, such as tornadoes and hurricanes). Since the characteristic parameters of these mesoscale processes cannot be measured directly, new techniques are under study to derive the information from other observations which can be directly measured. Such an activity requires advanced data handling and analysis techniques which rely upon man-computer interactive display and manipulation. A joint NASA-NOM project of this type was completed and is known as the Centralized Storm Information System. In the area of remote sensor development, successful flights of instrumentation on the ER-2 aircraft to observe cloud top dynamics have been completed, and a feasibility study of a potential lightning mapper has been completed.

The Climate Research Program seeks to develop a space capability for global observations of climate parameters which will contribute to our understanding of the processes that influence climate and its predictability. Research is focused in accordance with the National Climate Program wherein NASA has the role of lead agency for solar and earth radiation research. Future study thrusts will be aligned with programs of solar irradiance monitoring, earth radiation budget monitoring and analysis, the distribution and effect of cloud systems and stratospheric aerosols on the radiation budget, and selected process studies which relate to monitoring of climate change. The past year's activities have included extensive flight surveys to monitor the effect of the El Chichon volcanic aerosols on the climate, successful launch of the International Satellite Cloud Climatology Project (ISCCP), development of the First ISCCP Regional Experiment (FIRE), publication of an extensive Antarctic Sea Ice Atlas, and continuing support for solar irradiance monitoring activities through the flight of active cavity radiometers on Spacelab 1.

CHANGES FROM FY 1984 ESTIMATE

The decrease of $.9 million in FY 1984 is the result of a transfer to Space Telescope development to help solve ongoing technical problems. The decrease was made available by the deferral of selected activities

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required to conduct aircraft flights to study the detail of flows around thunderstorms and fronts, continue comparison of models, study atmospheric scale interactions, and develop techniques to display model outputs in 3-dimensions. Other activities will involve continued retrieval and archiving of global International Satellite Cloud Climatology Project data sets, analysis of data from the Earth Radiation Budget Experiment and the Stratospheric Aerosol and Gas Experiment, and continued ground based and rocket flight support for solar irradiance monitoring. Technology development of active temperature, pressure, and moisture sounders as well as basic lidar technology development will also be continued in FY 1985.

BASIS OF FY 1985 FUNDING REQUIREMENT

OCEANIC PROCESSES RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Research and analysis..................	17,000	18,200	18,200	19,400

OBJECTIVES AND STATUS

The Oceanic Processes Research and Analysis program emphasizes the development and application of spaceborne observing techniques to advance our understanding of the fundamental behavior of the oceans, as well as to assist users with the implementation of operational systems. As such, the program operates in concert with a variety of federal agencies (Defense, NOAA, NSF) and foreign countries (Canada, Europe, Japan).

The analysis of Seasat data has demonstrated the technical feasibility of utilizing satellite altimetry data to determine the surface topography of the ocean, from which surface currents can be estimated, and scatterometry data to determine the surface roughness of the ocean, from which surface winds can be estimated. Definition of global ocean altimeter and scatterometer technology are key elements in such an effort. NASA is currently reviewing the possibility of combining these activities with the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean/Global Atmosphere (TOGA) program, two international ocean-related activities being planned under the auspices of the World Climate Research Program, to study global ocean circulation.

An analysis of Coastal Zone Color Scanner data from Nimbus-7 has demonstrated the feasibility of utilizing satellite color scanners to determine near-surface chlorophyll concentrations. In addition to real-time cruise planning, this imagery can be used to quantitatively relate variations in biological activity to variations in the surrounding physical environment.

Recent analysis has also demonstrated the feasibility of both active and passive satellite microwave systems for determining characteristics of sea ice cover. For example, NASA plans to use data from the future microwave radiometer aboard the Defense Meteorological Satellite to estimate global sea ice cover, and to use the synthetic aperture radar aboard the European Space Agency's ERS-1 spacecraft to estimate detailed changes in the ice pack. Ultimately, this data will be used to try to relate how the circulation of the oceans and their sea ice cover mutually respond to changes in atmospheric forcing, how primary productivity responds to changes in nutrient distributions as affected by ocean currents, and how the oceans themselves affect our climate.

BASIS OF FY 1985 ESTIMATE

During FY 1985, analyses of both Nimbus-7 and Seasat data will be continued. Work will also be continued on the pilot ocean data system with major thrusts being focused on planning a data processing and archival facility for the Scatterometer which is being flown on the Navy's N-Ross mission, and the future TOPEX mission. Additionally, archival facilities will be established, in concert with NOAA, for sea ice data derived from the Defense Meteorological Satellite Program/Special Sensor for Microwave Imaging.

FY 1985 funds are also required to continue the definition of observational capabilities to advance our understanding of fundamental ocean behavior. For example, definition of the Ocean Topography Experiment (TOPEX), which will employ an altimeter to acquire information on global sea surface height, which is needed to determine ocean circulation, will be continued during FY 1985. These studies will be directed toward refining the design, performance, and cost of the proposed TOPEX program. In particular, satellite definition studies with industry, initiated in FY 1984, will be continued, as will breadboarding of the critical technology areas.

BASIS OF FY 1985 FUNDING REQUIREMENT

SPACE PHYSICS RESEARCH AND ANALYSIS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Plasma physics SR&T and data analysis........	8,824	10,800	10,800	11,500
Advanced technology development......	3,500	1,800	2,800	1,900
Solar terrestrial theory..	2,876	3,100	3,100	3,300
Total............................	15,200	15,700	16,700	16,700

OBJECTIVES AND STATUS

The space physics research and analysis program 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. These studies include: the complex coupling of the atmosphere with the ionosphere and the magnetosphere; the solar wind and how it interacts with planetary magnetospheres and ionospheres; and how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere. This discipline also includes the conduct of active experiments to extract information under controlled conditions and the use of space as a laboratory for the study of plasmas in parameter regimes that are unattainable on the Earth. The understanding of the plasmas in the solar system, the only naturally occurring plasmas to which we have direct access, will also enable us to refine theories regarding astrophysical plasma processes.

The major thrust of the space physics program is directed at studies of the near Earth environment, from the flow of solar wind past the magnetosphere, to manifestations of variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest to the Earth sciences community, but also there are other practical components concerned with these aspects, 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.

This field of research is one of relative maturity, with emphasis on multipoint and time sequence measurements and on active perturbation experiments rather than isolated exploratory observations. For example, there are presently three spacecraft systems--the Interplanetary Monitoring Platform, the

International Sun-Earth Explorer (ISEE) and the Dynamics Explorer taking such measurements. In addition, the Active Magnetospheric Particle Tracer Explorer (AMPTE), which is scheduled for launch in 1984, will be releasing tracer plasmas and making space and time measurements. There is an active program of sounding rocket and balloon investigations aimed principally at spatially or temporally isolated atmospheric, ionospheric or magnetospheric phenomena. An active theoretical and modeling program and a small supporting laboratory program are also being conducted.

The solar terrestrial theory program continues to provide a strong basis for all of the programs in both solar physics and space plasma physics. Theoretical groups are engaged in research on virtually every aspect of the solar terrestrial problem by using both fundamental process calculations and numerical models of the large scale phenomena.

CHANGES FROM PY 1984 ESTIMATE

The increase of $1.0 million is the result of additional appropriations in FY 1984. These funds will be used to enhance the definition activities on the Origin of Plasmas in Earth's Neighborhood (OPEN) mission.

BASIS OF FY 1985 ESTIMATE

During FY 1985, NASA will continue its program of suborbital investigations, theoretical and laboratory studies, and analyses of existing data from spacecraft. Particular emphasis will be placed on the analysis of data from ISEE-3, which has spent most of 1983 in the Earth's magnetotail. It is being redirected to encounter the comet Giacobini-Zinner in 1985 (ISEE-3 was recently renamed to be the International Cometary Explorer). Definition studies will be continued during FY 1985 on such missions as the potential cooperative European Origin of Plasmas in Earth's Neighborhood mission, which will be renamed the International Solar-Terrestrial Physics Mission and on Shuttle/Spacelab missions such as the Space Plasma Lab and chemical release investigations for a support to the DOD Combined Chemical Release and Radiation Effects Satellite (CRRES).

The solar terrestrial theory program will be continued during FY 1985 to research the full range of phenomena in this portion of the environment. Steps will be taken to build a comprehensive and quantitative aggregate model of the solar terrestrial interaction.

BASIS OF FY 1985 FUNIDNG REQUIREMENT

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT (ENVIRONMENTAL OBSERVATIONS)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Measurement of air pollution from satellites (MAPS)....................	400	500	500	650
Atmosphere trace molecules observed by spectroscopy (ATMOS)...............	2,100	2,000	2,000	2,000
Active cavity radiometer (ACR, ACRIM)...............................	700	2,500	2,500	2,000
Light detection and ranging (LIDAR)............................	300	1,700	1,700	2,000
Principal investigator instrument development and reflight program.....	200	900	900	1,150
Tbtal............................	3,700	7,600	7,600	7,800

OBJECTIVES AND STATUS

The Space Transportation System offers the unique opportunity for frequent short-duration flights of instruments. The Environmental Observations 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.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on the Shuttle orbital flight test in November 1981. The instrument performed successfully and obtained approximately 40 hours of data on the global distribution of carbon monoxide in the atmosphere. The MAPS experiment has been approved for a series of reflights on OSTA-3, currently scheduled for launch in 1984; and OSTA-5 and OSTA-7 scheduled for launch in 1986 and 1987, respectively. In addition, to provide data on seasonal variations of carbon monoxide, a flight of MAPS on EOM-1 (Environmental Observations Mission) in mid-1985 is being considered.

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 is scheduled for launch in 1984 on Spacelab-3.

In response to an Announcement of Opportunity, a number of principal investigator class instruments were selected for development and flight as part of the Shuttle/Spacelab payloads program. Payloads under development include Active Cavity Radiometer-I (ACR-1) which is designed to aid in the study of the Earth's climate and the physical behavior of the Sun. A reflight of ACR-I is currently under review. Other experiments have also been selected for reflight, including some instruments which were flown on the shuttle orbital flight tests and on Spacelab 1.

BASIS OF FY 1985 ESTIMATE

FY 1985 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 and new data recorder.

The initial flight of the Atmospheric Tracer Molecules Observed by Spectroscopy (ATMOS) instrument is scheduled for 1984. The FY 1985 funding is required to support the continued science team activities, data processing and analysis of the data, and refurbishment reflight in 1986.

FY 1985 funding is also required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on a future Shuttle mission. Definition studies of a potential free-flyer version of ACR will also be undertaken. The principal investigator instrument development and reflight program will be continued in FY 1985 with research efforts concentrated on atmospheric chemistry, solar intensity and variability, and upper atmospheric winds.

During FY 1985, preliminary definition and breadboard laboratory activities will be conducted on the Light Detection and Ranging (LIDAR) instrumentation. Discussions are underway with the French regarding the possibility of this becoming a cooperative project.

BASIS OF FY 1985 FUNDING REQUIREMENT

OPERATIONAL SATELLITE IMPROVEMENT PROGRAM (OSIP)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Improvement of operational satellite systems..	6,000	600	600	---

OBJECTIVES AND STATUS

The objective of operational satellite improvement program is to perform research and development activities leading to the definition of advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites. Current activities include the development of the solar backscatter ultraviolet (SBUV) instrument for monitoring of ozone fluctuations in the upper atmosphere; assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; and implementation of improvements to the high resolution infrared sounder (HIRS).

Delivery of the first unit of the solar backscatter ultraviolet instrument for integration and launch on NOAA-F occurred in 1983. The design of the high resolution infrared sounder instrument improvements is in process and will be implemented in the units to be flown on NOAA-H, I and J. The NASA Operational Satellite Improvement program is being phased out in FY 1984.

BASIS OF FY 1985 ESTIMATE

No FY 1985 funding is required.

BASIS OF *FY* 1985 FUNDING REQUIREMENT

EARTH RADIATION BUDGET EXPERIMENT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Spacecraft........................	12,000	4,700	5,100	---
Sensors...........................	9,000	2,650	3,400	---
Missions operations and data analysis....	3,000	8,150	7,000	8,100
Total........................	24,000	15,500	15,500	8,100

OBJ AND STATUS

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the Earth's radiation budget to gain basic insight into the causes €or climatic fluctuations.

Experimental Earth radiation budget instruments have been flown on the Nimbus satellites. sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. These studies also indicate the need for improved calibration of the sensors and measurements covering at least one full cycle of seasons. In order to provide adequate and meaningful coverage, identical Earth radiation budget instruments will be installed on the NOAA-F and G satellites and on one dedicated NASA observatory. The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

Development of the ERBE instruments is complete and sensors have been delivered for NOAA-F and ERBS; delivery for NOAA-G will occur in early 1984.

In addition to the ERBE instruments, the NASA observatory will carry the Stratospheric Aerosol and Gas Experiment (SAGE II). This instrument, which will provide aerosol measurement data, has been delivered and integrated with the observatory.

The Earth Radiation Budget Satellite (ERBS) was completed in 1983 along with instrument integration. Environmental testing will be completed in early 1984 with shipment of the observatory to the Kennedy Space Center in mid-1984. The ERBS observatory will be launched by the Shuttle to an altitude of 300 km and will then be propelled to the operational altitude of 600 km by an auxiliary onboard propulsion system. ERBS and NOAA-F are scheduled for launch in 1984 and NOAA-G is scheduled for launch in 1986.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The FY 1984 budget estimate is unchanged in total; however, the redistribution of funds within the ERBE project was required to cover increases in the instrument and spacecraft cost. Certain mission operations and data analysis activities have been rephased in accordance with the rescheduling of the NOAA-F launch.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding is required to support the operation and data acquisition of ERBS and NOAA-F and analysis of the data for updating the climate models.

BASIS OF FY 1985 FUNDING REQUIREMENT

EXTENDED MISSION OPERATIONS (ENVIRONMENTAL OBSERVATIONS)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Operations for the extended mission of:				
Nimbus 7	7,900	8,000	7,900	7,700
Stratospheric aerosol and gas experiment (SAGE)	500	100	300	---
Solar mesosphere explorer (SME)	1,000	2,500	2,500	2,300
Solar backscatter ultraviolet instrument/correlative measurement	800	900	1,500	1,650
Earth radiation budget experiment extended operations	---	---	---	900
Active magnetospheric particle tracer explorer extended operations	---	---	---	800
International Sun-Earth explorers	3,000	5,650	5,600	6,600
Interplanetary monitoring platform	600	650	600	650
Dynamics explorer	9,000	9,600	9,000	8,900
Total	22,800	27,400	27,400	29,500

OBJECTIVES AND STATUS

The objectives of the extended mission operations is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations.

Launched in 1978, the Nimbus-7 spacecraft continues to provide significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color. Preliminary evaluation of data has demonstrated the utility of these measurements, and the instrument techniques are being used on operational satellites. Reduction and validation of this data is continuing, as is the operation of the satellites themselves. There is a strong demand for historical and current data on radiation budget, atmospheric dynamics, and trace constitutent concentrations and distribution; all of this data is used for global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis, and Earth climate studies.

Data analysis of measurements provided by the Stratospheric Aerosol and Gas Experiment (SAGE), which was launched in January 1979, will be completed in FY 1984.

The Solar Mesosphere Explorer (SME), launched in October 1981, is providing major input into our overall atmospheric parameter data base. SME is producing simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere, including data measurements of ozone, atomic oxygen, nitric oxide and temperature. All instruments are functioning well. Early data results indicate greater short-term variations and magnitude than was expected of many of the mesospheric properties. SME also continues to make measurements of the El Chichon volcanic cloud. Not only is this data valuable for understanding the short-term impact of volcanoes on the Earth's atmosphere, but it will provide data for use in the study of El Chichon's long-term effect on the climate. A ground truth program to aid in the validation of the SME data is also being undertaken.

Solar terrestrial research activities rely on data received from the International Sun-Earth Explorers, the Interplanetary Monitoring Platform (IMP), and the Dynamic Explorers which are still operational. The ISEE-3 spacecraft, renamed the International Cometary Explorer (ICE), is presently travelling toward a rendezvous with the Giacobini-Zinner Comet in 1985.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required to support mission operations and data analysis activities on the International Sun-Earth Explorers (now International Cometary Explorer), the Interplanetary Monitoring Platform and the Dynamic Explorers. Activities will also begin in FY 1985 for possible extended operations support of the Active Magnetospheric Particle Tracer Explorer. Operation, processing, and validation of data from Nimbus and SME satellites will be continued in FY 1985 as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA weather satellite. These satellites continue to produce extremely valuable data on ozone concentrations which will be used to estimate the occurrence of natural variations, sea surface temperatures, aerosol measurements, and ocean productivity. In addition, necessary correlative ground truth activities will be continued in FY 1985; these in situ observations are needed to verify the quality of remote observations and improve our ability to interpret them.

In FY 1985, extended mission operations and data analysis support will be provided for the Earth Radiation Budget Experiment (ERBE), which is planned for launch in 1984, and the International Cometary Explorer (formerly named ISEE-3) which will rendezvous with the Giacobini-Zinner Comet.

BASIS OF FY 1985 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Interdisciplinary &search and Analysis.....	---	---	---	1,000

OBJECTIVES AND STATUS

Interdisciplinary research activities need to be conducted to quantitatively characterize chemical, physical, and biological processes on the land, along with the interactions between the land, the Earth's oceans, and 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.

BASIS OF FY 1985 ESTIMATE

In FY 1985, initiation of interdisciplinary studies is required to integrate the discipline-specific research activities of Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Tropospheric Chemistry, and Land Processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on initiating specific pilot studies in land-atmosphere and ocean-atmosphere interactions in energy, water, and key nutrient cycles.

BASIS OF FY 1985 FUNDING REQUIREMENT

TETHERED SATELLITE PAYLOADS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Tethered Satellite Payloads.............	---	---	---	3,000

OBJECTIVES AND STATUS

The Tethered Satellite System (TSS) will provide a new facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The TSS will allow unique science to be undertaken such as observations of atmospheric processes occurring within the lower thermosphere (below 180 km altitude), new observations of crustal geomagnetic phenomena, and direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125-180 kilometer region. In addition, the satellite, coupled to the conducting tether, can generate large amplitude hydromagnetic waves and electrodynamic waves in the local space plasma; thus enabling active space plasma and magnetospheric physics experiments to be performed. The objective of the initial TSS mission is to verify the controlled deployment, retrieval and on-station stabilization of the satellite tethered from the orbiter, and to carry out scientific research using a conducting tether extended 20 km above the orbiter. NASA is providing the scientific payloads for the initial flight of the TSS which is scheduled for launch in 1987.

The TSS is an international cooperative project with the Italian government, wherein the United States is developing the tether deployment system, is responsible for overall project management, system integration, and flight on the Shuttle, and for development of the instruments to be flown on the first mission. Italy is developing the satellite and is responsible for instrument and experiment integration into the Tethered Satellite.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding is required to initiate the design and development of the scientific instruments for the first test flight of the Tethered Satellite System which is scheduled for launch in 1987.

BASIS OF FY 1985 FUNDING REQUIREMENT

SCATTEROMETER

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Scatterometer..............................	---	---	---	15,000

OBJECTIVES AND STATUS

The purpose of the Navy Remote Ocean Sensing System (N-ROSS) is to acquire global ocean data for operational and research usage by both the military and civil sectors; and a Scatterometer sensor is required to meet the objectives of this mission. NASA will provide the Scatterometer sensor and the Department of Defense will provide the N-ROSS spacecraft and launch services for a launch in late 1988.

The Scatterometer will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to satisfying Navy operational requirements for providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, provide data on feedback effects of the oceans on the atmosphere, and provide improved marine forecasting (winds and waves). Flight of the N-ROSS in late 1988 will provide an overlap of data gathering with the World Ocean Circulation Experiment planned by the international oceanographic community. The feasibility of using the Scatterometer technique from space to accurately measure winds was demonstrated by Seasat in 1978.

Definition studies conducted by NASA during FY 1983 and early FY 1984 have resulted in a determination that the performance requirements as stated jointly by the research community and the Navy can be satisfied by utilizing system design concepts similar to those used on the Seasat Scatterometer. The major improvements include the addition of two antennas for improved wind direction determination and the addition of digital filtering to compensate for earth rotational effects. Additionally, preliminary definition of a ground data processor, which will utilize research quality algorithms to process the scatterometer raw data into geophysical products for utilization by the oceanographic and meteorological research communities, has been completed.

BASIS OF FY 1985 ESTIMATE

In FY 1985, design and development of the N-ROSS Scatterometer will be initiated leading to the scheduled launch in late 1988. In particular, long-lead time contracts must be initiated in FY 1985.

BASIS OF FY 1985 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft.............................	---	---	---	25,700
Experiments.....	14,000	20,000	20,000	35,000
Total............................	14,000	20,000	20,000	60,700

OBJECTIVES AND STATUS

The Upper Atmosphere Research Satellite (UARS) program is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission 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 NASA's overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics which will be required when very difficult decisions must be made in the future 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.

A final selection of eleven experiments has been made, including infrared and microwave limb sounders requiring advances in cryogenics, solid-state devices and microwave antennas beyond earlier capabilities. The instrument design and development activities are underway; also the central ground data handling facility, which will permit near-realtime interactive utilization of data by the twenty-one design and theoretical investigator teams, is being defined. Preparations for initiation of procurement activities for the UARS mission are also underway.

The planning estimate of the UARS mission is in the **$630-700** million range. A total of **90-100** direct civil service manyears is required in FY **1985** to support the UARS design and development activities, and a total of **560-570** direct manyears is required to support the UARS mission through launch in late **1989.**

BASIS OF FY 1985 ESTIMATE

The FY **1985** funds are required for continuation of the design and development of the UARS instruments, for continuation of science team research and algorithm development, for continued definition of design requirements for the ground data handling facility, and for initiation of the spacecraft design and development activities.

The instruments continue to be the long-lead time elements of the UARS program. Although there is considerable technological heritage for these instruments, timely development and testing requires that substantial instrument design and interface definition effort be accomplished in FY **1985.** In addition, procurement of long-lead spacecraft elements must be initiated in FY **1985.**

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 it be designed early in the UARS design and development activities so that individual experiment data processing subsystems, including algorithms, and the interactive data base can be designed for maximum interaction and effectiveness.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

MATERIALS PROCESSING IN SPACE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and Analysis...............	13,100	14,000	11,000	11,700	RD 8-3
Materials Experiment Operations....	8,900	7,600	12,600	11,300	RD 8-5
Total........................	22,000	21,600	23,600	23,000	
Distribution of Program Amount by Installation					
Johnson Space Center..............	660	1,100	1,595	2,000	
Marshall Space Flight Center.......	11,652	7,200	10,240	7,300	
Lewis Research Center.............	1,572	1,650	4,075	4,5 50	
Langley Research Center...........	630	400	560	750	
Jet Propulsion Laboratory........ ..	3,841	5,200	5,060	5,900	
Headquarters......................	3,645	6,050	2,070	2,500	
Total........................	22,000	21,600	23,600	23,000	

PROGRAM OBJECTIVES AND JUSTIFICATION

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1984 are being concentrated on six major processing areas: metals and alloys, electronic material, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. These activities will provide the scientific basis for future space applications of materials processing technology as well as providing a better understanding of how these processes occur on the ground. Definition studies will be performed for Shuttle experiment candidates in areas such as containerless experiments, combustion science, solidification and crystal growth, and blood storage. Also included are maintenance of capabilities for experimentation in drop tubes and towers, and aircraft. An outreach program, consisting of technical publications, workshops, experiment accommodation studies and support for Joint Endeavor and Technical Exchange Agreements, are included in this program.

Materials Experiment Operations is a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the materials processing program. These include Shuttle mid-deck experiments, the Materials Experiment Assembly and the Materials Science Laboratory, which is carried in the orbiter bay. These capabilities will enable users to develop different experiments in a cost-effective manner and allow a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, reflight of investigations on Shuttle/Spacelab missions and the mid-deck is provided for in Materials Experiment Operations.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (MATERIALS PROCESSING)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of	Dollars)	
Ground-based investigations, analysis and studies............	13,100	14,000	11,000	11,700

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects in the microgravity science and applications program. Emphasis is placed on ground-based research which is expected to evolve into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities, and commercialization activities leading toward privately funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1984 funding is being used to support ongoing research in infrared detector materials, spherical shell technology, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processing, combustion science, and containerless processing techniques. Commercialization activities will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in microgravity science and applications projects, and early negotiations and continuing technical support with companies interested in undertaking joint space endeavors with NASA.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The decrease of $3.0 million in FY 1984 is the result of a realignment of program funding between ground-based and flight research, which more properly reflects the current and planned activities. It does not reflect a change in emphasis in the Materials Processing in Space program.

BASIS OF FY 1985 ESTIMATE

Ground-based research and analysis will be continued in FY 1985 in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, fluid dynamics and transport phenomena. Research will be conducted to define the role of gravity-driven influences in generic processing methods. Effort will also be continued on establishment of university centers for bioprocessing research and a microgravity research lab at the Lewis Research Center. In addition, FY 1985 funding is required to support the physics and chemistry experiments in space (PACE) activities which were previously funded by the Office of Aeronautics and Space Technology (OAST). These activities are being transferred from OAST as the technology has been developed to the point where it is now ready for potential application in space.

MATERIALS EXPERIMENT OPERATIONS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Materials experiment operations..	8,900	7,600	12,600	11,300

OBJECTIVES AND STATUS

The materials experiment operations program provides a wide range of opportunities for scientific and commercial experiments in microgravity science and applications. Development of Shuttle mid-deck experiments are supported under this activity. The first materials experiment assembly hardware was launched in 1983, and early data analysis has shown promising results.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $5.0 reflects the transfer of $3.0 million from Materials Processing Research and Analysis to be more consistent with ongoing and planned activities, and the addition of $2.0 million, consistent with Congressional Committee request. The additional $2.0 million will be used to support the development of experimentation in areas such as blood storage, isoelectric focusing, crystal growth, and containerless processing.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required to continue basic and applied research activities using mid-deck and cargo bay experiments leading to several flights over the next few years which will include investigations using the first version of the acoustic containerless processing equipment and the first low gravity test of a method (isoelectric focused electrophoresis) for the separation of biological materials.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS | COMMUNICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of	Dollars)		
Research and analysis	5,100	8,500	8,500	9,100	RD 9-3
Search and rescue	3,700	3,800	3,800	2,400	RD 9-5
Technical consultation and support studies	2,600	2,700	2,700	2,900	RD 9-7
Experiment coordination and operations support	1,000	1,100	1,100	1,200	RD 9-8
Advanced communications technology satellite	20,000	5,000	5,000	5,000	RD 9-10
Total	32,400	21,100	21,100	20,600	

Distribution of Program Amount by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Goddard Space Flight Center	4,249	4,300	4,600	4,300
Jet Propulsion Laboratory	2,107	5,400	4,275	3,350
Ames Research Center	265	200	620	680
Lewis Research Center	24,629	10,200	10,243	11,050
Marshall Space Flight Center	---	100	---	---
Headquarters	1,150	900	1,362	1,220
Total	32,400	21,100	21,100	20,600

OBJECTIVES AND STATUS

In FY 1984, the research and analysis program continues to support the development of component and device technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. This technology development will address requirements identified in recent tests of proof-of-concept hardware associated with the Advanced Communications Technology Satellite (ACTS) ground test program and Department of Defense programs.

The Search and Rescue program is an international cooperative program that demonstrates the use of satellite technology to detect and locate aircraft or vessels in distress. "he United States, Canada, France, and the Soviet Union developed the system, in which Norway, the United Kingdom, and Sweden also participated. Two COSPAS satellites and one Search and Rescue-equipped satellite (NOAA-E) are currently in operation. Over 120 lives have been saved in numerous incidents in Canada, the U.S., and Western Europe, and the list continues to grow on a weekly basis.

The technical consultation and support program will continue to provide for studies of radio interference, propagation, and special systems required for the growth of existing satellite services and the extension of new satellite applications. Support to the Department of State, the Federal Communications Commission, the National Telecommunications and Information Administration, and the Federal Emergency Management Agency in the development of frequency and orbit sharing techniques and strategies for upcoming World Administrative Radio Conferences (WARC's) will continue.

The experiment coordination and operations support program assists other federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster and public service applications. The Applications Technology Satellites (ATS) 1, 3 and 5 will continue operating until FY 1985, at which time operations will be transferred to universities.

A contract will not be awarded for the Advanced Communications Technology Satellite (ACTS) flight program; however, technology development and ground testing will be continued in FY 1984 on components for future communication satellites.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (COMMUNICATIONS)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Research and analysis..................	5,100	8,500	8,500	9,100

OBJECTIVES AND STATUS

The Communications Research and Analysis program provides the high-risk technology required to ensure continued U.S. preeminence in the field of satellite communications. In FY 1983, the preliminary phase of the proof-of-concept program was successfully completed. This program demonstrated the laboratory feasibility of technology needed to alleviate orbit and radio frequency spectrum congestion and enable cost-effective growth in the capacity of communication satellite systems.

FY 1984 efforts will concentrate on the continuing development of large-scale integrated circuit functions needed to reduce power and weight of a flight baseband processor for future communication satellites. The implementation of various approaches to a more practical and efficient hardware design for modulator/demodulators for the baseband processor will begin, and the development of high efficiency and low cost traveling wave tube transmitters for space and ground terminal applications will be initiated. The development of proof-of-concept 30 GHz solid state ground terminal transmitters and antennas will be completed and preparation for the development of transmitter applications of 20 GHz devices will get underway. In-house evaluation of proof-of-concept hardware, integrated into an ACTS-type transponder, is being initiated in FY 1984. Intersatellite link technology, which emphasizes the development of devices and components, will be continued with the focus on preliminary proof-of-concept hardware design.

Research and analysis efforts are also directed toward defining the ground segment (i.e., mobile and base station equipment) and networking technology for a first generation mobile communications satellite service. This is a joint study with industry and Canada to define a two-way radio, radio telephone and low-speed message and data service to mobile terminals operating in rural and non-metropolitan areas. In November 1983, NASA signed an agreement with the Canadian Department of Communications to cooperate in the definition phase of the program. In FY 1984, a Notice of Opportunity will be released to solicit U.S. industry participation.

BASIS OF FY 1985 ESTIMATE

During FY 1985, the Communications research and analysis program will continue to address unresolved technology issues and risk-reducing tasks related to the proof-of-concept program in support of future communication satellites. In addition, definition of 20 GHz solid state transmitters utilizing improved devices will be initiated. In-house evaluation of the proof-of-concept transponders will continue in FY 1985 under simulated space flight conditions. Radiation hardening of baseband processor memory circuits will also be undertaken in FY 1985. The development of traveling wave tube transmitters (space and ground) and intersatallite link transmitters (space) will be continued. Ground terminal technology efforts will include proof-of-concept modems, codecs and field effect transistor, low noise receivers. Monolithic technology for large matrix switch arrays and antenna beam forming networks will also be pursued. All appropriate research and analysis efforts will continue to be coordinated with the Department of Defense. In FY 1985, mobile terminal breadboard development will be completed.

In addition to broadband spectrum and orbit conserving technologies, very high data rate technologies associated with future Shuttle payloads, low-earth orbital platforms and geosynchronous platforms will be continued in FY 1985. Low data rate technologies for public service, disaster/emergency and law enforcement applications will also be pursued, and studies to define advanced communications system concepts and requirements will be initiated.

BASIS OF FY 1985 FUNDING REQUIREMENT

SEARCH AND RESCUE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Search and rescue..........................	3,700	3,800	3,800	2,400

OBJECTIVES AND STATUS

The Search and Rescue program is demonstrating the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate general aviation aircraft and marine vessels during emergencies. This satellite system provides comprehensive coverage which enables rescue forces to arrive at accident scenes quickly.

The first satellite within the framework of the joint COSPAS/SARSAT project was launched by the Soviet Union on June 30, 1982. In March 1983, the second COSPAS satellite and the first SARSAT-equipped satellite, NOAA-E, was successfully launched. All three of the satellites are operating quite well. Ground stations and control centers are in regular operation in the U.S., Canada, France, the USSR, Norway, and the United Kingdom. The performance of the combined satellite/ground system has equaled or exceeded expectations in terms of sensitivity, accuracy, and ground coverage.

Although the demonstration and evaluation phase of the program has just begun, the results achieved to date indicate that the demonstration will be a success and that an operational system can be implemented. The next five NOAA satellites will be equipped with SARSAT instruments providing two-satellite coverage for the balance of the 1980's.

BASIS OF FY 1985 ESTIMATE

During FY 1985, work on the NOAA -H, -I, and -J spacecraft, and improvements to the ground stations, will be completed. Beginning in 1985, the major emphasis of the search and rescue program will shift from providing basic spacecraft and ground system coverage at 121.5 MHz, which has been the central focus of the program since 1978, to research and development activities required to permit the most effective possible operational system for the 1990's, based on a 406 MHz system.

The development of distress transmitters will be continued in FY 1985 and experiments using geosynchronous spacecraft to relay 406 MHz signals to complement the polar satellites will be conducted. In addition, a special purpose ground station compatible only with the 406 MHz system will be developed as a prototype for the potential international system of the 1990's.

BASIS OF FY 1985 FUNDING REQUIREMENT

TECHNICAL CONSULTATION AND SUPPORT STUDIES

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Technical consultation and support studies............................	2,600	2,700	2,700	2,900

OBJECTIVES AND STATUS

The technical consultation and support program provides the technical basis for regulatory and policy development needed 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 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 orbit and radio spectrum.

Program personnel recently completed three years of preparation for, and participated in, the 1983 Region 2 Administrative Radio Conference on planning for the Broadcast Satellite Service in the Western Hemisphere. Numerous technical and policy papers were prepared to provide the foundation for U.S. positions, many of which were ultimately adopted. A special spectrum and orbit utilization computer program was developed and chosen as an international standard for analyzing intersystem interference. Other accomplishments include the anticipated initiation of a Public Rulemaking Proceeding in the early spring of 1984 to establish a Commercial Land Mobile Satellite Service. This Proceeding is the culmination of almost ten years of technology development, economic analyses, user experiments, propagation studies, and regulatory proceedings. The end product is expected to be a commercial service owned and operated by the private sector by 1988.

BASIS OF FY 1985 ESTIMATE

Major emphasis during FY 1985 will continue on studies, experiments, spectrum and orbit utilization computer program updating, and regulatory processes, to assure the growth of space communications and bring into being new capabilities in data collection, multifunctional/multifrequency satellites, and thin-route communications. U.S. strategies, positions, and technologies will be developed and propagation experiments conducted to support U.S. positions at three International Telecommunications Union World Administrative Radio Conferences to be held in Geneva during the 1985-1988 time frame. Decisions reached at these conferences will directly affect our country's access to the geostationary orbit and radio spectrum

EXPERIMENT COORDINATION AND OPERATIONS SUPPORT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Experiment coordination and operations support..........................	1,000	1,100	1,100	1,200

OBJECTIVES AND STATUS

The objective of this program is to appropriately document and archive a wide range of user experiments and demonstrations in the application of satellite communications. Past experiments on experimental satellites such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have generated great interest nationally and internationally in satellite telecommunications. Nearly 400 communications experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites, thus providing users with the experience necessary for making informed decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities has led to wider application of commercial satellites, which can better meet the need for flexibility and continuity of services.

More than twenty organizations are currently using the ATS-1 and ATS-3 satellites for communication experiments. ATS-3 is supporting emergency medical experiments conducted in conjunction with the Southern Regional Medical Consortium (SRMC). The SRMC experiments determine the value and cost effectiveness of mobile communications via satellite for emergency notification, vehicle dispatch, and two-way voice and biomedical telemetry between paramedics and hospital physicians. Efforts toward rural, wilderness, and offshore oil rig applications are emphasized. Similarly, in the Pacific basin, ATS-1 connects 22 islands and provides disaster relief, medical, educational, and emergency service. ATS-1 has recently been repositioned from $149^{\circ}W$ to $198^{\circ}W$ longitude in an effort to extend its useful life to the Pacific users. This satellite service has been a valuable asset to Pacific users who, prior to ATS-1, received their news 24 hours after the fact.

BASIS OF FY 1985 ESTIMATE

Operational support for ATS-1 will be assumed by the University of Hawaii and for ATS-3 by the University of Miami in FY 1985, when the NASA Satellite Tracking and Data Network (STDN) facilities are dismantled. NASA will continue to maintain approval and policy control of the ATS program. Other FY 1985 activities will include continued planning for educational and public service communications; the development of low-cost Intelsat compatible ground terminals and alpha-numeric portable ground terminals; and the continuing support for the management and operatio of the Denver Satellite Access Facility The definition of experiments for a Advanced Communications Technology Satellite (ACTS) ground test program, and the Mobile Satellite will be also continued in FY 1985.

BASIS OF FY 1985 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Advanced Communications Technology Satellite........,...................	20,000	5,000	5,000	5,000

OBJECTIVES AND STATUS

The objective of the Advanced Communications Technology Satellite (ACTS) program is to prove the feasibility of certain advanced communications satellite technologies through a ground test program. The specific technologies to be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequencies and at baseband; (d) advanced system network concepts; and (3) dynamic rain-compensation techniques. These technologies will be applicable to a wide range of communications systems in the 1990's.

The ACTS program has been restructed to encompass only an experimental ground test program which will involve the development of a multi-beam communcations package similar to that proposed for ACTS. The objective of this program is to keep U.S. industry competitive in the world marketplace. A contract will not be awarded in January 1984 as previously planned for the ACTS flight program; however, technology development and ground testing efforts will be continued.

BASIS OF FY 1985 ESTIMATE

FY 1985 funding is required to continue ACTS technology development and ground testing activities based on the restructuring of the ACTS program into a ground test program to verify future communications satellite required components.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — **INFORMATION SYSTEMS PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Data systems..............................	7,500	8,900	7,900	8,400	RD 10-2
Information systems......................	---	---	1,000	7,800	RD 10-2
Total..............................	7,500	8,900	8,900	16,200	

Distribution of Program Amount by Installation	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Marshall Space Flight Center.............	75	100	10	11
Goddard Space Flight Center..............	2,875	4,525	4,064	11,058
Jet Propulsion Laboratory..................	4,045	4,100	4,311	4,584
Headquarters....	505	175	515	547
Total..............................	7,500	8,900	8,900	16,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — INFORMATION SYSTEMS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Information Systems program are to: develop and demonstrate advanced capabilities of managing, distributing, and processing data and information; implement information systems standards and provide common software in order to lower data systems costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and the space science and applications projects.

This program provides for timely development of data system capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data systems development risks and the chance of late data delivery.

CHANGES FROM FY 1984 ESTIMATE

The FY 1984 estimate has not been changed in total; however, the program has been divided into two elements which is more representative of the way in which the program is managed.

BASIS OF FY 1985 ESTIMATE

The FY 1985 Information Systems funding is required to provide support for space science and applications programs. Specifically, funds are required to continue development of the oceans, climate, planetary, and land pilot projects, which are system engineered to support those disciplines at the Jet Propulsion Laboratory, Goddard Space Flight Center, and universities; to complete implementation of on-line catalogs and common software for climate, oceans, and land data which support ongoing research; and to continue development of data management and data archiving with flight projects, discipline program offices, and other NASA program offices. In addition, the FY 1985 funding is required to support operation of the Science and Applications Computer Center, the National Space Science Data Center, and the Hi-Speed Vector Computing Facility at the Goddard Space Flight Center. Operation of these facilities was previously funded within Physis and Astronomy Mission Operations and Data Analysis and the Environmental Observations Program.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 BUDGET ESTIMATES

BUDGET SUMMARY

OFFICE OF EXTERNAL RELATIONS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Technology dissemination............ ...	5,800	2,200	5,500	5,800	RD 11-4
Technology applications..................	3,200	1,800	3,500	3,700	RD 11-4
Total...............................	9,000	4,000	9,000	9,500	

Distribution of Program Amount by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center...................	---	---	140	325
Kennedy Space Center...................	188	55	530	260
Marshall Space Flight Center...........	261	195	393	480
National Space Technology Laboratories	20	---	50	250
Goddard Space Flight Center............	929	380	929	840
Jet Propulsion Laboratory................	870	265	475	435
Ames Research Center...................	259	105	98	160
Langley Research Center................	771	435	721	910
Lewis Research Center..................	187	240	242	360
Headquarters..........................	5,515	2,325	5,422	5,480
Total...............................	9,000	4,000	9,000	9,500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 BUDGET ESTIMATES

BUDGET SUMMARY

OFFICE OF EXTERNAL RELATIONS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REOUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Technology dissemination.....	5,800	2,200	5,500	5,800	RD 11-4
Technology applications.................	3,200	1,800	3,500	3,700	RD 11-4
Total...............................	9,000	4,000	9,000	9,500	
Distribution of Proaram Amount bv Installation					
Johnson Space Center...................	---	---	140	325	
Kennedy Space Center...................	188	55	530	260	
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Lewis Research Center..................	187	240	242	360	
Headquarters	5,515	2,325	5,422	5,480	
Total...............................	9,000	4,000	9,000	9,500	

PROGRAM :S AND ICATION

The NASA Technology Utilization Program enhances the national economy and industrial productivity through a series of interactive processes designed to transfer aerospace technology evolving from NASA's R&D base to nonaerospace sectors of the U.S. economy. Almost every part of the U.S. industry is touched by the transfer process, especially such areas as automation, electronics, and materials. In the public sector, medicine, rehabilitation, and safety are but a few of the areas receiving benefit. The specific objectives of the program are:

- o Acceleration and facilitation of the application and use of new technology, thus shortening the time between generations of advanced aeronautics and space technologies and their infusion into the economy;
- o Encouragement of multiple secondary uses of NASA technology in industry, education, and Government, where a wide spectrum of technological problems and needs exist;
- o Understanding more fully the technology transfer process and its impact on the economy; and
- o Development of applications of NASA's aerospace expertise, with its technology, technologists and unique facilities, to priority nonaerospace needs of the Nation.

Since the Program's inception in FY 1962, many transfer mechanisms have been developed to facilitate the use of aerospace technology in the public and private sectors of the economy. These mechanisms include publications and announcements, industrial conferences, and seminars. Through such efforts, NASA has developed a viable working relationship with U.S. industry across a broad front of commercial enterprises. In FY 1985, NASA proposes to build on its technology transfer activities to strengthen expanded Government-industry cooperation.

OBJECTIVES AND STATUS

Conversion of NASA Tech Briefs, one of NASA's principal new technology transfer and announcement mechanisms, to a commercially viable, private sector publication, is scheduled for implementation in FY 1985. Pending this conversion, NASA has continued the free distribution of NASA Tech Briefs to 75,000 industrial scientists, engineers and businessmen on a quarterly basis to stimulate and promote secondary application and use of NASA-developed technologies for commercial purposes. It is anticipated that subscriber circulation will grow beyond the current level as a private sector periodical.

During the past year, thousands of U.S. industrial firms have been provided computerized access to NASA information through the NASA-sponsored dissemination center network. Technology transfer services growing out of this information, have focused on a wide array of problems specified by network industrial clients. These firms, especially those in the industrial manufacturing and research sectors, have found network information and technology transfer services to be beneficial in the development of new or improved products or processes. The NASA-supported center for computer software dissemination realized the highest level of activity yet in the sale/lease of NASA-developed computer programs for industrial use. Overall, the entire university-based dissemination network received nearly $4.5 million from industry last year for information products and technology transfer services, underscoring the continued interest and importance which these programs have in industry.

Emphasis during FY 1983 was placed on bioengineering, rehabilitation, manufacturing, and automation applications. Most of the projects funded during FY 1983 had joint participation from user agencies or industry. A major milestone was reached in bioengineering, when industry received the Food and Drug Administration's approval to implant numerous automatic defibrillators in human subjects. In addition, the Federal Emergency Managment Agency and industry adopted a NASA simulation concept to train firefighters; and industry has committed to apply NASA composite technology to several new industrial concepts. Two other highlights during FY 1983 were the commitment of industry to develop the percutaneous shunt, which is an ion beam textured pyrolytic carbon device that allows quicker and less painful access to the bloodstream far hemodyalysis, chemotherapy, etc.; and Klystron, power-efficient microwave tubes for communication, such as TV broadcasting.

CHANGES FROM FY 1984 ESTIMATE

The increase of $5.0 million in FY 1984, which is the result of Congressional action on the FY 1984 appropriation request, will provide for dissemination activities at approximately the FY 1983 level, and will allow continuation of ongoing as well as some new efforts in technology applications, This funding will also provide for increased dissemination activities in support of small business activities.

BASIS OF FY 1985 ESTIMATE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Technology dissemination...............	5,800	2,200	5,500	5,800

In FY 1985, NASA will continue to realign and improve its technology dissemination system, with particular emphasis on system efficiencies, centralization of information search capabilities, and modernization of the communications media. Such efforts will reduce technology transfer unit cost, improve capabilities to serve broader industrial user markets nationwide, and increase information product systems to match critical technological needs in industry. Realignment and restructuring of NASA dissemination programs will also be accomplished to promote greater awareness and involvement of State governments in relation to their initiatives to enhance the technological and economic growth of their respective industries. Particular effort will be made to serve high technology firms and high growth areas in U.S. industry through closer interactive processes between industrial users and NASA scientific and engineering capabilities.

In addition, NASA will encourage private sector involvement in commercialization of space and use of space-related technologies for industrial research and development purposes. Such efforts will include the conduct of NASA executive management symposia for major U.S. nonaerospace firms, analyses of extended commercial markets dependent upon NASA-developed technology, etc.

Technology applications................	3,200	1,800	3,500	3,700

In FY 1985, NASA will consolidate the transfer of NASA-developed technologies into three main thrusts: automation and electronics; materials; and bioengineering and rehabilitation.

The overall objective of each of these thrusts will be to transfer aerospace technology through adaptive or applications engineering projects supported by industry or interagency cost-sharing. NASA will participate with industry, other federal agencies and universities to support several high priority engineering projects. Applications team activities will be maintained in support of selected feasibility studies designed to apply existing aerospace technology to electronics, materials and industrial automation problems identified in cooperation with other government agencies, public sector medical organizations, universities and industry.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1985 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

	Budget Plan			
		1984		1985
	1983 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Aeronautical research and technology.........	280,000	300,300	302,300	342,400
Space research and technology...............	124,500	138,000	137,000	150,000
Total.....................................	404,500	438,300	439,300	492,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of	Dollars)		
Research and technology base.................	198,475	227,800	215,800	233,300	RD 12-4
Systems technology programs.................	81,525	72,500	86,500	109,100	RD 12-32
Tbtal.....................................	280,000	300,300	302,300	342,400	
Distribution of Proaram Amount bv Installation					
Johnson Space Center........................	700	200	1,200	1,200	
Marshall Space Flight Center.................	500	600	400	500	
Jet Propulsion Laboratory..........	300	500	500	500	
Goddard Space Flight Center.................	500	500	300	400	
Ames Research Center........................	93,700	122,200	121,100	134,700	
Langley Research Center.....................	93,000	93,300	93,900	116,100	
Lewis Research Center.......................	84,900	78,000	77,700	81,500	
Headquarters..	6,400	5,000	7,200	7,500	
Total....................................	280,000	300,300	302,300	342,400	

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the aeronautical research and technology program is to conduct an effective and productive program that contributes materially to the enduring preeminence of U.S. civil and military aviation by conducting appropriate disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; maintaining the research centers in positions of excellence in facilities and technical staff; assuring timely transfer of research results to the U.S. aeronautical industry; assuring appropriate involvement of universities and industry; and providing aeronautical development support to other government agencies and U.S. industry. Conducted well in advance of and independent of specific applications, the aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced military and civil aircraft. The program involves participation by aeronautical manufacturers to ensure that the technology is compatible with practical design considerations and can be successfully transferred into use.

CHANGES FROM FY 1984 BUDGET ESTIMATE

Congressional actions in FY 1984 resulted in a $2.0 million increase in the aeronautics program total. Internal programmatic realignments were made to provide for high priority research activities in response to specific Congressional recommendations.

In order to fund the advanced turboprop systems technology program at $15.0 million in FY 1984, $10.0 million was redirected from the research and technology base. In addition, $3.0 million resulting from adjustments in the systems technology programs and the $2.0 million Congressional increase referred to above were also applied to this requirement. Another $2.0 million was redirected from the research and technology base to systems technology in order to support priority work on small engine technology.

Within the research and technology base, $9.9 million was redirected to provide funding for laminar flow control, advanced transport operating systems, and general aviation activities.

These adjustments within the aeronautics program are described in the individual program narrative statements.

BASIS OF FY 1985 ESTIMATE

The FY 1985 estimates reflect the need to continue efforts both in the basic aeronautical disciplines and in areas of systems research and to maintain specialized facilities essential to aeronautical research.

Continuing emphasis in fluid and thermal physics will center on high Reynolds number cryogenic testing and turbulent drag reduction, while new emphasis will be applied to vortex flows and geometric modeling of, and grid generation for, complex aircraft configurations for advanced applications of computational aerodynamics. Areas of emphasis in materials and structures will include light alloy metals, new composite materials, high-temperature ceramics for heat engines, and the crash dynamics of composite structures. In the controls and guidance and human factors areas, research emphasis will be on flying qualities for highly augmented-controls aircraft, validation methodology for fault-tolerant systems, the human factors of advanced crew station automation, and the development of technology for improved simulation fidelity. In computer science, the major emphasis will be in concurrent processing architectures, algorithms, and techniques to support the agency's computational fluid physics research. Continued support of the two computer science research institutes and the university program will provide a strong research base in this critical area. In the numerical aerodynamic simulation program, the processing system development will continue with emphasis on bringing the first high-speed processor to full operational status by 1986.

In propulsion, emphasis will be placed on a broad spectrum of technologies offering the opportunity for potential advances. These include intermittent combustion engines for small aircraft; turbine engine components including inlets, nozzles, compressors, turbines, and combustors; and turbine engine systems technologies encompassing controls, gears, bearings, engine dynamics and stall recovery. Rotorcraft research will stress noise and vibration reduction and the unsteady aerodynamics of rotors. Areas of emphasis in high-performance aircraft research will include high angle-of-attack flight, vectored thrust and short takeoff/vertical landing, supersonic cruise/maneuverable aircraft, hypersonic propulsion, structures and configuration aerodynamics, and propulsion/airframe controls integration. Also included are efforts in the turbine engine hot section technology program to increase engine performance and durability. In subsonic aircraft research, emphasis will be placed on advanced composite structures technology, icing and lightning research, natural and controlled laminar flow, and technology problem areas identified in coordination with the Federal Aviation Administration (FAA) as critical to improved air safety and operations.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Fluid and thermal physics research and technology	42,665	52,200	44,700	49,000	RD 12-5
Materials and structures research and technology	23,200	27,700	23,200	25,000	RD 12-8
Controls and guidance research and technology	11,900	12,800	12,200	12,800	RD 12-10
Human factors research and technology	10,070	11,200	10,500	10,900	RD 12-12
Multidisciplinary research	3,600	3,700	3,700	6,100	RD 12-15
Computer science and applications research and technology	19,200	20,800	22,300	23,800	RD 12-16
Propulsion systems research and technology	16,600	28,500	20,000	22,000	RD 12-19
Rotorcraft research and technology	23,000	23,300	23,300	27,000	RD 12-23
High-performance aircraft research and technology	39,240	38,600	37,000	36,500	RD 12-26
Subsonic aircraft research and technology	9,000	9,000	18,900	20,200	RD 12-29
Total	198,475	227,800	215,800	233,300	

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Fluid and thermal physics research and technology................................	**42,665**	**52,200**	**44,700**	**49,000**

OBJECTIVES AND STATUS

The fluid and thermal physics research and technology program is a combined analytical and experimental research effort directed at external and internal aerodynamics. One of its principal objectives is the development of computational methods for the prediction and/or simulation of complex fluid flows over aircraft and within inlets, flow passages, and exhaust ducts of turbomachinery. A second objective is the maintenance of a coordinated experimental test program to provide insight into the fundamentals of flow physics, and to provide required detailed flow measurements for verification and validation of prediction and simulation methods. The experimental program also includes the development of advanced test methods and instrumentation to provide for increased accuracy and productivity of NASA wind tunnels and developmental facilities. Rapid progress is being made in the development of computational techniques for complex flow configurations that will lead to reduced development time and costs for future aircraft and will provide the basis for achieving new and higher levels of aircraft and missile performance.

A key goal of the computational fluid dynamics research is to provide a means for calculation of aerodynamic forces and moments acting on a complete aircraft under all conditions of attitude, speed, and altitude. The second part of this goal is the development of algorithms and predictive codes for gas flows over compressor and turbine blades and within the duct passages of gas turbine engines. During the past year, several schemes have been developed, yielding improved speed and accuracy but utilizing existing mathematical formulations. Of these, an outstanding example is a method in which simple rectangular grids form the network on which finite volume calculations are carried out. The simplicity of the method provides surprising accuracy when handling very complex three dimensional aerodynamic shapes. In other studies of flow over wings and bodies at transonic speeds, calculation times have been reduced by factors of three to ten for the difficult but precise Euler equations of fluid motion; this mathematical advance being equivalent to the development of a computer with three to ten times the speed of current machines. In parallel with the work on external flows, substantial progress has been made in the more difficult prediction of transonic flows in compressor and turbine stages of turbomachinery. Recent advances on 'shock-free" airfoils for external flows have been adopted for compressor and stator blading resulting in the development of a new computational technique that can now determine geometrical shapes yielding higher efficiency and increased pressure rise per stage.

Turbulent fluid motion continues to be the most difficult flow prediction problem and, while new methods for turbulence modeling have not yet achieved desired increases in accuracy, recent experiments associated with friction drag reduction methods have provided new insight into the structure of turbulent boundary layers on flat and curved surfaces. Studies have demonstrated for the first time the possibility of reducing turbulent friction on aircraft by seven to ten percent, a very significant and economically important reduction. The tests have verified that ruled vee grooves parallel to the flow can achieve the drag reductions even for flow inclinations as great as 15 degrees.

Experimental programs measuring the pressure rise and efficiency of compressor and turbine blade designs have shown detrimental effects of the engine's noise environment on blade performance. The noise and turbulence produced within the engine promotes flow streamline separation on the blade surfaces and limits the pressure rise per stage. As a result of these new findings, design codes are being modified to include and compensate for these effects.

Heat transfer to turbine blades continues to be an important area of research in improving the efficiency and life of gas turbine engines. During the past year, studies of cooling air ports in turbine blades have resulted in the invention of new port configurations which substantially improve the uniformity of cooling with the consequent reduction in cooling air requirements by thirty to forty percent. This reduction of cooling air bleed requirements leads in turn to specific fuel consumption savings of three to five percent or the enhanced cooling can be traded for increased turbine/blade life and safety.

The National Transonic Facility (NTF) at the NASA Langley Research Center in Hampton, Virginia, completed its final checkouts during 1983 and started its first year of operation in December of 1983. All design goals have been met, and the wind tunnel has been operated over its entire range of temperatures and pressures. This premier facility provides a unique national capability to maintain U.S. preeminence in aeronautical research and development. A wide range of aircraft models has been prepared for testing during FY 1985 by NASA and the aerospace industry. These models include pathfinder military and commercial configurations, aeroelastic models, missile configurations and advanced wing designs.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The fluid and thermal physics research and technology program was decreased by $7.5 million in order to provide funding for other priority requirements. This reduction was accomplished primarily by decreasing the scope of effort in fluid mechanics of turbomachinery and in combustion and heat transfer research. Due to the length of time required for bringing the NTF into operation, the planned funding for operation of this facility has been decreased without adversely impacting the FY 1984 program.

BASIS OF FY 1985 ESTIMATE

Studies of test techniques to provide improved wind tunnel test accuracy will be emphasized. These will include magnetic suspension systems for support-free testing in wind tunnels; new concepts for wall corrections in transonic and low-speed high-lift test conditions; nonintrusive laser instruments for direct measurement of velocity, density, and temperature in wind tunnels; and holographic flow visualization techniques.

Computational research will work to achieve solutions of greater geometric complexity and will utilize the more exact Euler and Navier-Stokes equations of motion that are now solvable with the help of the more powerful computer systems available at the NASA research centers. Increased emphasis will be placed on the development of advanced simulation techniques for turbulence and turbulent flows to provide new insight into the coherent structures prevalent in turbulent flows. Recent advances in the understanding of the interaction of viscous boundary layers and external flows will be applied to the problems of streamline separation that occur across the operating ranges of aircraft wings, as well as compressor blades in turbomachinery. A continuing effort will be supported to provide detailed experimental verification of the computational prediction methods.

Research in viscous flow control will explore both the maintenance of laminar boundary layer flow and the reduction of surface friction drag once turbulent conditions have been established. Experiments on transonic laminar flow will continue, utilizing new suction surface materials that are inherently smoother and approach the ideal of uniform suction over a large portion of a wing. Additional study will be made of hybrid systems in which suction is applied only over leading portions of the wing surface. Turbulent drag reduction experiments using recently developed turbulent drag reduction devices will be extended to realistic flight conditions, and new and innovative techniques to control the turbulent surface layers will be explored. These research areas offer great promise for reduction of aircraft drag leading, in turn, to increased range and fuel economy.

Combustion studies in the coming year will focus on new problems anticipated for the next generation of high-performance fan or turboprop engines. With the required higher temperatures and pressures following the compression phase of the cycle, new combustor designs may take advantage of higher flame speeds and improved mixing to reduce size and length, and to produce the heat addition in a smoother and more evenly distributed manner. The combustor and the following turbine stages should thereby achieve increased performance and time before failure.

The National Transonic Facility will become fully operational in 1985 and will be heavily utilized by the DOD and industry to finalize new designs and to calibrate existing lower Reynolds number test facilities. This latter function will increase the utility of existing wind tunnels and define those test parameters that are insensitive to Reynolds number variations.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Materials and structures research and technology....................	23,200	27,700	23,200	25,000

OBJECTIV AND STATUS

The objectives of the materials and structures research and technology program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) advance analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and (4) generate research data to promote improvements in performance, safety, durability, and economy in civil and military aircraft. Areas of emphasis include high-temperature engine and airframe materials and structural concepts; composite materials application, life prediction, and thermal and dynamic response, including aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

Significant improvements in the performance of turbine engines can be realized by increasing engine operating temperature. Ceramic materials offer the best potential for achieving increased operating temperature together with long life. During the past year, new processing methods for ceramics have led to substantial improvements in strength and reliability. A major step in the prediction of coating life for engine turbine blades has been achieved. Combining an analysis for superalloy coating spallation with an analysis of chemical interdiffusion has produced a highly accurate prediction of coating degradation.

Research on airframe materials concentrates on both metals and polymer-matrix composites. Through the use of a powder metallurgy process, small amounts of zirconium added to a common aluminum alloy resulted in nearly doubling the fracture toughness while slightly increasing the yield strength. Such improvements, if realized in commercial production, would save weight while maintaining high durability and damage tolerance. The solvent sensitivity of a thermoplastic polymer (polysulfone) has been markedly reduced by the incorporation of acetylene end caps to control chain length and provide some cross-linking. The slightly cross-linked thermoplastic retains the processibility and fracture toughness of the polysulfone but is much more resistant to high temperature creep.

In the aeroelasticity program, tests of a half-scale model of a forward swept wing have shown that the wing bending motion can couple adversely with rigid-body pitching motions. Although such a flutter mode was predicted by present theory, the location of the predicted flutter boundary was not accurately forecast.

A new nondestructive method for measuring residual stress in a metal has been demonstrated qualitatively. The technique measures the small (parts in a million) shift in acoustic phase velocity which accompanies changes in magnetic properties which can be related to the stress state in the material. Noise transmission losses for large unstiffened composite panels have been measured over a wide frequency range. Remarkably good agreement with predictions was obtained. The theory must now be extended to stiffened panels.

CHANGES FROM FY 1984 BUDGET ESTIMATE

In order to provide funding for other priority requirements, the materials and structures research and technology program was decreased by $4.5 million in the areas of high-temperature materials and engine structures, advanced materials concepts, life prediction and composites, aeroelasticity, and structures and dynamics.

BASIS OF FY 1985 ESTIMATE

Research on high-temperature engine materials will emphasize improved durability and reliability of ceramics, thermal barrier coatings for metal turbine blades, and tough, high-temperature polymers. The research effort on the conservation of strategic materials will focus on developing new high-temperature materials such as intermetallics to replace superalloys requiring substantial amounts of cobalt, tantalum, and chromium. The development of new advanced powder aluminum alloys will concentrate on lightweight alloys with increased modulus and higher temperature capability for more efficient airframes.

In engine structures and dynamics, the activity will emphasize the aeroelastic response of highly swept and twisted turboprop blades. Analyses will be expanded to include transonic and three-dimensional flow effects and the interaction between the turboprop engine system and the airframe. The relationship between parameters measured under constant temperature conditions and the parameters affecting fatigue crack initiation and growth in turbine engines will be developed. Fatigue of structural alloys will concentrate on microstructural effects on crack initiation and the growth of small cracks.

Research on composite materials will continue to place high emphasis on the toughness and durability of highly loaded structures. Studies in FY 1985 will concentrate on the micromechanics of load transfer and failure propagation in a laminate. These will be used to define the resin-fiber attributes that contribute to laminate toughness. Research on structural concepts that provide damage tolerance and fail-safe capability will continue. The principal effort will address the structural performance of stiffened curved panels for fuselage applications.

The dynamics and aeroelasticity program will continue to emphasize the development of improved analytical tools for predicting unsteady aerodynamic pressures, particularly in the transonic speed range, and the aeroelastic response of wings and turbine engine blades. Analysis methods will be verified through systematic tests of both idealized and true-scale airfoils and will concentrate on nonlinear three-dimensional flow effects. This effort will provide the basis for active control of aeroelastic response.

Data from the full-scale crash test of an instrumented Boeing 720 transport aircraft conducted in FY 1984 will be used to verify nonlinear dynamic analysis methods for large aircraft. This program is a joint NASA/FAA effort investigating structural dynamics and antimisting fuels in an actual crash environment. Future emphasis will be placed on the crash dynamic behavior of composite structural elements in simple, built-up components representing fuselage structure.

In the area of integrated analysis and optimization, efforts will concentrate on further development of the multilevel optimization method. The scope of the analysis will be expanded by increasing the number of global optimization parameters that can be considered in a tractable solution.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Controls and guidance research and technology.....................	11,900	12,800	12,200	12,800

OBJECTIVES AND STATUS

The objectives of the aircraft controls and guidance research and technology program are to: (1) develop handling qualities criteria and integrated control law analysis methods for extending the performance envelope and reliability of highly augmented future civil and military aircraft; (2) develop architectures for flight crucial systems for future aircraft and devise analytical methods and techniques for assessing the reliability and performance of complex integrated fault-tolerant flight control systems; and (3) investigate emerging control and guidance technologies which offer future alternative approaches for continued aviation safety and efficiency. Major program elements are: applied control theory, architectural concepts, system assessment methods, environmental effects research, and flight path guidance.

Applied control theory research is a major element in the controls and guidance program, and excellent progress has been made in developing and evaluating nonlinear inverse control system concepts. These concepts were tested on a UH-1H helicopter, and the envelope of operation was expanded close to the aircraft's performance capability. Also, as part of a joint/cooperative program with the British Royal Aircraft Establishment, nonlinear control laws were developed and tested on the NASA F-8 digital fly-by-wire aircraft. These control laws provided improved handling qualities over the F-8 stability augmentation system.

Significant progress has been made in flight crucial systems research. In April of 1983 the Avionics Integration Research Laboratory (AIRLAB) facility at Langley Research Center became operational. This facility is being used in the assessment and validation of flight crucial systems for aircraft and spacecraft. The engineering models of two pioneering fault-tolerant computers, fault-tolerant multiprocessor (FTMP) and the software implemented fault-tolerant (SIFT) computer, are currently being evaluated in AIRLAB. CARE 111, the computer-aided reliability estimation program, and an important analytical tool for assessing the reliability of fault-tolerant systems, has been developed and used to assess the reliability of the control system for the X-29A forward swept wing aircraft. CARE III is now operational in AIRLAB and is being used to evaluate SIFT and FTMP. Concern with the effect of lightning on digital electronics has led to increased research activity both in understanding lightning phenomena and in developing protection techniques. The effectiveness of protection schemes is being evaluated using induced voltage characteristics determined from analysis of flight data. Other activities in this area have resulted in a system for random injection of lightning-induced upset transients into microprocessors to characterize the effects. A program in generic fault-tolerant avionics was initiated in 1983 to develop an advanced information processing system which includes design methodology, assessment tools, and validation processes that will satisfy the most common set of requirements for selected aircraft and space missions.

Flight path guidance algorithms have been developed for jet transport aircraft to control aircraft approach in four dimensions (4-D) (3 spatial dimensions plus a time schedule). Also, the problems of mixing 4-D equipped and unequipped aircraft in the terminal area have been investigated. The results indicate a substantial reduction in workload and an increase in orderliness when more than 25 percent of the aircraft are 4-D equipped.

CHANGES FROM F 1984 BUDGET ESTIMATE

In order to provide funding for other priority requirements, the controls and guidance research and technology program was decreased by $0.6 million in the areas of control theory and analysis and in flight crucial controls and guidance.

BASIS OF FY 1985 ESTIMATE

In the applied control theory area, the research effort will increase in defining handling qualities criteria for superaugmented aircraft. Also, research will continue in developing tools and design guidelines for full-authority flight control systems and the validation of these designs. This research will provide a data base which includes flying qualities, control power requirements, and design considerations for the design and test flight control system where aircraft weight and natural stability can be traded for performance, and the aircraft becomes totally dependent on the flight control system.

In the flight crucial controls area, advanced fault-tolerant architectures are being defined for application to future aircraft. These and other architectures will be assessed and validated in AIRLAB.

The architectures are derived from the assessment of the engineering models of fault-tolerant computers, SIFT and FTMP, and from specific system studies such as the integrated flight and propulsion control system architectural study. To demonstrate the reliability of these systems, research will continue on validation methodology through a series of grants at several key universities with principal investigators performing research in AIRLAB. A strong emphasis remains on the development and assessment of fault-tolerant software. In the environmental effects area, emphasis will be placed on the design of digital system concepts to protect aircraft systems from upsets caused by lightning strikes. In the propulsion controls area, the principles of nonlinear robust control theories are continuing to be adapted or developed to the real-world problem of propulsion control, including control laws to accommodate failures. Fault-tolerant systems architecture for electronic propulsion controllers are also being developed along with sensor redundancy management algorithms. These concepts will be evaluated in a full-scale engine test facility. In the area of guidance concepts, energy management and full, conservative, 4-D concepts are being developed including onboard trajectory synthesis and trajectory control. The algorithms will be evaluated in an air traffic control system simulation which involves interactive participation of both pilots and FAA controllers. Research will continue on redundant sensor and actuator concepts.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Human factors research and technology....................	10,070	11,200	10,500	10,900

OBJECTIVES AND STATUS

The objective of the human factors research and technology program is to provide a technology base for the solution of human problems which impede the growth and safety of aviation. This is accomplished by developing a fundamental understanding of the capabilities, limitations and tendencies of aircrew members in interacting with each other, with cockpit systems, and with the air traffic control system. There are four areas of emphasis in the human factors research program: flight management, aviation safety, simulation technology, and research methods.

The flight management research program has continued to develop a basic understanding of information transfer, decision-making and resource management in the cockpit in order to provide a data base for improved cockpit systems and operational procedures. In this area, research on cockpit display of traffic information (CDTI) is continuing in cooperation with the FAA. In FY 1983, simulation studies of the interaction between CDTI and collision avoidance systems (CAS) showed that the availability of traffic information in the cockpit allows pilots to make small timely maneuvers which reduce the number of collision avoidance system alarms. Another series of simulation studies demonstrated that air carrier pilots using head-up displays (HUD) can safely reduce separation in low visibility approaches. Other flight management research is focused on developing cockpit function allocation strategies which make maximum use of automation technology in view of human capabilities and limitations. During the past year, a field study was completed on the effect of increased cockpit automation in such aircraft as the DC-9-80 and the 767 on aircrews. In addition, a human-computer interaction laboratory was developed which will be used to test hypotheses developed in the field study.

Simulation technology research is aimed at increasing the degree to which man-in-the-loop simulation can replace actual aircraft flight time in research, development, and training. Work is continuing on improving simulation of weather hazards, modeling of human perception, and the use of simulation for assessing crew performance. A recent accomplishment in weather hazard modeling is the development of a 3-D windshear model based on actual windshear data. In the human perception area, a model of monochromatic human vision has been developed which will serve as a tool in determining minimum requirements for simulator visual systems and €or electronic cockpit displays.

The goal of the aviation safety research program is to identify the physical, psychological and procedural aspects of the aviation environment which tend to induce human error. The two major projects in this area are the Aviation Safety Reporting System (ASRS) which NASA is continuing to manage for the FAA, and a joint NASA/Army/Air Force program to assess the effects of fatigue and circadian desynchronosis on aircrew performance. A review of existing knowledge on fatigue has been completed, and a field study using short-haul crews has been undertaken.

The goal of the research methods area is to develop crew workload and performance methods which can aid in assessing the relative merits of alternative man/machine interface designs. In FY 1983, a method of generating simulation scenarios that impose predictable levels of imposed pilot workload has been developed which will serve as a standard for evaluating workload measures.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The human factors research and technology program was decreased by $0.7 million in order to provide funding for other priority requirements. This reduction was accomplished by decreasing the scope of effort in flight management and flight simulation technology activities.

BASIS FOR FY 1985 ESTIMATE

Flight management research will continue to encompass CDTI and the human implications of increased cockpit automation. The CDTI program will change focus from part task simulation studies to full mission scenarios as the DC-9 simulator becomes available in 1984. Also, a generic look will be taken at the perceptual aspects of electronic cockpit displays which include not only traffic, but also weather, terrain map, aircraft pathway, etc. The cockpit automation research program will increase in scope and will encompass basic research on the interaction between crews and advanced cockpit information input/output systems such as multifunction programmable keyboards and touch-sensitive flat panel displays. It will focus on the use of artificial intelligence in alerting and warning systems, and in the use of multiple graphic windows in electronic displays.

In simulation technology, the windshear model will be evaluated and refined. An evaluation will be made of an aerosol fog generator for simulation visual systems, and guidelines will be developed for simulation of reduced visibility conditions. Research will continue cn improving the capability to simulate weather hazards. A physiological measure of brain activity, called evoked potential, will be investigated as a method of evaluating the psychological fidelity of simulation to the human subject. Fundamental research on how the visual perceives computer-generated imagery will focus on developing methods for minimizing graphic distortion and misperception of information. The human vision model will be extended to include the effects of visual eccentricity and visual motion.

In the area of aviation safety, both the fatigue study and the ASRS will continue. The fatigue and circadian desynchronosis study will expand to include crews on long-haul flights. Simulation studies of long- and short-haul flights will be undertaken to test the effects of fatigue on crew performance in emergency situations.

The research methods area will continue to emphasize workload measurement research. The focus will evolve from investigation of the components of the subjective workload phenomenon to the development of guidelines for the use of workload metrics for various applications. The guidelines will be ready in FY 1985.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary research..................	3,600	3,700	3,700	6,100

OBJECTIVES AND STATUS

The objective of the multidisciplinary research program is to conduct novel, long-term, innovative research of a multidisciplinary nature related to aeronautics. This research is conducted principally at universities through the following three programs: (1) graduate program in aeronautics, (2) joint university institutes, and (3) the computational fluid dynamics (CFD) training program.

The graduate program in aeronautics sponsors graduate training and research that is relevant and acceptable to both NASA and the university in the field of aeronautics, encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training, and provides excellent interaction among students, faculty, and NASA researchers in the conduct of research.

The joint university institutes program provides a core level of funding for the promotion of an active NASA/university interchange in certain key areas in order to maintain cooperative, innovative, venture research at the leading edge of the latest technology. Current elements include the Joint Institute for Advancement of Flight Sciences (JIAFS), the Joint Institute for Aeronautical Propulsion and Power (JIAPP), and the Joint Institute for Aeronautics and Acoustics (JIAA) located at Langley Research Center, Lewis Research Center, and Ames Research Center, respectively.

The CFD training program provides for the development of interdepartmental university curricula and sponsors graduate training in computational fluid dynamics in response to the rapidly escalating need €or specialists by NASA, the Department of Defense (DOD) and the aerospace industry.

BASIS OF FY 1985 ESTIMATE

The research and graduate student support sponsored under this activity will continue to address long-range innovative research related to the field of aeronautics and simultaneously insure a source of well trained students by means of strong interaction among students, faculty, and NASA center personnel. In FY 1985, the program will include dedicated funds to sponsor grants in the science, engineering, and interdisciplinary departments of historically black colleges and universities in order to enable the minority community to affect and contribute to the future scientific and engineering manpower pool in NASA, DOD, and the national aerospace industry.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Computer science and applications research and technology..	19,200	20,800	22,300	23,800

OBJECTIVES AND STATUS

The objective of the computer science and applications program is to develop an understanding of the fundamental principles underlying aerospace computing and the relationship and tradeoffs between algorithms and computing architectures, and to apply this fundamental insight in order to advance computational concepts and improve system architectures. The program supports work in concurrent processing, highly reliable cost-effective computing, information management, computer applications, and large-scale scientific computational facilities.

Concurrent processing research addresses system architectures and algorithms for computationally intensive problems in aeronautics, such as computational fluid dynamics (CFD), computational chemistry, and structural dynamics. In 1983, the new Research Institute for Advanced Computer Science (RIACS) opened, establishing as its research theme the use of knowledge-based systems to solve problems requiring massively parallel computation. In related research, representative computational chemistry codes were mapped onto alternative supercomputer architectures to perform evaluation studies through simulation at the instruction level. Extensions to the FORTRAN language were also defined to support concurrency, and a precompiler was designed to implement these extensions. A preliminary design was completed for an innovative data flow computer architecture tailored to CFD applications, and the prototype version of a multiprocessing operating system supporting the Path Pascal concurrent programming language was demonstrated in a single processor configuration.

Research on highly reliable, cost-effective computing focuses on the technology underlying the construction of systems for man-rated flight vehicles. The emphasis is on investigations of software fault tolerance and cost-effective tools and techniques for developing verifiably correct software. An evaluation of the DOD high-order language, ADA, was initiated, addressing the language's applicability to distributed fault-tolerant aerospace systems. An agreement was negotiated with the DOD to cooperate on the Software Technology for Adaptable, Reliable Systems (STARS) program, and an experimental software environment was developed to conduct software failure experiments in the AIRLAB facility.

Research in information management is addressing improved 3-D raster graphics display software for engineering applications. Work has begun on developing extensions to high-level programming languages to support graphical data types, hierarchical object modeling, and user interaction operations.

The objective of the research in computer applications is to exploit advances in computing technology to the benefit of aeronautics. Current emphasis is on the engineering design and analysis process. The integrated program for aerospace vehicle design (IPAD) is a joint NASA/Navy program to improve productivity through development of technology for the management of computer-aided design/computer-aided manufacturing (CAD/CAM) information. The first prototype of a project level data management system integrating geometric data with nongeometric information is being developed in FY 1984. Research is also being conducted on parallel computing architectures and algorithms for finite-element structural analysis. Methods have been developed and demonstrated on experimental hardware to reduce computational times for static stress analysis by two to three orders of magnitude.

A major objective of the computer science and applications program is to provide state-of-the-art high-performance computational facilities for aerospace research. Ames Research Center has upgraded its Cray 1S to a Cray X-MP, and has acquired a Cyber 205 to provide the necessary scientific computing capability to support a broad spectrum of research efforts. Lewis Research Center continues to operate a Cray 1S-2200 computing facility. These systems provide vital computational support to researchers in fluid dynamics, chemistry, and thermal and structural analysis.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The computer science and applications research and technology program was increased by $1.5 million to provide the necessary funding for large-scale scientific computing capability to support broad research efforts in computational physics. This incremental increase includes a portion of the funding for the Cyber 205 at the Ames Research Center.

BASIS OP FY 1985 ESTIMATE

RIACS will be attaining a mature size and capability as it enters its third year of operation. The research in concurrent processing will develop promising architectural concepts to achieve 10-100 billion floating point operations per second on problems characteristic of aerospace applications, and a computer emulation testbed will be completed to evaluate and validate these architectures. A multidisciplinary set of benchmark kernel codes will be developed and published to provide computer architects with precise, modern, and complete knowledge of the needs for scientific computation. In software engineering research, a prototype software development and management support environment will be demonstrated; experimental studies of fault-tolerant computer software will be completed; and debugging tools for a distributed network operating system will be demonstrated. Experiments in information presentation will be conducted with 3-D color graphics to develop effective dynamic displays of complex analytical results for scientific and engineering computing.

In computer applications, IPAD will develop an initial CAD/CAM data management capability supporting the distribution of a unified data base over a heterogeneous network of computers. Parallel computing methods for structural analysis will be developed to address large nonlinear dynamics analyses typical of aircraft crash scenarios.

Support for the large scale computational facilities including a Cray X-MP and a Cyber 205 at Ames Research Center and a Cray-1S at Lewis Research Center will continue. An initial mass storage capability will be provided at Ames, enabling the online storage of numerical simulation data required for interactive real-time computational flow field analysis. The Lewis Cray 1S is expected to provide the computational capability required for near-term analysis of propulsion system components.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Propulsion systems research and technology...	16,600	28,500	20,000	22,000

OBJECTIVES AND STATUS

The objective of the propulsion systems research and technology program is to derive fundamental understanding and generic propulsion technology from component experiments for verifying the computational methods developed under the fluid and thermal physics program and from analytical and experimental research on complete propulsion systems. These technology advances will allow future improvements in propulsion system efficiency, performance capability, fuel flexibility, reliability, and durability, as well as environmental compatibility. The potential benefits of advanced propulsion system concepts will also be evaluated within these programs. Research is being performed on inlets and nozzles, fans and compressors, combustors, turbines, power transfer mechanisms, controls, engine dynamics, and intermittent combustion engines. These component subsystems and engine systems technology advances will lead to major propulsion system improvements in military and civil aircraft ranging from small missiles and general aviation aircraft to transports, rotorcraft, and high-performance military aircraft.

During **1983,** performance comparisons were made between the measured values and values calculated from newly developed computer codes for several mixed compression and hypersonic inlets. Experimental data was successfully obtained for compressible flow in circular S-ducts and for incompressible flow in square S-ducts. In each case, good correlation between analytical and experimental results verified the availability of a new, working computer code.

Under fan and compressor research, dynamic pressure measurements and rapid radial traverses were taken of the flow downstream of a low-aspect-ratio fan stage operating in rotating stall. These data will provide the input to help extend computer modeling of the compressor map into the region beyond compressor stall. Such simulation will be required to permit future full authority digital control of engines over the entire engine operating range, including inadvertent stall regions. Instrumentation and test preparation for the multistage, axial compressor experimental research on stall recovery are nearing completion. An experimental program to determine, via laser velocimeter measurements, the detailed internal flow field and assess unsteadiness in the rotor shock system for a transonic fan stage was completed. These results provide a detailed understanding of the complex internal flow phenomena on which current transonic compressor design procedures are predicated.

In instrumentation, research in silicon carbide crystals appropriate €or high temperature electronic devices is continuing with signficant progress being made in the understanding of the crystal forming process, and with measurements of the electrical properties of the crystals showing good results. High-temperature instrumentation will allow high-response temperature and pressure measurements in the hot section components of a gas turbine engine.

In combustor research, an evaluation of fuel property effects on performance, emissions, smoke formation, flame radiation, and linear heat flux, as well as an evaluation of advanced combustor concepts designed to provide fuel flexible operation, has been completed. Results of these evaluations will lead to better performance and more durable and reliable combustors in which both current and broader property fuels can be burned.

In turbine research, advanced instrumentation, such as temperature probes, liquid crystals, and heat flux gauges, has led to the mapping of local gas temperatures, heat transfer coefficients, and heat flux throughout the turbine blade channel. Knowledge of these conditions in the blade channel will lead to more effectively cooled turbine blades and, therefore, more durable and reliable turbine engines.

In propeller research an initial version of a propeller aeroelastic code with enhanced unsteady aerodynamics has been developed. A comparison of lifting line analysis predictions of flow-field velocities with laser doppler velocimeter measurements on a research propeller was completed. Wind tunnel tests were completed on an advanced low-speed propeller with composite blades to evaluate aeroelastic characteristics.

In power transfer research, the first phase of testing of a 500-horsepower (hp) high ratio hybrid helicopter transmission was successfully completed. The hybrid (traction/geared) concept takes advantage of the lower noise, higher efficiency and reduced weight afforded by traction drive systems in the high-speed low-torque components, where traction systems are the most effective, and uses gears in the low-speed high-torque components, where gears have been conventionally used. The high ratio hybrid concept is ideally suited for helicopters, since high efficiency and lightweight transmissions can be achieved while eliminating the need for separate speed reduction units currently being used in conventional helicopter transmissions.

Progress was made in several areas of research involving engine system stall recovery. The initial experimental phase of the high bypass engine stall recovery investigation was completed with results showing combustor and control involvement in the nonrecoverable stall phenomena. The results are being incorporated into the continuing effort to develop a hybrid computer model for the stall recovery characteristics of high bypass turbofans. The stall recovery effort also includes the development of stall avoidance and recovery control modes and identification of in-stall compressor characteristics using unsteady engine test data. Each of these efforts is aimed at a fundamental understanding of the stall and nonrecoverable stall phenomena in gas turbine engines leading to design philosophy and methods for avoiding the problem.

Research is continuing in optical sensors and actuators with the delivery of an optical photoswitch and 800-degree Centigrade optical temperature sensor that will allow initial experiments to be conducted in the Lewis Research Center's fiber optics laboratory. Fiber optics for engine control system sensors and actuators will reduce system weight, increase control system speed, and reduce its susceptibility to outside electromagnetic interference such as lightning.

In the intermittent combustion engine research program, in-house basic research was initiated in rotary and piston stratified charge combustion for multifuel capability, and work was continued on a two-dimensional rotary airflow modeling code, resulting in the first computer-generated movies of flow conditions inside a rotary engine. This research is developing the enabling technologies for new, more efficient, more compact, and more reliable general aviation and commuter aircraft engines. The results will be a step increase in light aircraft performance and economy with similar implications for other land- or sea-based power needs.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The reduction of $8.5 million in the propulsion systems research and technology program reflects discrete reductions in the research and technology base efforts in high pressure turbine and advanced propeller research, as well as general reductions in the scope of effort in propulsion system studies; fans, compressors and instrumentation; and combustors and turbines in order to provide funding for other priority research activities.

BASIS OF PY 1985 ESTIMATE

Inlet research will continue on verification of design codes against wind tunnel data. Acquisition of three-dimensional viscous data for axisymmetrical supersonic inlets at angle of attack will be completed. Verification experiments with specific application to finite volume Euler codes and analysis methods for multistage compressors will continue in the area of fans and compressor research. Compressor stall recovery data base and analytical code development will continue with collection of stall inception fundamental data from the large low-speed compressor rig. Research on silicon carbide technology for high-temperature electronic components will continue, and the development of technology needed for producing pressure transducers capable of making precision measurements at temperature levels up to approximately 530-degrees Centigrade will be completed. In combustor research, newer areas such as nonmetallic liners, diffuser aerodynamics, and ignition relight fuel effects will be studied. The ability to understand turbine aerodynamics and turbine cooling will be enhanced by the fabrication of a high temperature cascade rig five times actual size to permit precision measurements and by the continued development of instrumentation suitable for the hot section environment. In power transfer research, development of a 3600-hp split-torque transmission will be continued in collaboration with Army Aviation Research and Development Command. The second experimental phase of the stall recovery program on a high-bypass-ratio engine will be conducted to verify improved analytical codes and control modes for avoidance of and recovery from stall. Development of high-temperature optical temperature sensors, optically switched actuators, and portable digital real-time engine simulation capability used for control theory checkout prior to engine tests will be continued. The intermittent combustion engine research program will continue to focus on the design, construction and testing of a high-performance, rotary, multifuel test engine, and the expansion of testing with a single-cylinder, two-stroke cycle, diesel test engine.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft research and technology..........	23,000	23,300	23,300	27,000

OBJECTIVES AND STAT

The objectives of the rotorcraft research and technology program are to provide a sound analytical capability, a high-quality experimental data base, and support for unique, national test facilities for rotorcraft testing. Specific objectives include: (1) validated theoretical aerodynamics analysis; (2) acoustic theory for external noise; (3) a data base for complex interactional aerodynamics; (4) an understanding of man-machine problems unique to helicopters; (5) analysis and test of selected structural components; (6) the reduction of dynamic loads; (7) the prediction and alleviation of icing buildup on a rotor; and (8) development of handling qualities criteria for new or difficult operating conditions. In addition, this program provides the wind tunnel, flight test, and simulation support for in-house, DOD, FAA, and cooperative research experiments. Many efforts are jointly supported by the co-located Army laboratories. This research is complemented by projects funded by the rotorcraft systems technology program including large-scale wind tunnel models and experimental aircraft flight testing.

In the area of theoretical aerodynamics, the transonic, quasi-steady analysis was coupled to a far-wake model. Fixed-wing methods (Euler and vortex panel methods) were adopted for helicopter rotating coordinates. These developments enabled work to begin on a "quiet" rotor blade design. In experimental aerodynamics, two new X-Wing airfoil sections were tested in the 2x2-foot wind tunnel, and the effects of sweep and wall interference, both unique to this circulation control concept, were investigated.

In acoustics, the prediction of broadband noise to an accuracy of ±3 dB was demonstrated. Modeling of blade/vortex interaction continued with analysis development and a carefully conducted experiment with synchronized pressure and acoustic measurements. Laser velocimeter measurements mapped the complex vortex formation behind a fixed, twisted rotor blade to analyze noise sources. Further work was delayed by wind tunnel rehabilitation and high-priority DOD testing. Work on transmission noise was begun. A complete survey of the Langley 4x7-meter wind tunnel was conducted to assess its potential for highly accurate helicopter noise testing. The survey report is being discussed with the helicopter industry to establish the feasibility of modifying this wind tunnel for high quality rotorcraft noise research. No such capability now exists in the United States.

Laser velocimeter measurements were made on the new 4-bladed model rig in hover and forward flight. The effects of the interaction with a fuselage and a wing were included in that test. Preparations for a larger scale interference test in the 40x80 foot wind tunnel were completed to examine main rotor-tail rotor-body aerodynamic interactions. This included a rotor body hover test and isolated tail rotor tests.

In human factors, analysis of pilot system information transfer continued, forming the basis for an integrated cockpit design. In flight dynamics, simulations were conducted examining yaw control power in nap-of-the-earth flight, roll control effectiveness in terrain following flight, and time delays with varied design parameters in autorotation flight. Tilt rotor simulations for civil operation continued in cooperation with the FAA.

Structural tests and analyses were conducted of high-performance woven fabrics, the response of thin-gauge composites to ballistic impact, and the performance of various cabin subfloor concepts in crash tests. Innovative structural concepts, such as thermofoam and thermoplastic composite materials, were developed. Flight service evaluations of composite components continued.

A new emphasis was started in rotor blade optimization, varying stiffness, planform, and weight for reduced vibration and loads. Dynamic stall analyses of oscillating airfoil tests were completed. Analytical work was initiated to support X-Wing and JVX (tilt rotor) testing in 1984.

An improved deicing boot was tested behind the CH-47 spray helicopter. Differences between icing theory and test results on rotors were resolved.

Support of the 40x80x120-foot wind tunnel upgrading continued. That work included: the design of an active control technique to alleviate ground resonance of rotor models; the development of a long range laser velocimeter for remote velocity flow measurements; and the simulation of emergency procedures in the expanded speed range.

BASIS OF FY 1985 ESTIMATE

Work on the "quiet" rotor blade will be expanded using fully unsteady, transonic analysis. Initial runs of the Euler and vortex panel codes will be feasible with new computer capability becoming operational. Optimized tip shapes for low noise will be examined for adverse aeroelastic properties.

Emphasis on wind tunnel testing will shift to full scale when the 40x80-foot test section becomes operational in 1986. A test of interactional aerodynamics will use a modern 4-bladed rotor, various body shapes, wing and a tail rotor previously tested in isolation. Each will be separately instrumented. Laser velocimeter mapping of the wake, pressure data, loads, vibration and acoustic data will be taken, combining the objectives of several previous small-scale experiments.

A UH-60 model rotor will be installed on a Rotor Systems Research Aircraft (RSRA) for complete documentation'in steady and maneuvering flight. This modern rotor data base will replace one which is over 20 years old and inadequate for today's configurations and the requirements for high fidelity, detailed measurements for computer analysis.

Transmission noise will be evaluated in an instrumented test, and point sources will be identified and analyzed. Noise propagation paths will be computed, and methods for suppression identified.

Research on revolutionary rotor concepts will continue with the test of a variable camber blade and a unique hub drag concept. Individual blade pitch control will also be tested in a feasibility study of high-speed actuators. These concepts are aimed at breakthroughs in performance, vibration and loads.

In human factors, flight dynamics, and advanced control work, planning will be underway to define "superaugmented" helicopter research. This research will build upon ongoing guidance and navigation research and will examine the promise of the microelectronics revolution in the demanding environment of single-pilot, all-weather, nap-of-the-earth flight with weapon systems macagement. Beyond merely automating pilot tasks, the efforts will examine the need for automating executive decisions at several levels, the need for artificial intelligence, the reliability and redundancy requirements, and the control authority and flying qualities necessary for the most demanding scenarios. This work will be conducted in conjunction with the Army's advanced rotorcraft technology integration project which will define the cockpit baseline for the proposed LHX helicopter.

New materials, specifically designed for rotorcraft, will receive increased emphasis. Specific characteristics involve high fatigue life and high inherent damping. Breakthroughs in this area may have enormous benefit for the helicopter and lead to broad, nonaviation application.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft research and technology............................	39,240	38,600	37,000	36,500

OBJECTIVES AND STATUS

The objective of the high-performance aircraft research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high-speed aircraft and missiles, including powered-lift aircraft and vertical or short takeoff and landing capabilities (V/STOL) , supersonic cruise and maneuver aircraft with conventional or short takeoff and landing characteristics, and hypersonic cruise aircraft.

In powered-lift research and technology, emphasis continues to be concentrated on analytical techniques and acquiring a data base essential for development of efficient and effective military V/STOL aircraft. Aerodynamic performance characteristics at low speed were obtained on two V/STOL models, and these tests are to continue into the supersonic speed range next year. A 0.3-scale semispan model with an ejector was recently tested for performance in the 9x15-foot wind tunnel. The full span model is now being fabricated and will be tested in the V/STOL tunnel for in and out of ground effects. A free-flight model of the ejector configured aircraft is also being constructed and will be tested in FY 1984 in the 30x60-foot wind tunnel. A Harrier YAV-8B aircraft will be acquired in FY 1984 and will be modified for flight control and performance evaluations in FY 1985.

In flight dynamics, an extensive analytical/experimental program continues in the high angle-of-attack stability, control, handling qualities, and stall/spin behavior of advanced aircraft concepts to improve the low-speed combat maneuverability and safety of high-speed aircraft. Investigations were initiated in novel and unconventional aerodynamic devices, such as thrust vectoring for enhanced pitch and yaw control and vortex flaps. In aerodynamics and propulsion integration, two advanced supersonic tactical aircraft models were completed and wind tunnel tested. A study of attainable leading-edge suction as applied to fighter-type wings was completed. Results indicate that aerodynamic performance benefits, due to maximizing leading-edge suction, are greater at flight conditions than that previously determined in the wind tunnel (large Reynolds number effects). Nonlinear full potential flow analytical methods are being developed and verified for fighter wings at supersonic maneuvering conditions. Currently, an aerodynamic technology data base for efficient weapons integration, carriage, and separation at supersonic speeds is being established. Cooperative efforts continue to be pursued with industry and DOD on high-performance military aircraft design, especially in the areas of wing design and weapons carriage.

The first phase was completed of a study to identify optimum control system architectures for highly integrated airframe and propulsion controls applicable to future high-performance aircraft utilizing two-dimensional vectoring nozzles that present multivariable coupled control system design problems. A set of experiments that exercise and validate key features of the selected architecture is being defined for the Avionics Integration Research Laboratory (AIRLAB).

Work in the supersonic aircraft integration technology program was directed at the application of emerging technologies in aerodynamics, propulsion, controls, structures and materials, to military concepts. Several concepts that synergistically integrate advanced technologies for large potential performance gains were identified. Supersonic propulsion integration research emphasis was on the design and fabrication of a variable diameter centerbody inlet and on the design and analysis of inlet concepts that will allow high angle-of-attack operation.

Mach 5 turbo/ramjet propulsion system studies have identified two promising inlet concepts of which model design and fabrication are underway. Tests of a Mach 5 liquid natural gas-fueled airplane model have been completed at supersonic speeds. Dual model subsonic/supersonic combustion was achieved with high levels of net thrust and without inlet-combustor interaction. Hypersonic air-breather missile concepts are under study for potential future Navy and Air Force mission requirements in order to provide a focus for NASA hypersonic research in aerodynamics, propulsion, and structures.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The reduction of $1.6 million in high-performance aircraft research and technology reflects a reduction in the propulsion/airframe integration effort and a decrease in emphasis on powered lift and flight dynamics and control activities in order to provide funding for other priority aeronautics research activities.

BASIS OF FY 1985 ESTIMATE

In powered lift, the critical technology areas that are being investigated are in ejector performance and vectored thrust, both in and out of ground effects. The specific program is directed at achieving an understanding of the factors that influence ejector system performance.

Flight dynamic activities will emphasize three areas of concern to future tactical military aircraft: analyses of nonlinear high-altitude, high angle-of-attack flight characteristics, stall departure/spin behavior, and improved high angle-of-attack combat maneuverability. Piloted simulation studies to define control system effectiveness and requirements for advanced configurations utilizing thrust vectoring for pitch and yaw control and for integration of vortex flaps into the control system will be conducted. Also, piloted simulation of thrust vectoring throughout the flight envelope will be applied to short takeoff and landing (STOL) and short takeoff and vertical landing (STOVL) concepts.

Aerodynamics and propulsion integration research will emphasize STOL and STOVL, sustained supersonic operation, and long-range missile concepts. The vectored-thrust, two-dimensional nozzle program will include analytical efforts addressing internal aerodynamics, heat transfer and materials, and improved hot section testing capability. This activity will also include tests on full-scale nozzles.

Advanced controls research will include component technology and subsystem interactions. Digital airframe and engine controls for aircraft with vectored thrust and reduced stability are also under study.

In the area of supersonic cruise, research will concentrate on configuration development and technology integration tradeoff studies for competitive vehicle concepts. Specific areas of interest include arrow and curved leading-edge wing configurations, transonic interference effects and high angle-of-attack performance. Testing will be initiated on the variable diameter centerbody inlet wind tunnel model.

Hypersonic vehicle activities are focusing on two applications with concurrent technology development. For the Mach 5 cruise vehicle with the dual engine propulsion system, research activities include variable geometry inlets, various geometry nozzles, and hot structures for nacelle construction. Buildup of the hypersonic dual-mode scramjet test module will also be completed. The space research program will include an evaluation of a high lift/drag (L/D) entry research vehicle which could provide aeronautical performance data in this flight regime.

Flight research operations support in FY 1985 will include chase operations, airspeed calibration pacer flights, remotely piloted research vehicle air drops, and flight crew readiness operations. High-speed wind tunnel operations will continue to generate extensive experimental data for a range of vehicle configurations with emphasis on high-performance military aircraft.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Subsonic aircraft research and technology	9,000	9,000	18,900	20,200

OBJECTIVES AND STATUS

The objectives of the subsonic aircraft research and technology program are to provide the necessary research and technology development for an improved and validated base of new technology for application by industry to future generations of the entire spectrum of civil/military aircraft. The program is organized into the following major categories: (1) aviation safety, (2) flight dynamics, (3) advanced transport operating systems, (4) configuration/propulsion airframe integration, (5) transport aircraft laminar flow, (6) systems analysis and integration studies, and (7) research airport support. The activities within this program encompass advanced engineering techniques and the demonstration of the feasibility of concepts to ensure rapid application of promising new technology essential to meeting one or more of the following goals: (1) defining the environment in which future systems will operate, (2) understanding the interaction of the system or subsystems with the environment, (3) developing advanced technology interaction of the system or subsystems with the environment, (4) developing advanced technology within the system itself, and (5) extending the capabilities of man in the system.

The objective of the aviation safety program is to provide a better understanding of aeronautical safety hazards and their consequences and to improve criteria for design of aircraft systems and operating techniques. It involves research in aviation meteorology, aviation operations safety technology, and aircraft systems operating efficiency improvement.

The objective of the flight dynamics program is to develop a better understanding of basic phenomena, improved analytical and experimental techniques, new concepts, and valid experimental data relating to flight dynamics and handling qualities of small and medium-sized subsonic aircraft.

The objective of the advanced transport operating systems program is more efficient and safe transport aircraft operations in the National Airspace System via integration of airborne capabilities with the evolving system; reduced individual aircraft costs through improved operations and reduced system complexity; and improved man-machine interface.

The objective of the configuration/propulsion airframe integration program is to reduce integration losses that are associated with integrating propulsion systems with the airframe.

The objective of the transport aircraft laminar flow program is to develop technology for application to future commercial transport aircraft. Elements of the program involve evaluation of laminar flow concepts including natural, hybrid and full laminar flow control; establishment of a design data base; and evaluation of the practicality of this technology.

The objective of systems analysis and integration studies is to provide a stable ongoing effort in the exploration of the potential benefits and advantages derived from the integration of advances in individual aeronautical disciplines into whole configuration concepts.

The objective of the research airport support program is to provide support and operations of the research airport and other supporting services at the Wallops Flight Facility for aeronautical research and technology in those areas dealing with flight characteristics and performance and related aircraft systems.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The subsonic research and technology program was increased by $9.9 million by redirecting funding from other ongoing research and technology base programs. This action provides funding to support priority research activities in laminar flow control and advanced transport operating systems and is in line with Congressional recommendations related to the FY 1984 program. In addition, it provides funding to support general aviation aerodynamics and flight dynamics efforts within the research and technology base.

BASIS OF FY 1985 ESTIMATE

In FY 1985 the aviation safety program will focus on expanding aircraft icing research into a cooperative broad-based National Aeronautics and Space Administration/Federal Aviation Administration/Department of Defense/National Oceanic and Atmospheric Administration program. The program will apply ongoing meteorology hazards research in simulation technology for research in human factors displays, aerodynamics, training, safe and efficient flight planning, instrumented aircraft participation in the interagency mesoscale meteorology field research program, and improving aircraft operations on nonstandard runway surfaces. The final phase of the cabin fire safety program will be completed with full-scale testing by FAA of large, lower weight fire-resistant wall and ceiling panels. The results of the full-scale controlled aircraft impact demonstration will be analyzed for validating structural impact dynamic computer codes.

In the flight dynamics area, emphasis will be directed toward cooperative activities with general aviation aircraft manufacturers to investigate the applicability of spin-resistant concepts and advanced aerodynamics for future aircraft designs. Both single- and multi-engine configurations will be considered. The implications of advanced flight dynamics technology on small aircraft certification standards will be developed and made available to the FAA.

In advanced transport operating systems, the program direction will be on air traffic control/aircraft system simulation studies, the establishment of airborne systems performance baseline, crew roles and procedures concepts, and specific airborne function concepts. Activities will include validation of a total energy control system, runway friction tests, microwave landing system transition techniques, advanced electronic attitude director formats, high speed runway turnoff guidance system and display evaluations, and integrated flow management concept studies.

In the configuration/propulsion airframe integration area emphasis will continue to focus on enhanced aerodynamic performance of new configuration concepts. Concepts for general aviation, commuter aircraft and large transports to minimize aerodynamic drag penalties associated with integrating the propulsion systems will be addressed.

The transport aircraft laminar flow program will involve completion of the demonstration of the effectiveness and practicality of wing leading-edge systems in maintaining laminar flow under representative flight conditions, establishing a flight data base for hybrid laminar flow control and natural laminar flow transition analyses/designs, and completion of design and evaluation of integral and glove surface panel structural concepts.

Systems analysis and integration studies will include further detailed investigation of the potential benefits and research needs related to advanced electric secondary power systems for large transports. This is a NASA-developed concept which evolved from space technology research. It will be investigated cooperatively with aircraft manufacturers to refine recently completed in-house studies and to delineate major areas requiring further research.

BASIS OF PY 1985 FUNDING REQUIREMENT

SYSTEMS TECHNOLOGY PROGRAMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Fbtorcraft systems technology................	22,300	27,600	27,600	26,500	RD 12-33
High-performance aircraft systems technology	14,950	19,900	19,900	21,000	RD 12-36
Subsonic aircraft systems technology.	16,975	5,000	5,000	19,000	RD 12-38
Advanced propulsion systems technology	27,300	---	17,000	16,100	RD 12-40
Numerical aerodynamic simulation............	---	20,000	17,000	26,500	RD 12-43
Total..................................	81,525	72,500	86,500	109,100	

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft systems technology				
Guidance and navigation....................	1,500	1,600	1,600	---
Rotor systems research aircraft (RSRA) flight research/rotors	5,000	3,300	3,300	---
Advanced rotorcraft technology.............	15,800	14,700	14,700	10,200
Technology for next generation rotorcraft..	---	8,000	8,000	16,300
Tbtal....................................	22,300	27,600	27,600	26,500

OBJECTIVES AND STATUS

The rotorcraft systems technology program conducts research on two fronts. The first thrust consists of efforts in broad systems technology areas that advance the state of the art in flight dynamics and controls, aerodynamic analyses, and the prediction and reduction of loads, vibration and noise. The second thrust involves advanced military and civil concepts which are investigated in conjunction with DOD and the FAA. These currently include the X-Wing demonstration test on the RSRA, and XV-15 tilt rotor flight testing. In both of these thrusts, integrated system testing is required and involves large-scale wind tunnel testing, flight testing and moving-base simulation.

The guidance and navigation research has been well integrated with the FAA. For remote site IFR (Instrument Flight Rules) approaches, a simulation of a high-resolution radar for limited visibility landings was conducted. The use of low-cost beacons and airborne radar for all-weather guidance was investigated. Curved-path flight tests using a flight director in an MLS (microwave landing system) environment were conducted. The simulation of an existing digital automated avionics system newly adopted to helicopter needs was initiated. In FY 1985 the primary elements of this effort will be continued in the research and technology base.

Flight dynamics research is well integrated with the Army in its co-located Aeromechanics Laboratory. A sling load operation under a CH-47 was simulated. Analysis of two helicopters (twin lift) supporting a single load was undertaken. Simulation of fault-tolerant control architectures was begun to study failure modes and system requirements. A study of fault-tolerant actuators was completed.

A variety of large-scale rotors have undergone only limited testing since the 40x80x120-foot wind tunnel upgrade is not yet complete. A modern 4-bladed rotor has been procured for the interactional aerodynamics testing described under the research and technology base program. Instrumentation of an existing rotor was completed for a test of vibration suppression using multicyclic control of blade pitch. The failure of the bearingless main rotor (tested in a hover in 1983) was diagnosed. Preparations have begun to test an advanced French rotor in 1986. In return for the use of NASA facilities, the French have agreed to make available the aerodynamic and structural design details for use by U.S. industry.

In 1984 the two RSRA aircraft were used to support the joint NASA program with DARPA to demonstrate the X-Wing rotor in flight. One RSRA was modified by the contractor to accept the X-Wing rotor. Simulations of the X-Wing/RSRA were conducted in the Vertical Motion Simulator (VMS) for transition, conversion and emergency operation. The second RSRA was tested at Dryden Flight Research Facility in a fixed-wing mode with its rotor removed to simulate various X-Wing conditions. Following this test, the vehicle resumed its original test program, completing documentation of the five-bladed S-61 rotor. For new testing to begin in FY 1985, a modern four-bladed rotor was acquired for acoustic and aerodynamic investigation. This effort will be continued in the research and technology base in FY 1985.

Tests on the XV-15 tilt rotor research aircraft resumed with the installation of new, stronger hubs. This enabled the XV-15 to complete portions of the flight envelope documentation previously limited by hub loads. The advanced technology blades were hover tested on the outdoor aerodynamics research facility together with an XV-15 rotor and a conceptual JVX (joint armed services vertical take-off aircraft) rotor. The advanced blades were installed on the XV-15 in preparation for flight testing. JVX simulations were supported with the construction of a special cab for the VMS.

In propulsion systems, ground testing of the convertible fan/shaft engine continued. This modified TF-34 engine is establishing a data base €or propulsion concepts for high-speed compound helicopters such as the X-Wing.

Rotorcraft systems studies continued, highlighting new opportunities for research. In 1984 several pilot projects were completed in applying fixed-wing optimization techniques to helicopter problems. NASA participated in a study and conference on future air transportation for the State of Alaska. Also sponsored were contracts that identified the technology needs of public service helicopters such as emergency medical service vehicles. Several advanced DOD vehicles were conceptionally designed (LHX/Army light helicopter, JVX/tilt rotor, X-Wing).

BASIS OF FY 1985 ESTIMATE

In flight dynamics research, Army field pilots will verify the simulation of sling loads, with areas for improvement to be identified. Simulation of twin lift will be accomplished, establishing its feasibility as a piloted task. Fault-tolerant control work will continue in the laboratory with the manufacture of several experimental fault-tolerant actuators. Flight dynamics and human factors research will also be involved in the "superaugmented" rotorcraft studies.

With the delay of 40x80x120-foot wind tunnel operation until FY 1986, a large backlog of tests will accumulate. The interactional aerodynamics test which seeks to examine main rotor/fuselage/tail rotor/wing interference and noise and loads measurements will continue in the preparation stage. Also undergoing preparation will be the test of multicyclic control for vibration suppression to investigate various control algorithms in order to document the promise of adaptive control theories for the first time. Arrangements for the French rotor test and a reconstructed bearingless main rotor to be tested in 1986 will continue. A UH-60 rotor will be instrumented for comprehensive noise testing in 1986.

The advanced technology tilt rotor blades will be tested on the XV-15. This will conclude the NASA flight test program of this very successful research aircraft. One vehicle may go to the Navy in support of the JVX full-scale development. A JVX rotor/wing combination will be tested in the 40x80-foot wind tunnel as a critical milestone in that program. It will be the first test in that facility when it becomes operational in FY 1986. Simulation support will also continue.

The X-Wing rotor program will be generating wind tunnel, simulation, and analytical data. This fast-paced program culminates in several crucial tests in 1985 and will require special NASA capabilities to support the contractor's efforts. In particular, a model rotor test will be supported for detailed aeroelastic behavior in helicopter transition, conversion and stopped rotor flight modes. The first demonstration flight of the X-Wing rotor concept is expected in 1985.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology				
High-performance flight research..........	9,150	8,700	8,700	9,200
Highly maneuverable aircraft technology....	200	---	---	---
Turbine engine hot section technology......	5,600	11,200	11,200	11,800
Total..................................	14,950	19,900	19,900	21,000

OBJECTIVES AND STATUS

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft for military and civil applications. The program objective is accomplished by analysis, ground-based simulations, and wind tunnel experimental research and flight research tests of aircraft, as well as development of specific analytical methods for turbine engine durability improvements.

In the joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) program, the AFTI/F-16 digital flight control system phase was completed, and the aircraft is undergoing modification for the automated maneuvering attack system flight phase scheduled for FY 1984. In the AFTI/F-111 Mission Adaptive Wing project, the modified wing was delivered by the contractor (Boeing) to NASA for installation in the F-111 aircraft. After final assembly and checkout is completed, the aircraft will undergo flight testing scheduled for mid-FY 1984. The joint NASA/Navy program to improve the high angle-of-attack flight characteristics of the F-14 was completed after extensive evaluations of the NASA-conceived aileron-to-rudder interconnect control system was shown to be effective in the high angle-of-attack flight region. After successfully completing the flight evaluations of the digital electronic engine control (DEEC) program, the F-15 aircraft will be used this year to continue propulsion system improvement flight investigations using an F-100 engine model derivation with the DEEC system to address failure detection and accommodation. In the NASA/DARPA X-29A forward-swept-wing flight demonstration program, NASA is continuing to conduct wind tunnel tests, simulations, computational analysis, and ground tests in preparation for the flight test phase scheduled for initiation in FY 1984. The highly maneuverable aircraft technology (HiMAT) program, after successfully demonstrating its vehicle design goals, was completed. Results from the flight tests are being analyzed and reported. An F-4C aircraft will be modified with spanwise nozzles located over the wing leading-edge root and near the tip to verify in flight the low-speed flying qualities improvements predicted by analytical and wind tunnel tests. In the powered-lift research and technology program, a YAV-8B Harrier will be acquired and modified in FY 1984 for flight control and performance evaluation studies.

In FY 1984, the turbine engine hot section technology (HOST) program continues to address the technical issues involved in engine durability. A 3-D thermal-structural data transfer module was developed and released to industry. Advanced turbine engine instrumentation was demonstrated with the development of an improved hot section viewing system and a high-resolution dynamic gas temperature probe. An assessment of existing combustor aerothermal models led to the realization that major improvements and new benchmark tests are required. A new test facility for combustor lines cyclic testing has been put in place at Lewis Research Center. Also, major improvements in the fatigue laboratory have been completed, allowing complex computer-controlled thermomechanical loading of turbine alloys and coatings.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding level reflects an increased emphasis on high-performance flight research to provide the technology foundation applicable to the development of future high-performance aircraft. The high-performance flight research activity in FY 1985 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will continue their flight test phases during this period. Under the joint NASA/Air Force AFTI projects, the F-16 aircraft will continue flight evaluation of integrated technologies comprising the automatic maneuvering and attack system (AMAS), and the F-111 mission adaptive wing will continue flight envelope expansion starting with the preliminary assessment of the automatic flight control system (AFSC). The joint NASA/DARPA X-29A forward swept wing flight demonstration program will continue its envelope expansion and begin its flight research phase of the program. The F-15 highly integrated digital electronic controls (HIDEC) program will begin flight research to evaluate the potential of improving the performance and mission effectiveness due to engine-airframe control integration. The high angle-of-attack flight research activity will be continued using other aircraft opportunities and will focus on developing the design methodology applicable to handling qualities improvement and control system design for aircraft operation at high angles of attack. In FY 1985, the YAV-8B Harrier program will concentrate on evaluation of the performance of the NASA-modified flight control system for comparison with simulations.

In FY 1985, the HOST program will concentrate on continued improvements in instrumentation to validate newly developed models; studies on multiple jet dilution mixing and flame radiation/heat flux modeling; and 3-D flow and heat transfer models for nonrotating and rotating components, including cooling passage effect. Advanced 3-D inelastic structural/stress analysis methods and solution strategies will be developed, along with anisotropic life/constitutive models for creep-fatigue interaction. Also, the role of oxide scale and coating composition in hot corrosion will be evaluated. The research program on the use of ceramic materials for long-life components will continue.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of	Dollars)	
Subsonic aircraft systems technology.........				
Laminar flow control......................	4,558	---	---	---
Energy efficient transport..................	1,322	---	---	---
Composite primary aircraft structures......	6,971	---	---	---
Advanced transport operating systems.......	4,124	---	---	---
Advanced composite structures technology...	---	5,000	5,000	19,000
Total..................................	16,975	5,000	5,000	19,000

OBJECTIVES AND STATUS

The objective of the subsonic aircraft systems technology program is to provide a substantiated base of key technologies, design data and validated design procedures. Individual concepts are examined in the systems context with other interacting components and technologies to define techniques and procedures for obtaining maximum benefit from these applications.

The objective of the composite primary aircraft structures program has been to provide a technology base for graphite composite material used in secondary and medium primary aircraft structures. Technology efforts have proceeded on schedule and major milestones have been met on lightly loaded, stiffness critical, secondary and medium primary Structures. Secondary composite structures are now state of the art and already in airline operational service on the Boeing 767. The FAA certified the B-737 composite horizontal stabilizer medium primary structure in August 1982, and five shipsets of this component will be installed on the B-737-300 line and will enter flight service evaluation by Delta and Alaska International Airlines in 1984. The L-1011 vertical stabilizer successfully completed all strength and damage tolerance tests, and small-scale elements have completed 20 years of simulated environment and fatigue testing. NASA will run residual strength tests on these specimens in-house. Ground tests of the DC-10 vertical stabilizer were successfully completed in 1983 with final failure occurring at 7 percent above predicted load. A flight article is being fabricated for flight test to support certification. The program on medium primary structares will be completed with the FY 1984 FAA certification of the DC-10 vertical fin.

The objective of the advanced composite structures technology program is to develop a composite primary airframe structures technology base that achieves the full potential of weight, fuel, and cost savings possible for the design of civil and military transport aircraft in the 1990's. The program's purpose is to establish a composite engineering data base which will permit government and industry management decisions to commit composites to advanced, large aircraft with acceptable cost and risk. Full airframe use of lighter weight composites in primary airframe structure can reduce overall aircraft weight and acquisition costs by up to 15 percent, significantly lowering operational costs and extending service usage.

BASIS OF FY 1985 ESTIMATE

The FY 1985 budget estimate for the second year of the advanced composite structures technology program is based on consideration of the existing state of the art for composite structures and the technology development needed to establish the engineering data and confidence required for the application of composite primary structures to large civil and military transport aircraft in the 1990's, as well as detailed proposals to conduct this research. Research and technology efforts were initiated in three major areas: (1) wing technology development focused on critical design issues, structural criteria, and certification requirements; (2) fuselage curved panel technology considering biaxial and post-buckled loading; and (3) advanced materials with increased resistance to damage and impact loads. These efforts will provide a basic understanding of composite performance in large airframe structures and will provide design guidance in the development of acceptable configurations and procedures to evaluate limiting structural effects.

In FY 1985, continuing wing structure activity will include test evaluation of design details for structural configurations and the development of a large body of design information to support the ongoing detail structural design work. Analytical procedures will be assessed and verified with small scale element tests, and structural criteria will be defined for thick laminates, fuel containment, and damage tolerance. This research will provide the design engineering data and criteria needed to support the detail design of the major structural test components, as well as future designs of large, heavily loaded composite wing structures.

The FY 1985 effort on technology development for fuselage structures will focus on establishing design concepts, identifying critical design issues, and determining damage-resistant configurations through a multitude of small-scale structural element tests. Additional work will define the limits of post-buckling behavior and will extend testing to larger curved panels under combined pressure and bending loads. These efforts will provide design approaches and engineering data on strength-critical, large curved panels to support the detail design of large test components, and establish design methods and criteria for large, thin pressure sections.

Advanced materials research and technology will develop and characterize tougher, more processable composite systems with increased resistance to flaws and induced damage. New resins will be synthesized to increase strain limits, and the fiber interface will be studied to improve bonding characteristics.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology				
Energy efficient engine....................	6,300	---	---	---
Advanced turboprop systems..................	15,000	---	15,000	14,000
General aviation/commuter engine technology	3,000	---	2,000	2,100
Broad property fuels.....................	3,000	---	---	---
Total........................	27,300	---	17,000	16,100

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore advanced concepts for future aircraft engines in high-payoff technology areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

The energy efficient engine program is nearly complete. The integrated core/low spool test has been completed successfully and the remaining component tests, which are compressor rig tests at both contractors, will be completed during 1984. All data support the goal of 15 percent fuel savings when these technologies are applied to advanced turbofan engines. Studies conducted during FY 1983 have shown that advanced component technologies beyond those developed in the energy efficient engine program have the potential to reduce fuel consumption an additional 15 percent.

Activities in the advanced turboprop systems program are focused on development of a broad research and technology data base and on support for potential future systems integration/flight research phase necessary to establish large-scale advanced turboprop feasibility. The preliminary design review for the large-scale advanced propeller (LAP), 9-foot-diameter SR-7, was conducted. The design recommended by Hamilton Standard was approved, and fabrication of the first large-scale single-rotation blade will be performed in 1984. An independent assessment of the SR-7 aerodynamic, acoustic, structural and aeroelastic characteristics is in progress at Lewis Research Center (LeRC). Detailed design of the 2-foot-diameter aeroelastic model of the SR-7 is underway and will be used to verify the aeroelastic scalability of the 9-foot LAP. The proposals for the propeller test assessment (PTA) are being evaluated, with contract award scheduled for 1984. A contract was awarded on November 22, 1983, (to the General Electric Company) to provide a counter-rotating propeller drive rig and several 2-foot-diameter propfan models to the Lewis Research Center for testing in the 8x6-foot wind tunnel. A proposal for an unducted fan engine ground test program for a gearless counter-rotation propfan concept is also in the evaluation process at LeRC with a contract award scheduled for 1984. High-speed wind tunnel aerodynamic performance investigations of the contoured over-the-wing nacelle installation on a semispan wing and low-speed wind tunnel stability and control investigation of aft-mounted configurations will continue in 1984. Subscale propeller model tests in high-speed wind tunnels and on the Jet Star aircraft have given encouraging indications of achieving cabin comfort and community noise goals with only minimal weight and configuration penalties.

The general aviation/commuter engine technology effort for 1983 and 1984 serves as a focus for small engine component research that is aimed at 25 percent improvement in small engine component efficiencies. Analytical design techniques that incorporate the small engine limitations associated with scale, surface finish and Reynolds number are being developed and verified through the use of advanced instrumentation and experimental techniques. Specific efforts include the testing of centrifugal compressors scaled from 20 lb/sec to 10 lb/sec, evaluation of transpiration cooled reverse flow combustor liners, and evaluation of innovative variable area radial inflow turbines.

The broad property fuels research in 1983 emphasized the testing of combustion systems, turbines, and fuel systems in order to understand the effects of fuel property variations. The objective was to provide an understanding that would lead to fuel flexible concepts, components, and systems to help aviation adapt to evolving world energy supplies.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The FY 1984 aeronautics budget request submitted to Congress contained no funding for advanced propulsion systems technology programs. The advanced propulsion systems technology program in FY 1984 is $17.0 million (advanced turboprop systems, $15.0 million; small engine technology, $2.0 million). In order to fund the advanced turboprop systems program at $15.0 million in FY 1984, $10.0 million was redirected from the research and technology base; $3.0 million resulting from adjustments in systems technology programs and the $2.0 million additional appropriation were also applied to meet this requirement. The balance, $2.0 million, was redirected from the research and technology base to provide funding for small engine technology.

BASIS OF FY 1985 ESTIMATE

In FY 1985, advanced turboprop systems program activities will continue to develop the broad-based supporting technology required for advanced high-speed turboprop propulsion and will include advanced concepts and configurations such as counter-rotation propeller systems. In FY 1985, the aeroelastic model of the large-scale propeller (SR-7A) will be fabricated, and wind tunnel aerodynamic performance investigations of improved under-the-wing and over-the-wing nacelle installations on improved semispan wings will be completed. High-speed wind tunnel stability and control investigations of wing and aft-fuselage mounted propeller configurations will be completed. High-speed investigations of wing- and aft-mounted counter-rotation propeller configurations will also be carried out. Additionally, validation tests of counter-rotation propeller model performance and acoustics will be completed.

The general aviation/commuter engine technology effort will continue to focus on the development of a fundamental understanding and analytical data base for flow phenomena and heat transfer in small gas turbine engine components. Fundamental efforts will include large low-speed rig and small high-speed 2 lb/sec centrifugal compressor flow-field measurements using laser doppler velocimeter instrumentation to provide benchmark data for size-related design variables. Emphasis will be placed on research that focuses on endwall aerodynamics and the effects of boundary-layer thickness on secondary flow fields. Research will be continued on the investigation of radial outflow combustors and advanced materials for combustor liners, as well as cooling and variable geometry concepts for cooled radial turbines.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Numerical aerodynamic simulation............	---	20,000	17,000	26,500

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the Nation's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. This program will provide the computational capabilities required to obtain solutions to problems which are currently intractable. Ongoing research and technology base efforts in computational aerodynamics will benefit significantly from the advanced computational capabilities to be provided by the NAS program. The combination of these programs will provide pathfinding aeronautical research for the future, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. The NAS program will develop an extensive, user friendly system to assist engineers and scientists in all aspects of problem solution, from problem formulation through graphical presentation of results. The heart of this system is the high-speed processors, which will be the most advanced commercially available supercomputers. These machines will provide the large-capacity/high-speed computational capability required in advanced fluid dynamic research and applications.

The NAS program study and planning phase was initiated in the research and technology base in FY 1983 with system development beginning in FY 1984. This phase will lead to a system design review in FY 1984 and will formalize the design of the NAS system. The system software development contractor will begin development of the network language and protocols during FY 1984. The initiation of the full-scale development of the system software will occur after the results of the network testbed tests are analyzed. The network testbed has been assembled and testing has begun on both networking languages and protocols. These tests will be completed in FY 1984 and will result in the selection of a candidate networking language and protocol that meets the NAS system requirements. Also initiated during FY 1983 were the procurement activities leading to the acquisition of the first high-speed processor.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The NAS program reflects a decrease of $3.0 million, which resulted from Congressional action that limited this program to $17.0 million and the acquisition of only a single high-speed processor in FY 1984.

BASIS OF PY 1985 ESTIMATE

The first high-speed processor for the NAS system will be acquired in 1984 and will continue under lease through FY 1985 and beyond. This high-speed processor is the heart of the NAS system and the key component around which the extensive, user friendly subsystems are assembled. The development of the system control and operation software will be continued during FY 1985 leading toward an FY 1986 initial operational status for the NAS system. The NAS system network development will continue with the acquisition of critical system components required to attain system operational status. The critical system components include additional work stations to provide access to the NAS system through the support processing subsystem and acquisition of components for the long-haul communications subsystem which will allow remote access to the NAS. Additionally, initial acquisition and assembly of the graphics subsystem will occur, which is required to support the output and analysis of large data-producing solutions/simulations. The combination of the work station, support processing, and graphics subsystems is critical to the successful initial operation of the NAS system. System tests and integration activities leading up to the initial NAS operations will begin in FY 1985. These tests and integration activities are necessary to assure that the NAS system meets the system requirements developed during the initial planning activities. FY 1985 will be a year of intense activities leading toward the initial operations of the NAS system in FY 1986.

BASIS OF FY 1985 ESTIMATE

The FY 1985 program in space research and technology will continue to be directed toward providing the broad base of innovative technology essential to the conduct of future space missions. It supports agency goals in space transportation systems operational effectiveness, space station concept formulation, science and applications mission capabilities, and provides synergistic support to the military and commercial space user needs.

In fluid and thermal physics, efforts will continue to improve the analytical and predictive techniques within, and the transition between, continuum and rarefied flow regimes while new emphasis will be placed on transatmospheric space flight. Materials and structures activities will include large-area structural concept development, solar array construction techniques, generic mechanisms technology, and the combined effects of structural dynamics and controls. The computer science and electronics program will stress concurrent processing, a critical element in computational fluid physics research, and will increase emphasis and focus on optics research. Advanced sensor technologies will continue to explore laser, electro-optic and microwave concepts for both remote and in-situ applications. The space energy conversion program will continue its emphasis on high-capacity power and thermal systems required for a permanent presence in space and on technology for high specific power, low weight systems for geosynchronous and planetary missions. Electric propulsion technologies will stress auxiliary propulsion applications with continuing attention on power processors and thrusters; resistojet technology will focus on more efficient orbit maintenance concepts; and, thermal-to-electric energy conversion in support of the SP-100 nuclear reactor power system research and technology program will receive increased emphasis. Research emphasis in the controls area will be placed on large, flexible, and precisely controlled structures; the integration of attitude control and energy storage functions in flywheels; and, the precision pointing of large spacecraft. Human factors efforts will continue to be aimed at the enhancement of astronaut productivity through improved information management techniques, extravehicular work stations, and a telepresence capability. In space data and communications, increased emphasis will be placed on information systems research including automation, robotics, optical information and data systems. Chemical propulsion technology will be directed toward: the understanding of life and performance parameters for liquid oxygen-liquid hydrogen engines such as the space shuttle main engine (SSME) and other potential advanced high-pressure engine systems, stressing component and integrated diagnostic instrumentation techniques; orbital transfer engine technology to enable Space-based, throttleable, and reusable systems; and, technology for gaseous oxygen-hydrogen propellant systems. When required to obtain valid research data, in-space flight experiments will be performed to support discipline or systems research programs by capitalizing on the shuttle as an economical experiment base.

Within the research and technology base, the spacecraft, transportation, and platform systems programs will continue to develop analytical tools that provide a continuing basis for planning, ranking, and identifying emerging technologies for focused transition to flight program application. The spacecraft systems efforts will emphasize development of spacecraft technology for advanced earth-orbital and planetary spacecraft. Satellite communications research and technology is directed toward long-term, relatively high-risk developments in the Ka band and at frequencies extending through the 100 gigahertz (GHz) range. In the transportation systems area, emphasis will be placed on identifying technology requirements for advanced earth-to-orbit transportation systems including improved space shuttle systems and orbital transfer systems with consideration being given to aeromaneuvering, space basing, maintainability, operational flexibility, and manned options. Efforts in the orbiter experiments program will continue to exploit the operational flights of the shuttle by installing instrumentation which provides a valuable source of flight research data. The platform systems program will be directed toward defining generic systems and advanced discipline technology efforts that support the agency thrust for permanent occupancy in space. Platform systems research and technology will establish technology for distributed data systems architecture, automated and teleoperated systems, life support systems, and operational extravehicular activities.

The advanced SSME systeins technology program will focus on providing system level data €or modeling performance and life, and validating component technology designed to improve life and reduce maintenance costs. The components will be installed on a testbed SSME and instrumented to provide the overall understanding and data base on performance in the realistic hot-fired engine environment. This is a joint program in which the Office of Space Flight will provide the testbed SSME.

BASIS OF FY 1985 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Fluid and thermal physics research and technology..	8,385	8,800	8,400	8,900	
Materials and structures research and technology	13,245	15,700	13,900	17,400	
Computer science and electronics research and technology	16,165	16,300	16,100	16,200	
Space energy conversion research and technology	17,900	18,000	22,100	22,600	
Multidisciplinary research	2,100	1,000	1,000	---	
Controls and human factors research and technology..	7,460	7,600	8,300	9,800	
Space data and communications research and technology	16,609	19,300	17,800	17,800	
Chemical propulsion research and technology..	16,600	15,700	16,400	17,400	
Spacecraft systems research and technology	4,520	3,700	5,200	9,700	
Transportation systems research and technology	7,300	8,000	7,400	8,400	
Platform systems research and technology	6,020	12,100	8,800	7,800	
Total	116,304	126,200	125,400	136,000	

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Fluid and thermal physics research and technology..............................	8,385	8,800	8,400	8,900

OBJECTIVES AND STATUS

The fluid and thermal physics program has the following objectives: (1) to develop validated experimental and computational techniques for predicting flow fields for a broad range of arbitrary aerospace vehicle configurations; (2) to improve techniques for predicting aerodynamic and aerothermodynamic characteristics of vehicle concepts in the continuum-to-rarefied flow regimes: and (3) to provide the experimental technology required for aerodynamic and aerothermodynamic testing. Improved techniques for predicting the capability and response of future aerospace vehicles in the various flow regimes, including ascent to orbit, low-earth orbit, and entry, will provide increased confidence needed for maximum use of the performance and payload potential of those systems.

Progress in the ability to predict flow fields about vehicles entering the Earth's or other planetary atmospheres has been accelerated by new computational techniques capable of analyzing shuttle-like vehicles at high angles of incidence that produce locally subsonic flow over the entire lower surfaces. These predictive codes have been validated by the data returned from shuttle flights one through five. Flow over the upper surfaces of such vehicles remains difficult to calculate because of the formation of separated zones that roll up into large vortex systems. At present, empirically derived methods provide limited capability for these upper surface predictions. Study of the very high Mach number flows over entry bodies has provided new information on chemical reaction rates and radiative properties of gases which will be useful in the future development of aeroassisted orbital transfer vehicles and heatshields for spacecraft entering the atmospheres of Saturn, Jupiter, Titan, and Mars. Exploratory studies of space-based aeroassisted orbital transfer systems have identified nonequilibrium radiation as an unknown factor that may control important decisions on heatshield geometry and material.

The theory of rarefied gases has been advanced by the use of a dedicated computer especially programmed for the multibody collision processes involved. The methods developed are being used in the study of contamination of spacecraft by control jets and, also, for estimation of forces and torques acting on reentry vehicles in the initial high altitude portion of the trajectories.

The orbiter experiments program has made use of the shuttle orbiter as a research aircraft permitting the evaluation of aerodynamic prediction methods. The flight data have generally corroborated predictions over much of the flight regime; however, several situations were found in which sizable differences occurred. Of particular interest for future aeroassist maneuvers is the variability in atmospheric density that was identified during the STS flight 5 as being as large as 25 percent of the best estimates. Variations of this size could pose serious problems for the guidance and control of space-based aeroassisted orbital transfer vehicles.

Aerothermal loads research focuses on the interaction of high temperature, high Mach number flows with specific surface structure. During the past year, analytical studies were performed to predict the heating of bowed quiltlike surfaces simulating advanced thermal protection systems, and a test program was prepared for the 8-foot high temperature structures tunnel at the Langley Research Center. The computed results show significant pockets or hot spots generated by the distorted surface. During the past year, the program supported the operation of high temperature, high Mach number facilities at the Ames and Langley Research Centers. These facilities provide a unique group of test jets and tunnels that were used extensively in the shuttle development. Also, they will be needed €or all future development of advanced vehicles and for validation of the developing computational methods of vehicle design.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $0.4 million reduction in fluid and thermal physics research and technology reflects a transfer of budgeting and management responsibility for the aerospace vehicle integrated design (AVID) effort to transportation systems research and technology and a reduction in planetary entry technology activities.

BASIS OF FY 1985 ESTIMATE

In FY 1985, computational methods will be advanced to treat the problems of vortex generation over upper surfaces of reentry vehicles of advanced design. Application of current prediction methods to high lift-to-drag ratio vehicles will be assessed, and approximate heating and aerodynamic force codes will be improved in accuracy and speed for use in the AVID system. The developing capability for computing rarefied gas flows will be applied to estimating the forces and torques on very large space structures, and flight test data from the shuttle will be evaluated to obtain comparisons with the theory. Ground based tests in this flow regime are not yet possible; therefore, reliance must be placed on the flight data.

Aerothermodynamic characteristics of a series of vehicle designs will be determined in a cooperative program with the Air Force. The vehicle shapes will be sufficiently different from that of the shuttle orbiters so that new problems with heating of leading edges must be addressed. Other blunt configured vehicles will be studied €or use as orbital transfer spacecraft, which requires addressing new environmental conditions. In particular, the determination of the magnitude and consequences of nonequilibrium heating will continue to be a major effort in FY 1985.

The aerothermodynamic facilities at both the Ames and Langley Research Centers will be used to provide data on forces, stability and control, and control and heating for the cooperative Air Force program, and to establish a data base for use in design of orbital transfer vehicles ranging from bent conical bodies to blunt and bulbous shapes simulating inflatable and deformable heat shields.

The aerothermal loads program will attempt the development of finite element methods for solving the Navier-Stokes equations applied to high temperature and Mach number flow over advanced thermal protection materials. The finite element methods will subsequently be matched to finite element structural codes to provide a complete method for determining interaction of structure and aerodynamic heating.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Materials and structures research and technology	13,245	15,700	13,900	17,400

OBJECTIVES AND STATUS

The objectives of the materials and structures research and technology program are to provide the performance, efficiency, durability, and economy required for large-area space structures, antennas and space platforms, advanced space transportation systems, orbiting spacecraft, planetary probes, and shuttle payloads. Major technical areas of emphasis in materials include basic understanding of advanced materials; development of computational chemistry methodology; characterization of long-duration environmental effects of space on materials; and the development of ceramic, metallic, and advanced carbon-carbon thermal protection systems. Structures technology is directed toward development of advanced truss structural concepts; reliable methods for deployment/erection of space structures; new concepts for advanced shuttle and orbital transfer vehicles; and efficient analytical methods for design and evaluation of advanced space structures, including integrated structures/thermal/controls analysis and optimization techniques.

In the past year, a highly packageable and deployable beam concept having controllable geometry was developed for use as a manipulator arm, docking device, or positioning platform. The working two-bay geodesic-truss beam model has demonstrated the potential for controllable geometry whether deployed straight, canted to the left in a C-curve, or fully retracted. A highly efficient rapid analysis capability for repetitive structure was developed and applied to an antenna-type structure. The vibration analysis of a complete complex antenna was accomplished with a repeating element of only 14 nodes at greatly decreased computation time. New analytical techniques have demonstrated the feasibility of applying heat to control the thermal distortion of orbiting spacecraft structure. Corrective temperatures, at specified control points which affect distortions, were analytically demonstrated to be an effective approach to the life-limiting problem.

Research on advanced thermal protection concepts has shown the feasibility of superalloy and oxide dispersion-strengthened materials for the hypersonic environment. Stable emittance exceeding shuttle requirements has been demonstrated in simulated reentry testing in a hypersonic arc tunnel, opening the way for more detailed structural concepts for future metallic systems. Additionally, Langley Research Center has established an advanced carbon-carbon fabrication capability to allow detailed materials characterization and the development of improved coatings for thermal protection application.

The space environmental effects facility, now in full operation, has been utilized to study the effect of combined electron and proton exposure on graphite-epoxy composites for spacecraft application. Detailed characterization of the radiation damage to these materials has shown that previous accelerated test methodology for simulated twenty-year doses produced less severe degradation than is now being seen at lower flux level/longer time tests that are possible in the new facility. Studies on the dimensional stability of graphite/aluminum metal matrix composites have shown that these new, lightweight, stiff materials appear unstable under thermal exposure when cycled between -250 and +250 degrees Fahrenheit in the unidirectional laminate layup configuration. Each cycle produces changes in specimen dimension. A recent shuttle flight experiment has significantly improved our knowledge of erosion rates in metals and ceramics due to atomic oxygen as encountered by spacecraft in low Earth orbit. The experiment also added to the basic understanding of the phenomena which can be expected to lead to a permanent solution to the problem.

The computational chemistry activity has successfully modeled the formation and growth of a fatigue crack in iron. Using a 2500 atom model, interatomic forces and dislocation theory, a prediction of fatigue crack growth rate was achieved. Plastic zone formation was clearly evident and simulated actual experimental observations.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The materials and structures research and technology program was reduced by **$1.8** million. This reduction primarily reflects the transfer of the funding and management of the large space structures antenna technology activity to the spacecraft transportation systems research and technology budget category. Other further minor reductions were also made to cover priority requirements.

BASIS OF FY 1985 ESTIMATE

The effect of the space environment on structural materials for spacecraft and potential space station application will continue to be a major thrust of the program. Included in the activity will be research on the durability of polymeric materials, thermal control coatings, films, adhesives, and seals. The radiation damage mechanism in epoxy matrix composites in a simulated environment at geosynchronous Earth orbit will be identified, and methodology for accelerated testing of these materials in the combined radiation of both electrons and protons will be developed. Thermal control coatings to allow full benefit of composite structures for large-area space application will be developed. The study of the dimensional stability of such structures in the space cyclic thermal load environment will continue. Basic research in the fundamentals of tribology of bearings for spaceborne mechanisms will be carried out with particular emphasis on solid lubrication for traction-drive actuators. Advanced carbon-carbon composite thermal protection systems will continue to be a major focus in the program, with activity directed at increasing the interlaminar shear strength by approximately 50 percent, and the development of new, improved oxidationresistant coatings. Activities in the ceramic thermal protection system area will be directed toward the further development of flexible ceramic blanket-type insulation €or application to advanced orbital transfer vehicles and for further upgrade of existing material currently employed on the orbiter. Research in advanced space structures will establish structural concepts, deployment schemes, and packaging techniques that will permit planar structures on the order of 100 to 200 meters in size to be carried into orbit in one shuttle flight and automatically deployed. Additionally, erectable concepts and assembly methods for structures between 100 and 1000 meters in size will be developed. Both analytical and experimental research will be conducted to develop procedures to characterize modular structures in ground tests, as well as in orbit. Active and passive damping techniques to reduce and isolate or suppress unwanted vibration will be achieved, leading to the development and validation of methods for predicting and reducing the response of large flexible space structures. Analysis will be carried out to provide minimum-weight thermal protection systems for fully reusable advanced space transportation vehicles.

	1903 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Computer science and electronics research and technology	16,165	16,300	16,100	16,200

OBJECTIVES AND STATUS

The objective of the computer science and electronics program is to provide advanced concepts, techniques, system architectures, hardware components, algorithms, and software for space information systems. The program contains disciplinary activities in electronics, sensor systems, automation, and computer science. Research in electronics is directed at new lasing media and detection methods, and developing new concepts in optical and solid-state technology. Sensor research is focused on extending the capabilities of active and passive sensor systems in terms of spectral range, sensitivity, and resolution. Automation research is developing the theoretical and technological base in artificial intelligence and robotics to increase the productivity and effectiveness of future operations in space. The computer science discipline strives to improve fundamental knowledge of computing principles and to advance the state of computational technology in aerospace applications such as spacecraft operations and image processing.

In electronics, advances have been made in the physics of radiation damage in silicon devices. A preliminary design for an electronic test chip to monitor radiation damage is in the planning stage €or the joint National Aeronautics and Space Administration/Department of Defense/Air Force (NASA/DOD/AF) Chemical Release and Radiation Effects Satellite (CRRES). In signal processing, an optical processor has passed initial tests, leading to real-time processing of Synthetic Aperture Radar (SAR) data. An optical receiver with a bandwidth of 500 megahertz (MHz) has been successfully tested, and experimental work is underway to increase the bandwidth by a factor of four. A well controlled tunable laser and data acquisition system have been developed for remotely sensing fluctuating temperatures and densities in high-speed turbulent wind tunnel flows. Basic research in electron-atom collision processes has resulted in the invention of a new mass spectrometer device which may have immediate application in contamination monitoring aboard the shuttle.

In sensor systems research, a prototype laser heterodyne spectrometer system was successfully fabricated and tested. A Stirling-cycle cooler with innovative magnetic bearings, designed for long-life applications in spaceborne sensor systems, completed 2,000 hours of life testing, and an experimental Joule-Thomson cycle absorption cooler, capable of lower temperatures, was built and successfully operated. Closed-cycle operation of a carbon dioxide laser radar system was demonstrated, completing a necessary step toward employing these systems in spaceborne applications. Laboratory detection of the oxygen-hydrogen (OH) radical, an important constituent of atmospheric chemistry, was demonstrated using a high resolution excimer (ultraviolet) laser. A successful airborne flight demonstration of the microwave pushbroom radiometer was completed.

In automation research, the knowledge base for the Voyager spacecraft was completed, paving the way for the use of the automated planning program called DEVISER, by the Voyager project during the Uranus encounter. DEVISER, developed at the Jet Propulsion Laboratory, is recognized as the current state of the art in artificial intelligence for planning and scheduling. Experimental versions of a telemetry monitoring program and a fault diagnosis program were demonstrated, providing an early feasibility test of the engineering concepts underlying space systems autonomy. Robot sensing and control research resulted in advances in machine vision and precision control. A stereo vision system operating at a rate of 30 Hertz was successfully demonstrated in the laboratory to perform real-time tracking of a moving convex object. This system was then coupled to the control system of an industrial robot arm to demonstrate automated grappling and controlled halting of a moving simulated spacecraft. Control algorithms for precise end point control of a one degree of freedom manipulator with very low structural rigidity in the plane of motion were also developed. Each of these represents a critical step toward automated space servicing, assembly, and repair capabilities.

The computer science research program focuses on three theme areas: concurrent processing; highly reliable, cost effective computing; and scientific information management. In concurrent processing research, the first order analysis of concurrent solution methods for linear systems was completed, including both direct and iterative algorithms. Research addressing testable fault-tolerant Very Large Scale Integrated (VLSI) circuit design principles resulted in the demonstration of an initial version of a software logic and fault simulator. This system is designed to verify the fault tolerant properties of new circuit designs, and exhibited a factor of ten improvement in performance over conventional serial simulation techniques. Data base research resulted in the specification of functional architecture for a data independent access method for distributed heterogeneous data bases. In software engineering, a Software Management Laboratory was established to evaluate software measures, and a conceptual model for a software life cycle dynamic simulation and cost estimation model was developed. The Center for Aeronautics and Space Information Sciences (CASIS) was established at Stanford University to develop a multidisciplinary academic center of excellence in aerospace computing.

CHANGES FROM FY 1984 BUDGET

The computer science and electronics research and technology program was decreased by $0.2 million. This action primarily reflects enhancement of university research in aerospace computing, offset by a reduction in sensors technology. CASIS at Stanford University is the principal recipient of this increased grant support.

BASIS OF FY 1985 ESTIMATES

Electronics research and technology development will continue to focus on submillimeter wave technology. The interaction structure of a submillimeter traveling wave tube for local oscillator applications in a heterodyne spectrometer receiver will be demonstrated. "Super-lattice" devices with material properties that are tunable will be demonstrated for application in the sensing systems technology program. Synthetic aperture radar signals with a signal-to-noise ratio of 30 dB will be processed in real time including a real-time zoom capability.

The sensors research and technology program will focus on the development of advanced lasers for space-based laser-radar systems. Development of a solid-state laser for application in spaceborne remote sensing of winds and atmospheric species will be initiated. Detector research will continue to develop and test detector arrays in the 2-200 micron range of the electromagnetic spectrum. A technology demonstration model of the Stirling-cycle cooler and a comprehensive program in microwave radiometry for large space antennas will be initiated.

In automation research, the three components comprising rudimentary autonomy (planning, monitoring, and fault diagnosis) will be integrated to demonstrate the fundamental technology of space systems autonomy. The Voyager project will be testing the DEVISER capabilities in a live mission environment, and a similar system will be undergoing test in the Kuiper Airborne Observatory in preparation for the shuttle infrared telescope facility (SIRTF) mission. The architecture of a space qualifiable knowledge-based system will be defined, paving the way for onboard applications of artificial intelligence. Robotics research will continue to advance sensing and control technology needed for robotic applications in space. Machine vision algorithms to distinguish classes of three-dimensional objects will be extended for space operations; vision algorithms suitable for VLSI implementation will be selected; and active, compliant arm control employing force/torque feedback will be integrated into the tracking and grappling experiment, providing a testbed for designing and evaluating supervisory control techniques.

In computer science, research in concurrent solution methods and algorithms will be extended to include nonlinear discrete systems, and simulation techniques will be applied to evaluate promising computing architectures suited to these methods. In fault-tolerant circuit research, applicable techniques and approaches will be consolidated and formalized into a design methodology for testable fault-tolerant VLSI circuits, and techniques will be developed for simplification of on-chip test generation and fault diagnosis. Data base research will focus on defining, investigating, and recommending concepts and architectures for rapid update and retrieval of information contained in very large (10^{12} to 10^{15}) multisource data bases. Software engineering research will maintain close coordination with the DOD Software Technology for Adaptable, Reliable Systems (STARS) program. A full set of software design measures and a rapid prototyping environment tailored to space systems software will be developed, and parametric values for the software life cycle simulation and cost estimation model will be quantified and utilized to validate the model. CASIS, at Stanford University, will achieve its mature size and capability, performing research and educating students in concurrent processing, information management, and large-scale system architecture.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Space energy conversion research and technology	17,900	18,000	22,100	22,600

OBJECTIVES AND STATUS

The objectives of this program are to: (1) increase the performance, capacity, and cost effectiveness of space electric power generation and energy storage subsystems; (2) provide the technology for efficient, reliable, and low-cost management and distribution of electrical and thermal energy for space systems; and (3) provide electric thruster system technologies for a unique national capability in electric propulsion. In FY 1983, significant advances were made in a number of technical areas. In photovoltaics, the Air Force selected the NASA-developed large silicon solar cell using wrap-around contacts and welded interconnect technology for the MILSTAR program. An important milestone in the achievement of effective concentrator solar arrays for large space systems was reached with measurement of gallium arsenide solar cell efficiency of over nineteen percent at a solar concentration of 100 suns. Nuclear reactor power offers potentially enabling benefits for future high-power civil and military space missions. To address this need, a tri-agency (Department of Defense/Department of Energy/National Aeronautics and Space Administration) effort called the SP-100 program was initiated both to advance the critical technology for such systems, and to explore mission applications. This research is expected to provide the information base for a future ground engineering system. In the electrochemistry program area, a laboratory regenerative hydrogen/oxygen fuel-cell-electrolysis subsystem was designed, fabricated and tested with highly promising initial results. Such systems are needed to reduce the mass of energy storage in large systems. Progress was also made in advancing the safety of the primary lithium battery which is becoming widely used in spacecraft because of its superior energy density. For the first time, the chemistry of these batteries was defined during normal operation and the critical importance of impurity and material controls to avoid the generation of explosive intermediates was specified.

Under the power management program, a space test was concluded which provided insights into the power losses and arcing phenomena of solar arrays in low-earth orbit (LEO). Understanding of this behavior is necessary to the design of power systems for future large space systems in LEO. Design guidelines for the assessment and control of charging of high-altitude spacecraft were broadly distributed for review. This step represents a major milestone in NASA's spacecraft charging program, the output of which is already widely used by U.S. and European spacecraft designers and builders. In the area of high-power components, direct-current remote-power controllers with the capability of handling greater than fifty times the power of present devices were demonstrated. Such devices are essential in the design of large, utility type, space power systems. The laser program is aimed at providing enabling technology for civil missions in high radiation as high-drag orbits in which the conventional solar array power sources are unsuitable. The emphasis of this research is to achieve continuous lasing using sunlight and on the development of suitable receivers that would efficiently convert the laser energy to electrical or heat energy to be used for power or propulsion. Major milestones toward these goals during the last year were the achievement of continuous lasing of a carbon-dioxide laser by means of blackbody radiation and the increase in lasing time by two orders of magnitude of a solar-pumped laser. Operation of an ion thruster was demonstrated with a power processor having more than a factor of ten fewer parts than required at present. This improvement will allow significant reductions in the cost and risk of application of ion thruster systems. A simple, low-cost, and scalable heat pipe radiator concept was successfully demonstrated on a shuttle orbiter space test. This space test was the first of several which are planned to establish the technology for high-power, two-phase, thermal-rejection systems. In ground tests, the accomplishments in thermal management included demonstration of a tenfold increase in heat-pipe transport capability and successful demonstration of a long (17m) radiator heat pipe using a basic space constructible design.

:ES FROM FY 1984 BUDGET ESTIMATE

The increase of **$4.1** million over the FY 1984 budget estimate reflects realignment of power and thermal technology activities from platform systems research and technology and increased emphasis on nuclear reactor space power and primary lithium batteries, offset by reductions to cover other priority requirements.

BASIS OF FY 1985 ESTIMATE

Overall, FY 1985 efforts will be directed at significant improvements in both the performance and capacity of space energy conversion systems. Solar cell and array concepts with promise of a factor of two increase in efficiency and specific mass, including advanced gallium arsenide thin cells and lightweight deployment mechanisms, will be evaluated along with concepts, such as concentrator arrays and advanced fabrication techniques, to improve the lifetime and reliability, and to reduce the cost of photovoltaic systems. Efforts will be directed at producing improved and safer lithium batteries, bipolar nickel-hydrogen batteries suitable for low-Earth orbit application, and demonstration of both alkaline and acidic regenerative hydrogen-oxygen fuel cells. In the thermal-to-electric program, efforts under the tri-agency SP-100 activity will continue to analyze civil missions benefited by use of nuclear power and to define candidate nuclear reactor systems using thermionic, thermoelectric, and dynamic conversion systems. Resistojet and arcjet electric thruster concepts will be evaluated on a variety of propellants in order to identify designs for the control of large Earth-orbital space systems, and the lifetime of inert gas ion thruster systems will be defined by test. Guidelines for the control of charging of high-altitude spacecraft will be completed, and major emphases will be directed toward definition of the low-altitude

Earth environment and its interactions with space systems. Advanced power management components, such as rotary power transformers and intercalated graphite conductors, will be studied to determine their feasibility and benefits for space power systems. In the thermal management area, effort will be focused on the technologies for two-phase systems and will include studies of fundamental fluid phenomena in zero gravity and testing of two-phase system components for thermal acquisition, transport, and rejection.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Multidisciplinary research..................	2,100	1,000	1,000	---

OBJECTIVES AND STATUS

The objective of the multidisciplinary research program has been to conduct long-range, basic research in the engineering and physical sciences focusing on high-risk areas with revolutionary high-potential payoff for space application and technology. A majority of the research has been conducted at universities through the physics and chemistry experiments in space (PACE) program which supports studies for the design of basic science and engineering experiments that will resolve fundamental scientific questions and discover new phenomena in which conditions of zero or near-zero gravity are prerequisite. The PACE program has progressed to the point where it should more appropriately be conducted as a science program. Beginning in FY 1985 it will be budgeted and managed by the Office of Space Science and Applications.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Controls & human factors research and technology................................	7,460	7,600	8,300	9,800

OBJECTIVES AND STATUS

This program consists of two discipline areas, controls and human factors. The goal of the space controls research and technology program is to develop the design methods and techniques required to enable precise pointing and stabilization of future spacecraft. Emphasis has been placed on developing control theory and analysis and validating advanced controls and guidance concepts. Recent accomplishments include the development of new control algorithms and computer programs to simulate and identify vibrational frequencies and damping ratios of systems having multiple vibration modes, in addition to the successful demonstration of a new real-time adaptive control technique. Dynamic modeling of a reference initial and evolutionary space station has begun to characterize the dynamic behavior of the combination of rigid core modules, flexible solar arrays, deployable masts and radiators, rigid payload modules and nonrigid payloads. This effort will develop the models that will be used to test and evaluate new technologies for controlling and operating a large space system such as a space station.

The goal of the human factors program is to develop techniques, data bases and standards for the design and evaluation of man/machine interfaces for use in space operations, including ground control. This program was initiated in FY 1983. Some FY 1983 accomplishments are as follows. Teleoperator simulation facilities were developed for assessing the effects on system capability of varying visual and force feedback to the operator and of varying the amount and type of computer aiding. In the area of extra-vehicular activity (EVA) performance aids, a miniature head-up display (HUD) has been generated for mounting on a space suit helmet. A space station control room simulator has been developed, and studies of the effects of types of habitats analogous to a space station (e.g. submarines, artic military outposts, etc.) on behavior have been initiated. Development of an algorithm for determining the types of space station tasks most appropriate for humans and for automation has been undertaken.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The controls and human factors research and technology program was increased by $0.7 million. This action reflects the transfer of budgeting and management responsibility for human capability efforts from platform systems research and technology to this program.

BASIS OF FY 1985 ESTIMATE

Specific FY 1985 controls technology activities will include continued development of analytical techniques for onboard model error estimation which will lead to interactive structure/control design methodologies. The fault tolerance/management of sensors, actuators and related control strategies will be validated/verified in laboratory experiments. An experimental version of an advanced three-dimensional shape and orientation sensing system, which can be used to determine configuration and vibration motion of a large space structure, will be tested to characterize and determine system performance. A hierarchical structure of "levels of control" will be developed for the evolutionary space station concept. A new emphasis on the design and control of flexible structures is underway which will generate a technology data base for evaluating structure versus control design/performance criteria.

In 1985 the human factors program will continue developing technology for man/machine function allocation strategies, crew station design, teleoperators, extravehicular activity (EVA), and ground control man/machine interface. Research will be undertaken on the teleoperation simulator to assess the effect of zero gravity on pointer control of a six degree-of-freedom hand controller. In the EVA tools area, the helmet-mounted head-up display will be evaluated, and a generic restraint system for use on unprepared surfaces will be developed. The space station control room simulator will be used to study the applicability of advanced input/output devices. Space station habitat design alternatives will be evaluated in a habitat module mockup that is now under construction. Validation will begin on the man/machine function allocation algorithm now under development.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Space data and communications research and technology	16,609	19,300	17,800	17,800

OBJECTIVES AND STATUS

The space data and communications program consists of research and technology efforts to advance the capability in processing, storage, management, and communication of space-derived data.

The objectives of the data systems program are to provide the technology to enable more cost-effective space-derived information, to increase substantially the capability of onboard and ground processing, and to provide the computational systems necessary for the modeling of global phenomena. In 1983, the massively parallel processor (MPP) was delivered to Goddard Space Flight Center. This unit contains 16,384 processors; is capable of executing six billion instructions per second; and, provides a major technological advance in computational capability for multidimensional modeling. Early exploratory applications include image analysis and weather and climate modeling. In addition, an experimental 250 million bits per second optical-fiber data bus was demonstrated in FY 1983 at Langley Research Center. This technology, required for future spacecraft, is potentially expandable to ten billion bits per second through the use of wave division multiplexing. An optical disk recorder will be completed and delivered to Marshall Space Flight Center in 1984. The delivery and integration of this unit will provide an online storage capacity of 10 trillion bits. This system will ingest data at a rate of up to 50 million bits per second and will automatically catalog and archive data packets to support online users. A major effort has been initiated to apply the DOD Very High-speed Integrated Circuit (VHSIC) technology to spacecraft onboard processors. A tenfold increase in performance is anticipated from this effort.

The objective of the communications technology program is to provide the high risk research and technology required to ensure U.S. preeminence in satellite communications. In 1983, a research program in intersatellite optical communications was initiated. The first 29 gigahertz (GHz) tunnel ladder traveling wave tube (TWT) was fabricated, and its performance exceeded specifications. The dynamic velocity taper was demonstrated experimentally on two TWT tubes resulting in a 25 percent improvement in output power and more than 100 percent improvement in the linear amplification range. The dynamic velocity taper has already been included on production TWT's and will be tested further in the future. The multistage depressed collector (MDC) has been applied to a high perveance TWT that is a candidate for use in an Air Force electronic countermeasure program, increasing tube efficiency by 50 percent. In the future, the application of low secondary electron yield materials to the MDC will be pursued. A four-stage, 20 GHz monolithic microwave integrated circuit (MMIC) amplifier has been developed as one of the components of the MMIC transmitter module. This MMIC amplifier exceeded specifications for power and efficiency. The near-field antenna test facility was brought into operation in **FY 1983** and will be used to test proof-of-concept antenna concepts. **A 30 GHz** low-noise receiver was developed and a 12-watt solid state X-band amplifier, for use as a component for a deep space transponder, has been developed jointly by the Office of Aeronautics and Space Technology (OAST), the Office of Space Science and Applications (OSSA), and the Office of Space Tracking and Data Systems (OSTDS). Computer simulations of surface distortion of large, deployable parabolic reflectors have been verified experimentally in **FY 1983** and tests of the 15-meter diameter antenna will begin in **FY 1984.**

CHANGES FROM FY 1984 BUDGET ESTIMATE

The space data and communications research and technology program was reduced by $1.5 million, reflecting the transfer of a portion of the data systems effort to platform systems research and technology for management and budgeting purposes.

BASIS OF FY 1985 ESTIMATE

The development of a high-performance onboard array processor for space platform data processing will be initiated. This will enable analysis and experiment control critical to instrument management and onboard manufacturing. The computational requirements for global habitability modeling and analysis demand an increase of three to four orders of magnitude in performance.

In **FY 1985** efforts will continue to advance TWT technology by continued work on the dynamic velocity taper, the tunnel ladder and multistage depressed collectors made from low secondary yield materials. Research on the critical components for a laser intersatellite link will be continued. Work on TWT's, impact avalanche transit time (IMPATT) diodes, and low-noise receivers for 60 GHz intersatellite links will also continue. Efforts to develop MMICs for use as transmitters at 20 GHz and low-noise receivers at **30 GHz,** and work on novel antennas and antenna feeds to make use of these MMICs will be continued. Measurements of the 15-meter diameter antenna with multibeam feeds will be completed and evaluated. The X-band transponder for deep space communications will be demonstrated. Activities in space communications, such as multiuse, multifrequency antennas, antenna coverage modeling, wide bandwidth intra-vehicle and proximity communications, and laser ranging and tracking, will be continued.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Chemical propulsion research and technology..	16,600	15,700	16,400	17,400

OBJECTIVES AND STATUS

The objective of the chemical propulsion program is to provide the technology base for improving the life, performance, reliability, and maintainability of chemical propulsion systems for future space transportation and spacecraft systems. The program includes efforts directed at longer life, reusable propulsion systems for lower cost operations; high-performance, variable-thrust propulsion for increased mission flexibility and capability; and efficient, long-life, on-board auxiliary propulsion for precise attitude control and station-keeping functions.

Technology for large thrust (SSME class) advanced, high-pressure, reusable propulsion systems is focused primarily on technology to extend the life of engine components subjected to the severe internal dynamic environments, both mechanical and thermal, that are typical of high-pressure rocket engines of this class. Although both hydrogen-fueled and hydrocarbon-fueled engines will benefit from these technology advances, primary emphasis is on the former. Advanced thermal barrier coating processes have been developed that show promise of greatly increasing the life of highly stressed turbine blades. Silicon chip technology and micro-electronics applied to advanced pressure transducer designs have demonstrated much greater accuracy, reliablity and reduced temperature sensitivity in breadboard system testing. Fabrication of hybrid bearings for both liquid-oxygen and liquid-hydrogen high-pressure pump service has been completed, and testing of the bearing tester has been initiated.

Work on advanced, high-performance, variable-thrust, orbital transfer propulsion is now focused exclusively on exploratory technology development with the objective of verifying the feasibility of each of the promising conceptual designs that had been generated previously. The concept of using oxygen as a regenerative coolant and as a turbine working fluid demands the use of materials that are compatible with oxygen under a variety of operating conditions, both normal and abnormal, including accidental rubbing of parts. A program to evaluate potentially compatible materials under rubbing and particle impact conditions has been initiated. Analyses of components promising highly efficient operation over a wide throttling range have been completed and fabrication of parts being readied for rig testing has been initiated. These include partial admission turbines, pump high-diffusion crossovers, and heat transfer enhancing combustor designs.

In the auxiliary propulsion area, trade studies identifying critical technologies for candidate oxygen-hydrogen drag make-up and attitude control systems have been completed, and technology efforts initiated. Small gaseous oxygen-gaseous hydrogen thruster testing has demonstrated the feasibility of attaining desired performance without sacrificing thruster life. System definition studies have been initiated to establish optimum component operating conditions.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $0.7 million increase reflects increased emphasis on advanced orbital transfer propulsion technology. Realignment of $1.5 million into this priority area was offset by a $0.8 million reduction in other ongoing chemical propulsion technology activities.

BASIS OF FY 1985 ESTIMATE

The technology effort for advanced, high-pressure, reusable propulsion systems will be directed toward continued development of analytical models designed to define hot gas flow distributions and resulting dynamic loads; the characterization of the structural response and material behavior of parts subjected to these dynamic loads; and, the development of accurate life prediction techniques. In addition, advanced designs with greater load resistance will be developed, and advanced instrumentation will continue to be developed to more accurately measure the true engine dynamic environment and to provide better validation of computer codes analytically simulating the engine environment.

The focus of research effort in hydrocarbon-fueled, high-performance, reusable propulsion systems will continue to be on fundamental work in combustion, stability, heat transfer, and cooling. Experimental testing with subscale hardware will be conducted for the purpose of validating computer codes that analytically model combustion processes, carbon deposition, and heat transfer coefficients. Cold-flow rig testing will be used to supplement hot firings with subscale hardware.

Technology for variable-thrust orbital transfer will emphasize component research activities that are directed toward generating analyses and design criteria for major engine components that are critical to achieving the life, performance and maintainability goals essential to a space-based, man-rated orbital transfer vehicle which uses aeroassist recovery at low-Earth orbit. Critical components include high-performance, long-life, high-heat transfer combustors, highly efficient variable flowrate turbopumps, and integrated diagnostic instrumentation. Test rigs will be used to validate analytical models and advanced component designs as they evolve.

Auxiliary propulsion technology will focus on component technology development guided by the system definition and evolution studies that have now been completed. Primary emphasis will be on gaseous oxygen-gaseous hydrogen thruster performance and life evaluations, propellant conditioning components and diagnostic instrumentation.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spacecraft systems research and technology...	4,520	3,700	5,200	9,700

OBJECTIVES AND STATUS

The objective of this program is to develop and demonstrate technology for the advanced Earth-orbiting and planetary spacecraft necessary to satisfy planned space missions. Research and technology activities are conducted in those areas where a systems approach is essential to bring individual discipline accomplishments into integrated technology capabilities. The goal is the effective transfer and use of technology in future spacecraft within acceptable levels of risk and cost.

The advanced Earth-orbiting spacecraft technology program includes Earth observation, scientific, and communications spacecraft. Efforts include defining the technology requirements, developing systems concepts, developing advanced analytical tools to aid in spacecraft design, and defining the flight experimental programs to validate broadly applicable technologies that will enable future planned missions.

The final assembly of ground test hardware for a 55-meter wrap-rib aperture, 4-rib, 3-gore mesh antenna will validate deployment and retraction and also mesh roughness performance. Hardware for a hoop/column antenna model is also being assembled and readied to undergo radio frequency testing in a near-field antenna test facility. Further structures and structural/dynamics testing is planned. Flight experiments to validate antenna systems technology, which build on ground test experience, are in a preliminary definition age. An interactive conceptual design and analysis tool is under development to enable early technology assessments and tradeoffs to guide spacecraft discipline and flight experiment definition. System analyses are underway to define advanced configurations and technology requirements for precision pointing spacecraft, intersatellite optical communications, and communication satellite bus technology. In addition, the definition and assessment of configurations and technology requirement options for a 10- to 30-M large infrared/submillimeter reflector telescope are in progress. This joint effort with the scientific community will provide various sets of scientific requirements as inputs for the system technology tradeoff studies. The laser reflector remote displacement measurement system and shuttle bay video. measurement systems are being completed for a large space systems structural dynamics experiment using the 4Mx10M solar electric propulsion stage (SEPS) array.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $1.5 million increase in spacecraft systems research and technology primarily reflects transfer of large space structures antenna technology activity from materials and structures research and technology program.

BASIS OF FY 1985 ESTIMATE

The effort to identify the high-leverage technologies for future commercial and military spacecraft will be expanded. The work will center on advanced spacecraft bus technologies and integrated subsystem technologies. In addition, evaluation of in-space experimental testing requirements for large space antenna systems technology will continue with analyses of the integrated structures, controls, and electromagnetic systems technologies needed for shuttle/station attached antennas. Emphasis will be placed on defining technology experiments that have a high generic value and aid the understanding of the control of large space systems. Development of analytical tools will include integration of dynamics and controls modules into the advanced spacecraft conceptual design tool.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Transportation systems research and technology	7,300	8,000	7,400	8,400

OBJECTIVES AND STATUS

The objectives of this program are to: identify the technology requirements for advanced transportation vehicles which satisfy anticipated national needs and integrate these requirements into a comprehensive plan for supporting a technology base; develop technology programs which satisfy these requirements; and support the development, enhancement, and improvement of the space transportation system in areas of recognized technical expertise. These objectives are accomplished through system level studies, analyses, and requirements definition efforts, as well as system and discipline research and technology efforts utilizing ground-based facilities, in-space hardware, and instrumentation which permits the shuttle orbiter to be used as an advanced research vehicle.

Flight data from both the orbiter development flight instrumentation (DFI) and the orbiter experiments (OEX) have been used to verify preflight predictions of the shuttle's aerodynamic performance. Prediction methods have been refined and updated with flight data from DFI and OEX. These predictions have been used to certify the orbiter's thermal protection system, to support the expansion of the vehicle's operational envelope, and to support the completion of the space transportation system (STS) operational flight test (OFT) program.

Instrumentation developed by the OEX program for determination of the aerodynamic coefficients of the orbiter was flown successfully on all shuttle flights during FY 1983. Aerodynamic coefficient instrumentation was also installed on the second orbiter, Challenger, and has supported certification of Challenger. OEX instrumentation to measure tile-gap heating and thermal protection system surface catalytic heating properties was flown during FY 1983. Information from the tile-gap experiment was used to investigate anomalies experienced on early shuttle flights associated with scorching of the gap-filler material. Sensors which measure payload environment in the cargo bay were flown during 1983. Data collected are being used to validate structural and acoustic load models to predict payload-bay environments. These models will provide design specifications and test environments for satellites and payloads flown in the future.

An effort to identify systems level requirements for the use of aeroassist to recover reusable orbital transfer vehicles was continued and two major studies of vehicle concepts in the low-to-moderate lift/drag regime were initiated and completed in FY 1983. These studies identified the enhancing and enabling technology for aeroassist and showed that thermal protection was the driving technology. A study of a representative post-2000 vehicle was completed. The results identified key technology issues related to the vehicle conceptual design, especially the structural and thermal protection systems associated with the integral and nonintegral tankage vehicles. The results also identified major increases in ground and flight operation flexibility related to a decoupled cargo bay. Orbit-on-demand studies were initiated for conceptual design of a quick response Earth-to-orbit vehicle.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $0.6 million decrease in transportation systems research and technology reflects a reduction in the orbiter experiments in order to cover other priority activities within the research and technology base.

BASIS OF FY 1985 ESTIMATE

Systems analyses efforts will continue for definition of scope and direction of technical programs needed to reduce the cost and improve the performance of future space transportation vehicles. Specific technology issues from previous future space transportation systems (FSTS) and orbit-on-demand (OOD) studies will be addressed. In addition, heavy-lift cargo vehicles (HLCV) system and subsystem trade studies will be made to identify an optimal HLCV concept for NASA/DOD requirements. The studies will focus on technology to enable low cost delivery of both solid and liquid cargoes to low Earth orbit. The study to identify the technology data base and systems level requirements for the use of aeroassist to recover orbital transfer vehicles will continue; specific aerobraking technology issues and the requirements for space basing will be emphasized. System studies for a potential high lift/drag (L/D) entry research vehicle will be initiated, including an evaluation of the use of the Shuttle to deliver the research vehicle to orbit.

A major OEX activity during FY 1985 will be the installation of key aerodynamic/aerothermodynamic research experiments on the Columbia. These include low- and high-altitude research-quality air data systems and an infrared scanner in the vertical stabilizer to measure entry heating on the shuttle upper wing and fuselage surfaces. The first flight for these experiments is expected to be in FY 1985.

The shuttle flights in FY 1985 will continue to be used as a source of flight data for the validation of analytical and ground facility test techniques. The resulting research-quality data base of critical vehicle characteristics will permit advanced vehicle concepts and designs to be analyzed with increased confidence and, thus, designed with reduced technical risk and better cost control.

Two flight control experiments will be integrated into the orbiter in FY 1985. The first experiment will quantify orbiter handling qualities; the second will provide flight data on an advanced, adaptive autopilot. This data will permit the supporting technology programs to be responsive to actual flight conditions.

Several advanced thermal protection system test panels will be in development for flight opportunities in FY 1985/1986. These panels will provide actual flight data on more durable, higher performance concepts which could become options for retrofit on the current orbiter fleet, as well as candidates for subsequent orbiters. The panels will provide a validated data base for the thermal protection system for advanced post-shuttle vehicles.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Platform systems research and technology... ..	6,020	12,100	8,800	7,800

OBJECTIVES AND STATUS

The objective of this program is to develop the systems level research and technology capability which enables future manned and unmanned large space platforms. These research and technology activities require a multidisciplinary approach to determine technology requirements for interacting systems, for phased mission needs, and for ground and in-space tests of systems technology. The generic system and integrative technology efforts support the system and subsystem developments necessary for future space platforms and space stations to satisfy science, technology, applications, and operational mission requirements. Efforts in the areas of systems analysis, operations technology, and crew and life support technology are directed toward reducing the cost of station operations and increasing station productivity and versatility.

Functional requirements definition of automated unmanned spacecraft have been completed, and the techniques are being adapted for determining system level technology requirements of an inhabited, highly automated platform. Data systems architectural studies have begun to determine technology requirements for highly automated, evolvable data systems both for platform operation and user experimentation. The system strategies and technology requirements for highly automated systems, such as a multihundred kilowatt power subsystem, are being defined. Experimental validation of software is underway for simulation and analysis of a teleoperated satellite servicing system. Simulation and analysis of soft docking and berthing are identifying technology guidelines for latches, attenuators, and microprocessor controls; engineering design of soft docking system for technology testing has begun. Studies of large structural subsystem interactions are being conducted using interactive graphic analysis and system simulation tools. Advanced life support systems technology capable of partial closure on-board of the water, air, and waste cycle is being verified; a portable life support system and on-orbit servicing system are being defined that would provide space-based extravehicular activity (EVA) systems. Platform systems analyses have resulted in focusing on critical technologies for manned platforms to enhance the cost-effective operation and evolutionary growth in size and capability. Emphasis is on advanced automation techniques, human factors research for station productivity and EVA, auxiliary propulsion for orbital attitude control and station-keeping, fuel handling, distributed and adaptive control, and energy management.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The $3.3 million reduction in platform systems research and technology reflects realignment of discipline research in the areas of life support systems technology, space-based extravehicular activity system definition, and vicinity operations technologies to appropriate discipline programs for management and budgetary purposes.

BASIS OF FY 1985 ESTIMATE

For FY 1985, the platform systems research and technology program is grouped into three subprograms: system analysis, operations technology, and crew and life support technology.

The systems analysis effort will complete evaluation of automated and autonomous system concepts which could provide an early capability, and analytical and experimental verification of space assembly and construction concepts. Based on system level analyses, requirements for platform autonomy, information system architecture, human-machine partitioning, and automation technology will be determined.

Operations technology includes experimental investigations of teleoperations and robotics through software simulation and hardware validation. A hardware/software simulation of remote orbiting systems for the teleoperated servicing of satellites and structural assembly will be conducted. Systems integration of existing teleoperation component technology will be analyzed and simulated to identify technology needs for EVA-equivalent telepresence capability.

Crew and life support research and technology activities will continue in water reclamation, air revitalization, and waste disposal. The technology to enable closing of the water and air loops will be treated in an incremental fashion. Design of an advanced technology space-based EVA portable life support system and its on-board servicing system will be completed, and fabrication started.

SYSTEMS TECHNOLOGY PROGRAMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Space flight systems technology.............	5,196	7,200	7,000	7,000	
Chemical propulsion systems technology	---	---	---	2,100	
Tbtal....................................	5,196	7,200	7,000	9,100	

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Space flight systems technology				
Space flight experiments.......	2,490	5,500	5,775	5,900
Long duration exposure facility............	1,800	700	700	800
Ion auxiliary propulsion system...........	906	1,000	525	300
'Ibtal..................................	5,196	7,200	7,000	7,000

OBJECTIVES AND STATUS

The objective of the space flight systems technology program is to conduct research in space, capitalizing on the use of the Space Shuttle, Spacelab, and free-flying vehicles, where it is impossible or too costly to simulate the space environment in ground laboratories. The space environment uniquely provides long-term, zero gravity and the combination of space-vacuum and space-radiation environments necessary to the development and characterization of many technologies important to future space systems. This program element encompasses the design, development, integration, and flight test of experiments and the development of special purpose, reusable, flight research facilities for use in space.

Current experiment efforts include: (1) a series of structures experiments to understand the static, dynamic, and control characteristics of structural elements leading to the capability to produce the next generation of precision deployable/erectable large space systems; (2) a cryogenic fluid management experiment which will provide the understanding for storage, acquisition, and transfer of cryogenic fluids; and (3) thermal and space plasma interaction experiments that will provide the technology data base for future multi-100kw power systems.

In FY 1984 the following experiments will have completed preliminary design review: Mast structure (MAST), cryogenic fluid management facility (CFMF), voltage operating limit test 1 (VOLT 1), and thermal energy management process 1 (TEMP 1). In addition, launch of the following experiments will occur in 1984: long duration exposure facility (LDEF), drop dynamics facility, feature identification and location experiment (FILE), solar cell calibration facility, and the solar array flight experiment (SAFE).

CHANGES FROM 1984 BUDGET ESTIMATE

The $0.2 million decrease in the space flight systems technology program reflects a portion of the general reduction of the agency's 1984 research and development appropriation. Remaining funds were realigned within the program to cover priority requirements.

BASIS OF FY 1985 ESTIMATE

In 1985, the superfluid helium experiment will go to flight; the long duration exposure facility, having orbited for approximately twelve months, will be retrieved by the shuttle and the experimental data analyzed. The ion auxiliary propulsion system will have completed technology readiness and will be awaiting flight on a DOD spacecraft.

Long lead time hardware procurements and component fabrication for the CFMF, TEMP 1 and the MAST experiments will be initiated. Hardware fabrication and systems testing will be completed for the VOLT 1 experiment in preparation for a 1986 flight date. Additional flight experiments and concept definition activities will be initiated based on evolving requirements identified in the research and technology base program, technology urgency, and funding availability.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Chemical propulsion systems technology				
Advanced SSME technology..................	---	---	---	2,100
Total.................................	---	---	---	2,100

OBJECTIVES AND STATUS

The objective of the advanced SSME systems technology program is to utilize a testbed engine assembled from existing SSME hardware for the purpose of providing data to assist in developing models and validating analytical methods and advanced component concepts emanating from the SSME base research and technology program. Initially, advanced instrumentation will be installed on the engine in order to experimentally establish the internal dynamic environments of the engine. This data base will then be used to validate computer codes developed to analytically simulate these dynamic environments, which will have been validated initially through the use of test rigs designed to experimentally simulate the engine environments to the degree possible. In addition, advanced components designed for extended life and/or performance will now be evaluated at the engine system level in the true engine environment. This will be accomplished through the assembly of engine components, such as turbopumps or combustors, with advanced technology subcomponents (e.g., bearings, seals, turbine blade dampers/coatings, advanced materials, etc.) installed and then delivered to the testbed engine for engine level testing. The subcomponent technology advances will have been screened and evaluated initially in test rigs, again simulating the engine environments.

The testbed engine will provide the lowest risk path for transferring technology from the research and technology base program into a mainstream development program such as the SSME. Many promising technology products are beginning to emerge from the research and technology base program that could find early application in the SSME and which will be ready for testbed engine testing in the FY 1987-1988 time frame. In addition, the testbed engine program will provide the experimental tool needed to evaluate longer term, higher risk technology items that will lay the foundation for more advanced SSME derivatives or for even more advanced high-pressure, reusable engines of the future.

BASIS OF FY 1985 ESTIMATE

The SSME system technology program funding will allow the acquisition and assembly of a major engine component that will have advanced technology subcomponents incorporated into it and which will be ready for testbed testing in the FY 1987-1988 time frame. The initial component will be a turbopump, incorporating advanced technologies such as longer life bearings, low-leak seals, and improved turbine blade coatings. In addition, advanced instrumentation will be fabricated and delivered to the testbed engine for environmental mapping of engine dynamics in FY 1987. Primary focus of the early advanced instrumentation program is on high-response pressure and temperature sensors.

BASIS OF FY 1985 FUNDING REQUIREMENTS:

STANDARDS AND PRACTICES

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Standards and practices..............	3,000	4,600	4,600	4,800

OBJECTIVES AND STATUS:

The objective of the standards and practices program is to support Agency goals through activities in systems engineering; reliability and quality assurance; safety; software assurance; and program practices which reduce program risks, improve product confidence, and encourage good program procedures in the technical execution of NASA programs.

During FY 1982, the Office of the Chief Engineer was reorganized to consolidate agency-level safety, reliability and quality assurance activities, and to assume four new areas of responsibility (aerospace flight systems; data and communication systems engineering; test and environmental systems; and engineering technology). This expansion of the oversight function in the engineering discipline area has the objectives of improving product quality, increasing confidence in NASA's ability to achieve mission objectives and accelerating the pace of achieving greater productivity. In FY 1982 through FY 1983, reliability and quality assurance activities have emphasized solving concerns related to degredation of critical electronic parts in space applications; laying a solid foundation for testing and qualifying very large scale integrated (VLSI) circuits for future use in the space program; assessing and mitigating the effects of space radiation on electronics in space; developing non-destructive test techniques for verifying product quality; evaluating NASA-wide software practices with goals to improve productivity and reduce costs; and continuing materials and parts assurance activity. Program practices activities include continuing support to voluntary consensus efforts which will result in a new American Institute of Aeronautics and Astronautics (AIAA) standard for symbols and units for use in planning and design of large space structures; workmanship standards; support to the measurement of the Shuttle payload bay dynamic, acoustical and thermal environment; and providing electrostatic discharge information designed to achieve good practices which will minimize the potential loss of electronic systems containing microcircuit parts. In the area of safety, activities include assessing the ignitability of metals in oxygen; studies concerning safe siting of future pressure vessels; development of an accident investigation training program; and a project to assess the use of an in-flight aircraft data recorder to enhance maintenance procedures.

BASIS OF FY 1985 ESTIMATE:

In support of the goals of the Agency, the FY 1985 standards and practices program will continue to conduct activities related to reliability and quality assurance, safety, software assurance, and program practices. Emphasis includes software engineering assurance, special technology reviews and risk assessments; improved assessment and evaluation of test facility capabilities, hardware and, particularly, software systems engineering assessments; and continuing special activities to maintain or improve productivity, quality and mission success. Non-destructive testing and evaluation techniques and standards will be extended to new materials, such as composites, and to developing pressure vessel hazard mitigation guidelines. The FY 1985 funds will also continue to provide for special Congressional or NASA directed taskings which result from technical problems arising from programmatic activities.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE NG AND DA SYSTEMS

TRACKING AND DATA ADVANCED SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
Advanced systems...............	13,400	14,200	14,200	15,300	RD 14-2
Total..................	13,400	14,200	14,200	15,300	

Distribution of Program Amounts by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Marshall Space Flight Center....	---	---	---	---
Goddard Space Flight Center.....	4,227	4,500	4,500	4,800
Jet Propulsion Laboratory..... ..	9,173	9,700	9,700	10,500
Ames Research Center...........	---	---	---	---
Headquarters....................	---	---	---	---
Johnson Space Center...........	---	---	---	---
Total.........................	13,400	14,200	14,200	15,300

ADVANCED SYSTEMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Advanced systems.....................	13,400	14,200	14,200	15,300

OBJECTIVES AND STATUS

The overall objective of the Advanced Systems Program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions and near term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

This program is a relatively small but vital portion of the Space Tracking and Data Systems Program. Activity continues under this program to assess and make use of the dramatic changes taking place in the state of the art in telecommunications and computer technology. Such effort is critical for proper planning and for the application of new technology to future support capabilities that are cost effective and reliable. Efforts include the investigation of upcoming missions and studies of ground systems and telecommunications links to determine design approaches and overall tradeoffs for the lowest life cycle costs to support future space missions.

BASIS OF FY 1985 ESTIMATE

The following are examples of activities planned for FY 1985. Techniques aimed at obtaining tracking accuracies to the sub-decimeter level for Earth-orbiting spacecraft will be investigated. Such precision is needed to gather image and topographic data for science and applications programs. The techniques to be investigated include using the military's Global Positioning System and Very Long Baseline Interferrometry. Work will also continue on extremely precise radiometric techniques for determining angular direction of future planetary missions to an accuracy of five nano-radians. Such activity typically leads to improved spacecraft navigation and the carrying out of science experiments not previously possible.

New methods of increasing NASA's capability to communicate with spacecraft will also be investigated. Improving space-to-ground link performance can benefit many future missions by reducing mission costs or increasing the amount or quality of the data returned. Studies and developments will include investigations of antenna surface tolerances and pointing control techniques precise enough to operate at K-band. Future deep space missions using K-band rather than X-band will achieve a several-fold improvement in telecommunications. In addition to K-band, the program includes the investigation of millimeter wave technology and optics to meet telecommunications needs beyond the 1980's.

As the TDRSS era begins with the launch of the first of three satellites, the data handled from Earth orbital missions has increased from a peak of 15 megabits per second to 85 and is expected to reach the TDRSS design limit of 300 in the future. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperture radars plus a continued growth in single access users of the TDRSS. New techniques and systems will be developed for ground transfer and processing of high volume data. These include custom Very Large Scale Integrated (VLSI) circuitry design, digital receivers, filters, and high data volume processors, decoding schemes, and optical disc storage to handle the increasing image data buffering requirements.

To keep systems life cycle costs at a minimum in an era of expanding use of digital systems, effort will be increased on software development technology that will aid in automated systems design, integration, test and maintenance. Methods and techniques will continue to be investigated to reduce future manpower levels needed to operate the mission control and tracking facilities, and to provide the necessary real time interaction between the experimenters or investigators and their space experiments.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1985 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. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY: A program to provide the national fleet of Space Shuttle orbiters including main engines, launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities.

SPACE TRANSPORTATION OPERATIONS: A program to provide the standard operational support services for the Space Shuttle and the 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. This support is currently provided by a worldwide network of NASA electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. In 1985, the Tracking and Data Relay Satellite (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions.

NATIONAL AERONAUTICS AND SPACE ADMININSTRATION

STRUCTURE OF THE FY 1985 BUDGET *
(SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS)

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
SPACE TRANSPORTATION SYSTEM	3,147,510	3,070,600	3,101,300	2,804,600
Shuttle Production and Operational Capability	1,725,810	1,500,000	1,649,300	1,465,600
Space Transportation Operations	1,421,700	1,570,600	1,452,000	1,339,000
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	485.500	686,000	674,000	795,700
TOTAL	3,633,010	3,756,600	3,775,300	3,600,300

* Prior to the FY 1984 budget, these programs were included in the Research and Development appropriation.

PRODUCTION AND OPERATIONAL

SPACE TRANSPORTATION SYSTEMS

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 Aeronautice and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, hire. maintenance and operation of other than administrative aircraft; [and including not to exceed (1) **$1,500,000,000** for space shuttle production and capability development; (2) $1,570,600,000 for space transportation operations; (3) **$50,000,000** for expendable launch vehicles; and (4) not more nor **less** than **$44,000,000** shall be obligated for space communications operations and maintenance and support associated with the tracking and data relay satellite system, excluding amounts to be obligated for award fees earned on the contract; without the approval of the Committees on Appropriations; $3,791,600,000,] to remain available until September 30, [1985:] *Provided,* That up to **5** per centum of the amount appropriated for "Research and Development" or "Space Flight, Control and Data Communications" may be transferred between such accounts with the approval of the Committees on Appropriations. (42 U.S.C. 2451, et. **seq.**; Department of Housing and Urban Development - Independent Agencies Appropriation Act, 1984)

$3,600,300,000

1986:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS
Program and Financing (in thousands of dollars)

Identification code 80-0105-0-1-250	Budget plan (amounts for research and development actions programed) 1983 actual	1984 est.	1985 est.	Costs and obligations 1983 actual	1984 est.	1985 est.
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Capability development.............	---	1,649,300	1,465,600	---	1,566,800	1,475,800
(b) Operations........................	---	1,452,000	1,339,000	---	1,379,400	1,344,600
2. Supporting activity: Tracking and data acquisition.........................	---	674,000	795,700	---	640,300	789,600
Total direct program..................	---	3,775,300	3,600,300	---	3,586,500	3,610,000
Reimbursable program........................	---	715,000	980,000	---	679,250	966,750
10.00 Total obligations......................	---	4,490,300	4,580,300	---	4,265,750	4,576,750
Financing:						
Offsetting collections from:						
11.00 Federal funds..........................	---	-536,250	-735,000	---	-536,250	-735,000
14.00 Non-Federal sources....................	---	-178,750	-245,000	---	-178,750	-245,000
Unobligated balance available, start of year. For completion of prior year budget plans:						
21.40 Direct................................	---	---	---	---	---	-188,800
21.40 Reimbursable...........................	---	---	---	---	---	-35,750
23.40 Unobligated balance transferred to other accounts......................	---	---	---	---	---	---
Unobligated balance available, end of year: For completion of prior year budget plans:						
24.40 Direct................................	---	---	---	---	188,800	180,100
24.40 Reimbursable...........................	---	---	---	---	35,750	48,000
25.00 Unobligated balance lapsing.............	---	---	---	---	---	---
39.00 Budget authority.....................	---	3,755,300	3,600,300	---	3,775,300	3,600,300

Identification code 80-0105-0-1-250	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1983 actual	1984 est.	1985 est.	1983 actual	1984 est.	1985 est.
Budget authority:						
40.00 Appropriation	---	3,791,600	3,600,300	---	3,791,600	3,600,300
41.00 Transferred to other accounts	---	-16,300	---	---	-16,300	---
43.00 Appropriation (adjusted)	---	3,775,300	3,600,300	---	3,775,300	3,600,300
Relation of obligations to outlays:						
71.00 Obligations incurred, net					3,550,750	3,596,750
72.40 Obligated balance, start of year					---	480,150
74.40 Obligated balance, end of year					-480,150	-575,900
77.00 Adjustments in expired accounts					---	---
90.00 Outlays					3,070,600	3,501,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Space Flight, Control and Data [redacted]cations

Reimbursable Summary
(In thousands of dollars)

Space Flight, Control and Data Communications	Budget Plan FY 83	FY 84	FY 85
Shuttle Production and Capability Development	8,910	211,000	177,000
Space Transportation Operations	312,896	264,000	675,000
Expendable Launch Vehicles	315,375	210,000	98,000
Tracking and Data Acquisition	21,600	30,000	30,000
Total	658,781	715,000	980,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

PISCAL YEAR 1985 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION
(In thousands of dollars)

Code		FY 1983	FY 1984	FY 1985
253	Space Flight.,....................................	3,147,510	3,101,300	2,804,600
255	Supporting Space Activites..........................	485,500	674,000	795,700
	Total, General Science, Space and Technology....	3,633,010	3,775,300	3,600,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1985 ESTIMATES
DISTRIBUTION OF SPACE FLIGHT CONTROL AND DATA COMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

Program		Total	Johnmon space Center	Kennedy Space Center	Marshall Space Flight Center	National Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
Office Of Space Transportation Systems	1983	3,147,510	1,398,410	442,200	1,181,400	700	68,100	100	3,900	---	---	46,100
	1984	3,101,300	1,230,200	449,600	1,251,000	---	45,300	200	2,300	---	---	116,100
	1985	2,804,600	1,047,200	349,300	1,260,100	---	600	---	2,500	---	---	144,900
Shuttle Production and Operational Capability	1983	1,725,810	1,035,810	99,900	574.500	---	---	---	---	---	---	15,600
	1984	1,649,300	837,700	109,500	614,500	---	---	---	---	---	---	87,600
	1985	1,465,600	697,300	86,800	588,300	---	---	---	---	---	---	93,200
Space Transportation Operations	1983	1,421,700	362,600	342,300	612,900	700	68.100	100	3,900	---	---	31,100
	1984	1,452,000	392,500	340,100	642,500	---	45,300	200	2.300	---	---	29.100
	1985	1,339,000	349,900	262,500	671,800	---	600	---	2,500	---	---	51,100
Space and Ground Network Comm and Data System	1983	485,500	480	---	2,500	---	321,264	99,553	4,550	---	---	51,153
	1984	614,000	500	---	13,500	---	352.700	95,900	6,500	---	---	204,900
	1985	195,700	---	---	11,400	---	434,800	106,600	8,700	---	---	228,200
Total Budget Plan	1983	3,633,010	1,398,890	442,200	1,189,900	700	395,364	99,653	8,450	---	---	97,853
	1984	3,115,300	1,230,100	449,600	1,210,500	---	398,000	96,100	8.800	---	---	321,600
	1985	3,600,300	1,041,200	349,300	1,211,500	---	435,400	106,600	11,200	---	---	373,100

FISCAL YEAR 1985 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE TRANSPORTATION SYSTEM PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of	Dollars)		
Shuttle production and operational capability..	1,725,810	1,500,000	1,649,300	1,465,600	SF 1-1
Space transportation operations	1,421,700	1,570,600	1,452,000	1,339,000	SF 2-1
Shuttle operations..	(1,338,700)	(1,520,600)	(1,402,000)	(1,339,000)	
Expendable launch vehicles	(83,000)	(50,000)	(50,000)	(---)	
Total	3,147,510*	3,070,600	3,101,300	2,804,600	

Distribution of Program Amounts By Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center	1,398,410	1,222,600	1,230,200	1,047,200
Kennedy Space Center	442,200	462,300	449,600	349,300
Marshall Space Flight Center	1,187,400	1,227,200	1,257,000	1,260,100
National Space Technology Lab	700	---	---	---
Goddard Space Flight Center	68,100	49,400	45,300	600
Jet Propulsion Laboratory	100	---	200	---
Ames Research center	3,900	3,200	2,300	2,500
Headquarters	46,700	105,900	116,700	144,900
mtal	3,147,510	3,070,600	3,101,300	2,804,600

*Prior to FY 1984, these programs were included in the Research and Development appropriation.

OFFICE OF SPACE FLIGHT | **SPACE TRANSPORTATION SYSTEM PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national and international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space applications, scientific experiments, and national security payloads. The Space Shuttle offers unique capabilities that cannot be achieved with today's expendable launch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions.

Shuttle production and operational capability provides for the national fleet of Space Shuttle orbiters, including main engines, and provides for the launch site facilities, initial spares, production tooling, and related supporting activities to meet the needs of NASA, the Department of Defense (DOD), and other domestic and international users of space. This line item contains orbiter production for three flight orbiters; the initial modification of Columbia (OV-102) for Spacelab with a subsequent major modification to effect its changeover into its operational configuration; the procurement of major structural orbiter components to be used as spares for the orbiter operational fleet; the residual development tasks for the orbiter, main engine (SSME), external tank (ET), and solid rocket booster (SRB); Johnson Space Center (JSC) mission support capability development; the provision of the second set of facilities and equipment for launch processing at the Kennedy Space Center (KSC); the development of the filament wound case (FWC) solid rocket booster; the initial lay-in of spares; ground support equipment; and the rate tooling for the ET and SRB. Modifications to two orbiters, mobile launcher platforms (MLP), and launch pads for the conduct of the planetary missions (Galileo and International Solar Polar Mission) in 1986 using the Centaur as an STS upper stage are also funded under this budget item.

Shuttle operations provides the standard operational support services for both of the primary U.S. launch systems: the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, ET and SRB flight hardware is produced; operational spare hardware is provisioned, overhauled, and repaired; and the manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The Space Shuttle operations program provides for the launch of NASA, DOD, omj!/ B.S. Government, commercial, and international missions. The 1984-1987 launch schedule calls for seven to eight flights in FY 1984 and eleven flights in FY 1985. The flight rate in later years is planned to accommodate twenty-four launches per year by 1988-1989. The first Vandenberg launch is scheduled for early FY 1986.

PRODUCTION AND OPERATIONAL

The Space Shuttle provides launch services to non-NASA users on a reimbursable basis with payments determined by the size and weight of the user's payload and the services required to support launch requirements. For flights through FY 1985, commercial and foreign users will pay for standard launch services on a basis of $18.0 million per flight in 1975 dollars; for 1986-1988 flights, the charge will increase to $38.0 million in 1975 dollars. The budget is based on charging DOD $16.0 million in 1975 dollars in FY 1984 and FY 1985 and $29.8 million in 1975 dollars for flights during FY 1986-1988. The Bureau of Labor Statisitics computation of compensation per hour is used as the index for escalating 1975 dollars to current dollars for billing purposes.

The expendable launch vehicle program provides for the procurement of expendable launch vehicles and launch support services for NASA's spacecraft missions and for other agencies and organizations utilizing these systems and services on a reimbursable basis. The Delta is the most widely used launch vehicle. Commercialization of the Delta and Atlas-Centaur are being actively explored.

STATUS

The continuation of the orbiter production program has been a major activity during the past year. Discovery (OV-103) was delivered in November 1983 and brings to three the number of orbiters now available for flight. Columbia (OV-102) and Challenger (OV-099) were previously delivered and have flown several flights each. Atlantis (OV-104) also continued its production progress and is now into the mate and final assembly phase at the Palmdale contractor facility. Support of the flight program has also been a major activity of the orbiter program. OV-102 was modified at KSC in order for the vehicle to support the recently completed Spacelab mission. A final period of OV-102 modifications will take place in the January 1985 - August 1985 time frame to place the vehicle in its fully operational configuration.

Resolution of orbiter flight anomalies is accomplished under sustaining engineering, leading to the development of fixes necessary to support the flight program. The emphasis on the orbiter logisitics program also continued as effort proceeded to support the provisioning of orbiter spares for the initial lay-in at the launch site.

The procurement of structural spares is also progressing. This program will provide major structural spares for the four orbiter fleet and includes elements such as wings, mid-fuselage, and payload bay doors.

At KSC, the second line of vehicle processing stations is being phased in to support the parallel launch processing of orbiters. Parallel processing can be done in the Orbiter Processing Facility (OPF) and Vehicle Assembly Building (VAB) since activation in FY 1982 of the second OPF high bay and second MLP and in FY 1983 of the Software Production Facility, the second launch control room, and the second set of VAB high bays. Parallel processing at the launch pad will be possible after Pad B completion January 1, 1986, consistent with the requirements to support the Centaur launches of Galileo and International Solar Polar Mission (ISPM) in May 1986. The third MLP is planned for a September 1986 operational readiness date.

Other facilities in work are the SRB processing and storage facility, available in FY 1984, and the restoration of the KSC railroad.

At JSC, the expansion of training capacity is being accomplished by modification of a Gulfstream II into a third Shuttle training aircraft and continued modification to the simulators. Mission Control Center systems monitoring and flight control capability will be expanded to two vehicle operation (sixteen flights per year) by April 1984. Three-vehicle capability (twenty-four flights per year) is on schedule for April 1986. Permanent TACAN navigation hardware will be installed in 1984 at Dakar, Senegal and Edwards Air Force Base in support of contingency landing sites. Three additional contingency abort sites will be brought to operational status by the end of FY 1985 in time to support Shuttle launches from the western launch site.

Initial certification of the Space Shuttle main engine (SSME) in a full power level (FPL) configuration was completed. The FPL capability is necessary to allow NASA's payload commitments to be met. The successful completion of the FPL certification then allows flight operations at the 109% thrust level. However, during the course of FPL certification testing, it became apparent that the current SSME configuration requires an unacceptably high level of maintenance. In addition, a detailed review and assessment of the SSME program (prompted by the pre-flight delays of STS-6) revealed that there is an inadequate logistics base of engines and spare parts to ensure an uninterrupted operational program. As a result of the FPL certification test experience and the SSME review, the SSME program has been re-planned so as to focus on solutions to the excessive maintenance problem and the inadequate logistics base. A two-phase effort is directed at significantly improving the life of the high pressure turbopumps; four additional engines have been added to the production schedule; and, the production and engine overhaul schedules have been accelerated. During this year, five flights of the Space Shuttle were completed (STS-9) with no SSME anomalies which impacted launch performance. Thus the concept of a high thrust, reusable rocket engine continues to be viable.

The experience with the SRB's during earlier flights indicated the need for design improvements to reduce the amount of water impact damage to the SRB aft skirt and the hydraulic power units mounted internally to the aft skirt. Design improvements have been incorporated subsequent to the loss of the STS-4 boosters and have proven to be successful in reducing structural damage. Problems still exist with water intrusion and damage to the thrust vector control (TVC) hydraulic power units. Development activity has been initiated for design changes to the TVC system to eliminate this problem. In order to reduce the water impact velocity which is the major contributor to the damage at water impact, the use of larger main parachutes is also being explored.

The first high performance motor was successfully flown on STS-8. The performance characteristics of the motor were normal and well within specifications. Post-flight inspection of the motor indicated some minor changes are required in the manufacturing process for the carbon phenolic nozzle material. Efforts are underway to correct this problem.

Continued emphasis is being focused on cost-reduction/producibility/production efforts to identify improvements in processing required to satisfy production rate requirements. Recompetition for the booster assembly/refurbishment contract has been initiated to insure a production capability at possible lower costs.

Performance of the ET on all nine Shuttle flights has been excellent. All flight hardware has been delivered on or ahead of schedule. Weight savings on the lightweight tanks have been greater than baselined and should continue to be realized as additional planned improvements are implemented. cost reduction/producibilty/production readiness efforts continue to be a high priority, as additional tooling and equipment is introduced to meet production requirements of 24 tanks per year. Significant improvements have been realized in the reduction of ablator on the tank and associated labor and tooling.

The development of the FWC for the SRB's to improve the payload capability of the Space Shuttle for high performance missions has been progressing toward achieving major program milestones. During the past year, design allowables were established; manufacturing processes and tooling were verified; and six full diameter segments were manufactured (3 twelve-foot length; and 3 full-length). Hydro-burst tests were performed on a full-diameter segment as well as a combined segment/joint hydrotest. Major emphasis has been placed on technical areas related to the composite FWC development by the formation of an expert working group from within NASA and contractors organizations to address materials/processes, non-destructive evaluation, and fracture mechanics.

The Shuttle operations budget provides funding in three principal areas: flight operations, flight hardware, and launch and landing operations. Flight operations includes the training, mission control, and flight operations planning, payload integration analysis, mission analysis, and post-flight anomaly resolution.

Flight hardware includes the procurement of ET's; solid rocket motors, booster hardware, and propellants; and engineering and logistics support for external tank/solid rocket booster/maine engine hardware elements. The funding requested for the ET, solid rocket motors and boosters includes long-lead time raw materials, subassemblies, and subsystems required to sustain production.

At KSC, four operational missions were processed and launched successfully during FY 1983. The first Spacelab processing and launch took place this fall; KSC plans to launch an additional seven missions in FY 1984. Five of these launches are scheduled to land at the KSC Shuttle landing facility. KSC has completed the first full year with the base operations contractor and recently awarded the Shuttle Processing Contract which established one consolidated contractor for Shuttle launch and landing activities both at KSC and Vandenberg. Preliminary plans are also underway to propose consolidation of the cargo processing effort in the FY 1986 timeframe.

Since the Delta's first use in 1960, this vehicle has been utilized in 173 launches and has experienced a success record of over 92 percent. The last 39 launches in a row were successful. It is presently operational with two- and three-stage configurations. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation. The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) or, in the 3920 configuration, a 1,270 kilogram (2,800 pounds) payload into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). The Active Magnetospheric Partical Tracer Explorer, the last NASA mission scheduled for launch on Delta, is planned for August 1984.

BASIS OF FY 1985 FUNDING REQUIREMENT

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Orbiter	903,910	729,600	716,300	606,800	SF 1-3
Launch and mission support	246,300	245,500	277,700	234,800	SF 1-6
Propulsion systems	575,600	472,200	618,000	599,000	SF 1-8
Changes and system upgrading	---	52,700	37,300	25,000	SF 1-12
Total	1,725,810	1,500,000	1,649,300	1,465,600	

Distribution of Program Amounts by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center	1,035,810	833,500	837,700	697,300
Kennedy Space Center	99,900	106,400	109,500	86,800
Marshall Space Flight Center	574,500	467,700	614,500	588,300
Headquarters	15,600	92,400	87,600	93,200
Total	1,725,810	1,500,000	1,649,300	1,465,600

OBJECTIVES AND STATUS

The objectives of this program are to provide for: the completion of the national fleet of Shuttle orbiters; the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and, the potential changes and upgrading of the Space Transportation System.

The planned four-orbiter fleet includes: Columbia (OV-102), the orbiter vehicle developed under the Space Shuttle design, development, test and evaluation (DDT&E) program and used for the first five flights and the first Spacelab flight; Challenger (OV-099), the second flight orbiter, which was fabricated using elements of the DDT&E structural test article; and, two orbiters - Discovery (OV-103) and Atlantis (OV-104) of a lighter-weight configuration. OV-103 is being processed at KSC for its first flight in FY 1984. The planned delivery date for OV-104 is December 1984. OV-102 underwent modifications at KSC in order to support the launch of the first Spacelab mission in November 1983. The final phase of modifications for

OV-102 is now planned for FY 1985. Work was initiated in FY 1982 on modifications to orbiters and the related systems integration analyses for the use of the Centaur and its payloads. The provisioning of orbiter spares is an on-going activity to support the requirements for the initial lay-in of line replaceable units of equipment at the launch site. In addition, the budget provides for the extensive acquisition of orbiter structural spares to support the four-orbiter fleet.

Launch and mission support provides for the second set of processing stations at KSC to support parallel orbiter processing; the additional astronaut training, mission preparation and mission operation capabilities required for higher flight rates; the modifications to the launch site capabilities to accommodate the new Centaur upper stage: and, studies and analyses of program level improvements for the operations and management of the STS. The first line of KSC facilities (funded under Space Shuttle DDT&E) supports the launch processing and checkout of one orbiter vehicle at a time from landing through launch. The second line of processing stations allows for parallel processing of orbiters to meet the East Coast launch rate of up to twenty flights per year. A third Shuttle training aircraft is being modified to support increased training requirements and to permit the existing two aircraft to be overhauled when fatigue considerations make this necessary. The upgrading of the Mission Control Center (MCC) will provide for reconfiguration of the JSC MCC to support two, and finally three, simultaneous orbiter operations (flights, tests, or simulations). Support for the Vandenberg launch site, including provision of three abort landing facilities, is proceeding. Inflight refueling capability for the Shuttle Carrier Aircraft (SCA) will be available prior to initiation of Vandenberg launches.

Propulsion systems provide for the production of the SSME and the development of the capability to support operational requirements established for the SSME, SRB, and ET. The SSME program includes: production of the main engines necessary to outfit and provide spares for the orbiter fleet, ground testing in support of engine development, and an anomaly resolution capability. The SRB production and capability development activities include: the development of the solid rocket motor's FWC, the redesign of hardware to meet reusability and cost savings requirements, and the procurement of tooling and equipment to support a flight rate of 24 flights per year. In the ET program, the objectives are to provide manufacturing tooling and equipment to support the 24 per year flight rate and to improve manufacturing techniques and management processes in order to reduce the time and cost of producing tanks. Systems engineering support and main engine testing in the main propulsion test article configuration are both provided in system support.

Changes and systems upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements.

BASIS OF FY 1985 FUNDING REQUIREMENT

ORBITER

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Orbiter production....................	729,410	464,700	405,100	226,600
Systems integration..................	59,700	62,900	60,800	48,700
Orbiter spares.......................	114,800	202,000	250,400	331,500
Total.....................,........	903,910	729,600	716,300	606,800

OBJECTIVES AND STATUS

Successful continuation of the orbiter production activities remains the objective of this program. This production program will provide the authorized four orbiter fleet plus a group of selected major structural spare elements for that fleet.

With the delivery of OV-103 (Discovery) in November 1983, the number of orbiters available for flight has increased to three: OV-102 (Columbia) from the DDT&E phase and OV-103 (Discovery) and OV-099 (Challenger) from the production phase.

During the past year, Columbia underwent modifications at KSC. These modifications were necessary to conduct the recently completed Spacelab mission. OV-102 will undergo a final period of modifications in 1985 to bring it to its fully operational configuration.

Discovery was delivered in early November 1983, approximately five weeks behind the originally planned date of September 30, 1983. This delay was made in order to complete additional work on the vehicle and to avoid having OV-103 arrive at KSC while both Orbiter Processing Facility (OPF) bays were filled. This latter circumstance arose when OV-102 was rolled back to the OPF while changes to the SRB were made prior to STS-9.

Substantial progress was also made on OV-104. Several structural elements have been delivered to Palmdale including the mid-fuselage, wings, vertical tail, and payload bay doors. Mating of these elements is underway and thermal protection system installation has been initiated. Additional modules and systems will be delivered over the next several months and the vehicle will be in final assembly and systems **installation** phase during FY **1984.**

The structural spares program was initiated in FY **1983** in order to maintain a continued production capability and to assure adequate structural repair capability in the event of damage to one of the four orbiters. Fabrication of these major elements is underway and will continue throughout the year. 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 major structural deliverables will be completed up to the point where they would be ready for installation of the thermal protection system, plumbing, wire harnesses, and major electrical, propulsion, and hydraulic components.

The procurement and fabrication of orbiter spares is ongoing. **A** concerted effort was made to better define the spares requirements and production capability at various vendors. Provisioning conferences were held at *36* of the major subcontractors in support of this effort. Studies were conducted of suppliers who were completing orbiter commitments to determine current and future production and repair capabilities. Where necessary, contracts were let to insure production and/or repair capability.

CHANGES FROM FY 1984 BUDGET ESTIMATE

There are several changes from the **FY 1984** budget request to the current estimate totaling a net decrease of **$13.3** million. The major contributor to this decrease is the savings realized as a result of the improved performance by the prime contractor and subcontractors in the fabrication, installation and assembly of the various parts system and structures of **OV-103** and the fabrication and assembly of **OV-104--** which is to be delivered in December **1984.** Additions included a fifth cryogenic tank to a second orbiter (OV-104) to allow more flexibility to support Spacelab missions; an improved APU to increase the mission life and reduce operating costs; and the addition of back shop facilities at Palmdale to replace facilities returned to the DOD. In addition, other changes were incorporated such as orbiter ground support equipment for MLP-3, redesign of the rotational hand controller, and provisions for a second manned maneuvering unit to be carried on the orbiters.

The orbiter spares program has increased as more hardware is being procured. Provisioning conferences were held with the major vendors which have identified a need for more shop replaceable units and piece parts. In addition, more line replaceable units are being procured such as spares for the Ku-Band rendezvous radar, orbital maneuvering system pods, star tracker, and S-Band communications system. Increased funds have been provided to improve the support of the logistics management function.

BASIS OF FY 1985 ESTIMATE

A major effort in FY 1985 will be the completion of the final stages of manufacturing on OV-104 at the Rockwell Palmdale facility, including final assembly and integrated testing, leading to its delivery in December 1984. Another major effort in FY 1985 is the full-up modification of OV-102 to its operational configuration (at Palmdale) including changes for vehicle loads requirements. FY 1985 funding provides continuing procurement of major structural components as spares for the orbiter fleet. These structural components will include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These items will be assembled into varying stages of completion so that they can be used as structural spares for the current fleet. FY 1985 funding will also be utilized for performance augmentation activities primarily to conduct orbiter loads analysis in support of the FWC development program, and for modification of OV-099 and OV-104 to accept, boost, and deploy the wide-bodied Centaur upper stage. Ground support equipment and test hardware are also being provided to support KSC activities. In FY 1985, systems integration activities will be concentrated on the engineering analysis and integration support for vehicle capability changes including the Space Shuttle performance improvements (such as the FWC); analysis of compliance to system specifications as the result of performance, including the investigation/resolution of flight problems; and support of the Vandenberg launch site activation.

Logistics support to the Space Shuttle program requires the lay-in of orbiter initial spares and rate spares to meet the 24 per year flight rate and for support to ground processing operations as the fleet size and flight rate increase. Projected failure rates for each item and turnaround times for repairs are two significant factors in determining the quantity of spares to be procured. The funding for orbiter spares covers not only the cost of orbiter flight spares and ground support equipment spares, but also the logistics support to analyze requirements and procure these spares. In addition, acquisition of maintenance test equipment will be initiated to support establishment of depot maintenance capabilities.

LAUNCH AND MISSION SUPPORT

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of	Dollars)	
Launch site equipment................	99,900	107,400	109,500	86,800
Mission support capability...........	79,200	75,100	87,500	98,000
Mission operations capability.........	67,200	63,000	80,700	50,000
Total.............................	246,300	245,500	277,700	234,800

OBJECTIVES AND STATUS

The first line of facilities previously activated at KSC supports the launch processing and checkout of an orbiter vehicle from landing through launch. The second line of processing staticns is being phased in to support parallel launch processing of more than one orbiter through the various work areas. The second high bay of the OPF and the second MLP were activated in late FY 1982 to support parallel processing of OV-102 and OV-099. The second set of high bays in the VAB, the software production facility, and the second control room were activated in FY 1983 to enable parallel processing through orbiter - ET mate. When Pad B is activated in FY 1986, parallel processing will be possible from the start of OPF flow through launch.

A solid rocket booster processing and storage facility will be activated in FY 1984 to provide off-loading of segments from rail cars, segment rotation capability, storage capability for two flight sets (sixteen segments) at KSC and the buildup of SRB aft segments. A third MLP will be activated in late FY 1986 to help meet the flight rate scheduled in 1987 and beyond. Facility modifications supporting the FY 1986 Centaur launches are in process. A new responsibility is to maintain the on-site railroad which was formerly maintained by the Florida East Coast Railroad. A Federal court decision in FY 1983 transferred ownership of the entire railroad to KSC along with the responsibility of restoration and maintenance.

Also under launch and mission support are the capability investments in the JSC program support areas necessary to support a 24 flight per year capability. These include additional simulation capabilities, necessary replacements of obsolete equipment, and the production costs of procuring the Government furnished equipment. This equipment includes the extravehicular mobility units (space suits) as well as other crew related equipment. Development of needed changes to the spacesuit (soft goods and portable life support system) to meet zero pre-breathe mission requirements and facilitate extravehicular activity operations are being undertaken. Modification of a Gulfstream II for use as a third Shuttle training aircraft (STA), and the provision of inflight refueling capability in the Shuttle carrier aircraft (SCA) is included here. Both efforts will be completed in FY 1985. Specific capability development items include TACAN navigation equipment, data reduction and flight design system improvements.

The Mission Control Center upgrading (Level II) is also within launch and mission support. The Mission Control Center (MCC) upgrading (Level II) will provide for the reconfiguration of the MCC at JSC to support the STS's operational flight schedule requirements. The use of additional hardware, equipment, and software to operate the MCC will provide for systems monitoring and flight control capability in support of two and later three (24 flights per year capability) simultaneous operations (flight, test or simulation). Completion of the second flight control room on the second floor of the MCC and capability for two vehicle operations is planned for April 1984.

CHANGES FROM FY 1984 BUDGET ESTIMATE

Launch and mission support has increased by $32.2 million dollars since the FY 1984 budget. The new responsibility to restore the former Florida East Coast railroad accounts for the launch site equipment increase. The major increases in mission support and mission operations include: the acceleration of the modification work necessary to provide an earlier training readiness date for the third Shuttle training aircraft; the acceleration of inflight refueling capability for the SCA; and the initial investment to provide three abort landing sites for launches from Vandenberg. Funds have also been added to mission support to perform conceptual designs and hardware development for extravehicular mobility units enhancements for operational requirements such as zero pre-breathe and improved satellite servicing.

BASIS OF FY 1985 ESTIMATE

Outfitting and activation of launch pad B, MLP-3, and the Centaur-related modifications to KSC facilities are underway now and will continue to be the major activity during FY 1985. Pad B operational readiness date (ORD) of January 1, 1986, MLP-3 ORD of September 1986, and two Centaur launches in May 1986 continue on schedule. Restoration of the KSC railroad will continue.

In the area of mission support capability, the expansion of communication and data handling will continue in FY 1985. Development of an advanced extravehicular mobility unit will be initiated. Production of Government furnished equipment including extravehicular mobility units, cameras, and other crew equipment is continuing in order to achieve the inventory required to support the 24 per year flight rate.

The mission operations capability area will support completion of the modification of a third Gulfstream II for use as an STA; continued mission support activities for training and simulations; continued reconfiguration of the MCC II to support operational flight requirements leading to three-vehicle capability; make the Vandenburg Air Force Base interface operational; continue development of three western abort sites; and begin early software development and hardware acquisition for Shuttle Post-Flight Data Reduction Facility.

PROPULSION SYSTEMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Main engine..........................	355,700	280,700	398,500	432,600
Solid rocket booster.................	102,300	108,400	146,200	103,700
External tank....,....................	97,600	83,100	66,800	61,600
Systems support......................	20,000	---	6,500	1,100
Total..............................	575,600	472,200	618,000	599,000

OBJECTIVES AND STATUS

Propulsion systems provides for the production of the SSME's and the development of the capability to support operational requirements established for the SSME, SRB, and ET. The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations, and anomaly resolution capability. In the SRB, the development of the FWC solid rocket motor and the redesign of the hardware to meet program requirements for reusability and operational cost reduction are being pursued. In the ET program, the objectives are to provide manufacturing tooling and equipment in addition to improved manufacturing techniques and management processes to reduce the time and cost of producing tanks. Also included within SRB and ET requirements is the procurement of manufacturing tooling and equipment to support fabrication and transportation for meeting the 24 per year flight rate. Systems support primarily provides for the testing of the SSME in the main propulsion test article configuration in addition to providing systems integration engineering support.

The main engines continued their,record of superb flight performance with the five flights of the Space Shuttle completed last year. These flights were completed with no SSME anomalies that impacted flight performance. However, a series of engine problems was experienced during FY 1983 which required significant, unplanned maintenance. On one of these occasions, the lack of logistics spares resulted in the delay of the STS-6 flight. Also during 1983, the initial certification testing at the 109% full power level (FPL) was completed. The SSME can now be used for those missions requiring the higher thrust level. The total SSME ground test experience now exceeds 1,000 tests totaling approximately 200,000 seconds of test time. This experience includes 400 tests exceeding 40,000 seconds of operation at the FPL.

During the course of FPL testing, it became apparent that design margins are inadequate for full power level flight operation and that the current SSME configuration requires an unacceptable amount of maintenance at that power level. Consequently, the SSME program has been re-planned so as to reduce the maintenance required and to provide quantities of logistics hardware adequate to preclude the flight delays experienced with STS-6.

Design modifications are underway to improve component life, increase reliability, and reduce the high maintenance costs. The solution to the environmental problems appears to require not only the modification of the turbopumps but also the reduction of operating temperatures and pressures induced by the design of the key elements of the powerhead. Due to the design and testing lead times, changes will be introduced incrementally. The first of these changes will occur in the 1985/1986 time span when the current engine will be retrofitted with improved turbopumps. The second change will be to redesign the hot gas manifold and the powerhead to change the operating environments experienced by the pumps. Efforts are being maae to introduce competition into this phase of the improvement program to assure that the Agency takes maximum advantage of all available talent. Prior to implementation into flight engines, these changes will be put through an initial certification test. They will also be incorporated into the flight certification extension program to demonstrate long term usage.

The number of engines being procured has been increased to provide the necessary assurance of engine availability for the support of the flight program and ground testing. Four additional engines, 2028-2031, will be fabricated, plus long-lead materials for critical components, allowing for potential future fabrication of one or more engines have been added. In addition, the production and engine overhaul schedules have been accelerated. The revised SSME development, certification and acceptance test requirements will fully utilize the three existing single engine test stands. A 1985 Construction of Facilities project is included in this budget to modify the main propulsion test (MPT) stand at the National Space Technology Laboratories to provide capability for single engine testing. This stand will be used initially to meet high pressure turbopump green run requirements which have increased due to the lower than anticipated mean time between replacement and the accelerated spare pump deliveries. A major replacement and upgrading to engine manufacturing machine tools has been initiated jointly by NASA and Rocketdyne to improve production efficiency and quality. Funding has also been included to provide a "test bed" engine by overhauling an existing engine. This engine will be used in concert with the OAST engine technology activities to provide a thorough mapping of the engine environment using improved sensors developed by the OAST program. In addition, design improvements generated through the engine technology studies will be tested on this engine. The selection of an engine testing site is still under review, but consideration is being given to utilization of an existing site at the Marshall Space Flight Center. Modification of a facility for this purpose would be a future facilities project not included in the current budget request.

Additional SRB design improvements are required to reduce the damage being incurred during booster water impact. Although the effort to strengthen the aft skirt structure has been effective in minimizing structural damage, continued damage is being experienced with the thrust vector control system.

Improvements to this system are being studied. In addition, since water impact damage is dependent upon the velocity at impact, development of larger main parachutes has been initiated. The new high performance motor was successfully flown on the STS-8 flight, although post-flight inspection indicated that erosion on one of the nozzles was greater than nominal. Modifications in manufacturing procedures and configuration are being evaluated as possible solutions to these recent problems.

The SRB program includes the development of a filament wound composite motor case. This development effort will enable the replacement of the current steel case segments for high performance launches. The performance increase is achieved by a reduction in the Shuttle liftoff weight resulting in a payload capability improvement of approximately 5,000 pounds. Several structural development tests were conducted in 1983 at the subscale, quarter scale, and full diameter configuration levels. The first flight use is planned for late 1985 on the initial Vandenberg launch.

Transition to the production mode in the ET program is well underway. Production readiness activities continue to smooth this transition and favorably improve production capability. The producibility program is already providing substantial cost savings, in many cases greater,than original estimates. Rearrangement of existing tools and new tools to eliminate manufacturing "choke points" and smooth the production flow for the buildup to 24 tanks per year has been emphasized.

In systems support, preparations are underway for the test of the engines at FPL in the main propulsion test stand at NSTL in March 1984. This test will provide for a check of the main engines' performance in conjunction with the main propulsion system test hardware mounted in the aft end of the simulated orbiter.

CHANGES FROM FY 1984 BUDGET ESTIMATE

Propulsion system requirements have increased by $145.8 million from the FY 1984 budget request. Main engine requirements have grown by $117.8 million largely as a result of the life problems identified during FPL development and certification tests and as a result of the need to provide an adequate logistics base. The engine delivery schedule was accelerated and four additional engines, previously planned as long-lead items, were added. In addition, long-lead materials were added for future fabrication of critical components and one or more new engines in the event of severe damage to or loss of existing hardware. Other improvements were incorporated such as repair and replacement of government-owned machine tools and additional software mods in the Block II configured controller.

The increase in funding of $37.8 million required for the SRB is related to redesign of the TVC system to reduce repair and refurbishment requirements, better definition of baseline tooling funding requirements, and increases due to FWC development test problems that prompted redesigns and additional test requirements.

ET funding requirements decreased by $16.3 million as a result of reduced ablator tooling requirements and revised tooling need dates due to flight hardware delivery need date changes.

The increase of $6.5 million systems support is attributable to the extension of the MPT for full power testing to FY 1984. Following completion of these tests, the MPT stand will be converted to a single engine capability to support the SSME production program. Previously, it was assumed that this test would take place in FY 1983.

BASIS OF FY 1985 ESTIMATE

In FY 1985, funding for the SSME provides for those activities necessary to support the orbiter production, flight schedules, and ground testing. Production flows have been adjusted to allow the addition of four new engines, 2028 through 2031, and to accelerate the delivery of engines 2023 through 2027. Other on-going activities also provided for within the SSME budget estimates include flight spares lay-in, anomaly resolution testing,, and continued certification and development testing.

In the SRB, efforts will continue on the improvements to the TVC system and other program elements to minimize flight damage and improve turnaround times on reusable hardware. Procurement of manufacturing tools, transportation support equipment, and related items will continue in support of reaching a 24 per year flight rate objective. In the FWC development activity, funding in FY 1985 provides for reusability/refurbishment studies, completion of development testing, and fabrication of the first two flight articles.

In the ET program, enhancement of manufacturing processes to achieve cost reductions will continue through the producibility and production readiness efforts. The major thrust for FY 1985 will be continuing procurement and installation of tools and equipment to support the build-up to a production rate of 24 per year. To increase productivity, improved weld techniques and automated riveting tools are being introduced.

CHANGES AND SYSTEMS UPGRADING

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Changes and systems upgrading.......	---	52,700	37,300	25,000

OBJECTIVES AND STATUS

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

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

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

CHANGES FROM FY 1984 BUDGET

The changes and systems upgrading funds identified in the FY 1984 budget have been reallocated as identified in the individual program justifications of changes from the FY 1984 budget estimates. The decrease reflects the reallocation of funds to Shuttle production and operational capability primarily for the SSME program.

BASIS OF FY 1985 ESTIMATE

The funding requested for FY 1985 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, by facilitating improved mission-to-mission turnaround time, and by improving mission performance margins.

BASIS OF FY 1985 FUNDING REQUIREMENT

ORTATION OPERATIONS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
		(Thousands of Dollars)			
Shuttle operations....................	1,338,700	1,520,600	1,402,000	1,339,000	
Flight operations....................	(317,500)	(315,000)	(323,900)	(316,000)	SF 2-3
Flight hardware....................	(679,200)	(848,400)	(739,100)	(758,000)	SF 2-6
Launch and landing operations.......	(342,000)	(357,200)	(339,000)	(265,000)	SF 2-8
Expendable launch vehicles	83,000	50,000	50,000	---	
Total..............................	1,421,700	1,570,600	1,452,000	1,339,000	

Distribution of Program Amounts by Installation

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
Johnson Space Center..................	362,600	388,400	392,500	349,900
Kennedy Space Center..................	342,300	354,900	340,100	262,500
Marshall Space Flight Center..........	612,900	755,000	642,500	671,800
National Space Technology Laboratories	700	---	---	---
Goddard Space Flight Center...........	68,100	49,400	45,300	600
Jet Propulsion Laboratory.............	100	---	200	---
Ames Research Center..................	3,900	3,200	2,300	2,500
Headquarters..........................	31,100	19,700	29,100	51,700
Total..............................	1,421,700	1,570,600	1,452,000	1,339,000

OBJECTIVES AND STATUS

Shuttle operations direct appropriated funding is combined with the reimbursements received from other U.S. Government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. During the first full year of Shuttle operations, four missions were flown (STS-5, -6, -7, -8). These missions demonstrated many of the Shuttle's capabilities, including deployments of spacecraft and their upper stages, proximity operations using the remote manipulator, extravehicular activity operations, a night landing, and a widening of the Shuttle's performance envelope. In FY 1984, another seven to eight missions are scheduled to be flown. The first of these, the initial flight of a dedicated Spacelab, had both the largest crew and longest flight time experienced to date. Eleven flights are scheduled for FY 1985.

Flight operations is divided into three major elements: mission support, integration, and support. Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Integration includes sustaining engineering for cargo analytical integration, systems integration, and operational support. The support element includes base operational support at JSC and systems activity at Headquarters and Goddard Space Flight Center (GSFC).

The flight hardware program element provides for the procurement of ET's, solid rocket motors, booster hardware, and propellants; spare components for the SSME, orbiter spares; sustaining engineering and logistics support for the external tank, solid rocket booster, and main engine flight hardware elements; and maintenance and operations of flight crew equipment. Included in the funding request for ET's, solid rocket motors, and boosters are the long lead time raw materials, subassemblies, and subsystems necessary to sustain the production of elements in a consistent manner with the increasing flight rate.

Launch and landing operations provides for the launch preparation and the launch and landing operations of the Space Shuttle and its cargo.

Since the Delta's first use in 1960, this vehicle has been utilized in 173 launches and has experienced a success record of over 92 percent. The last 39 launches in a row were successful. It is presently operational with two- and three-stage configurations. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation. The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) or, in the 3920 configuration, a 1,270 kilogram (2,800 pounds) payload into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). The Active Magnetospheric Particle Tracer Explorer, the last NASA mission scheduled for launch on Delta, is planned for August 1984.

FLIGHT OPERATIONS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Mission support	153,400	118,200	159,100	142,500
Integration	97,100	155,800	94,700	72,900
Support	67,000	41,000	70,100	100,600
Total	317,500	315,000	323,900	316,000

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission support, integration and support. Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include flight planning, preparation of development system and software handbooks, flight rules, detailed crew activity plans and procedures of MCC and network systems requirements from 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. The flight design task also includes supporting the crew training simulations and development flight techniques. The software activities include the development, formulation, and verification support of the guidance, targeting, and navigation systems software requirements in the orbiter and MCC. In addition, the flight-dependent data located in the erasable memory (mission-to-mission changes) is developed from the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The flight operations total has increased $8.9 million from the budget estimate which reflects rephasing of analytical integration tasks on payloads which are classified as DOD "launch-on-need"; the addition of entry verification activity to SAIL due to the closing of the Flight Systems Laboratories (FSL) at Rockwell;

provision for improved customer support; and less learning than anticipated in streamlining and reducing the number of pre-flight planning cycles in the flight/mission design process. The changes among the sub-elements of flight operations are the result of the rearranging of the work activities as described above.

BASIS OF FY 1985 ESTIMATE

The flight operations portion of the Shuttle operations budget provides the maintenance and operation of the onboard avionics software and the mission control systems; maintenance and operations of the training and flight proficiency aircraft and simulators for crew training; and analysis and generation of the mission planning necessary to conduct and control the mission and instruct the flight crew. Flight operations also includes the sustaining engineering required to integrate all flight elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; support of crew operations and training programs; and program support at JSC and NASA Headquarters. In addition, orbiter sustaining engineering manpower is required in support of the orbiter vehicle to ensure maintainability, reliability, and anomaly resolution during operations. The operations and maintenance of the SAIL are provided to test and verify the ongoing operations software and hardware modifications. The SAIL operations are funded as well through the engineering and technical base budget element; this core facility is a key element in the capability of the system to investigate and resolve anomalies experienced on the ground or in flight.

Further, flight operations includes the Getaway Special support managed by GSFC, the payload integration activities at KSC, and the flight crew mission requirements and the safety certification at JSC. Included are the additive (to the core engineering and technical base) operations and maintenance support, printing, equipment rentals, and supplies and materials for the base operations activities at JSC. Other activities are the updates to and verifications of flight software, post-flight assessment, and ground turnaround evaluation. In addition, the current estimate includes engineering, testing and quality assurance necessary for system operations, including avionics verification. These functions were transfered from the integration budget.

Integration includes the identification of operational requirements for the design of improved future spacecraft and STS component systems; the development of flight techniques for utilization of these systems;

conceptual level profile development and analysis, beginning about two years before the flight; and operational profile development and analysis, accomplished in the period immediately prior to the flight. Analytical integration is performed for payloads in the cargo bay and mid-deck. The current estimate for integration retains this sustaining engineering and payload analytical integration effort and adds the systems integration effort transferred from the support budget.

Support continues to include that portion of JSC base operations support related to Shuttle operations; systems activities necessary for mission planning and execution; the "Getaway Special" payload cannister effort performed by GSFC, Headquarters programs including assessments for agencywide activities; and efforts by the Space Shuttle Project Office associated with system-wide improvements necessary to achieve the planned flight rate and schedule reliability required for mature system operations.

BASIS OF FY 1985 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Orbiter..............................	100,600	159,000	160,400	153,200
Solid rocket booster..................	309,200	353,200	341,000	323,900
External tank.............:.........	269,400	336,200	237,700	280,900
Total..............................	679,200	848,400	739,100	758,000

OBJECTIVES AND STATUS

The flight hardware program element provides for the procurement of ET; solid rocket motors, booster hardware, and propellants; spare components for the SSME's; orbiter spares; sustaining engineering and logistics support for external tank/solid rocket booster/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Included in the funding request for ET's, solid rocket motors, and boosters are the long lead time 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 as smooth and efficient a buildup of the production capability as possible. The procurement of some elements of the SRB have been accelerated to reflect the need for addditional hardware to protect against hardware attrition and refurbishment problems encountered during flight tests. In the ET, an efficient and nondisruptive production process continues to be developed which enables manufacturing, assembly, and checkout operations to proceed on a basis which allows for timely delivery of flight hardware to the launch site. The orbiter line element includes: SSME overhauls, procurement of replacement spare parts and attendant sustaining engineering; provision for the fixed level of annual support for the liquid hydrogen plant; orbiter spares for replenishment of line and shop replaceable units, and the manpower for supporting this logistics operation; and, 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 the pre-flight training and flight usage of the extravehicular maneuvering unit, emergency portable oxygen Systems, radiation instrumentation, survival radios, closed-circuit television cameras, and food and other galley-related items.

CHANGES FROM FY 1984 BUDGE" ESTIMATE

The current estimate reflects a net reduction from the budget estimate of **$109.3** million. This reduction is primarily in the ET requirements as a result of the reduced mission model, later hardware deliveries as the result of changes to launch site need dates and reduced delivery schedule margins, and achievement of greater than predicted labor reductions. The current SRB estimate in total is less than the budget estimate primarily due to the reduced mission model. SRB increases have been experienced as a result of booster reusable hardware requirements, additional nozzle requirements, and reestimated refurbishment costs. The increase in orbiter flight hardware reflects minor changes in anticipated shop replaceable units and.repair parts procurements and repair cost estimates.

BASIS OF FY 1985 ESTIMATE

Orbiter flight spares, crew equipment spares, and logistics are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure spares. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity required to support the project flight rate. Main engine hardware provides for manufacturing and delivery of overhauled engines and engine component spares. Engine overhaul cost has increased to allow for the staggered removal and earlier than planned overhaul of the engine in the near term. Flight hardware requirements for the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown after FY **1985**, as well as supporting the production of units which will be flown in that year. Deliveries planned for FY **1985** include thirteen sets of SRB's and twelve ET's.

BASIS OF FY 1985 FUNDING REQUIREMENT

LAUNCH AND LANDING OPERATIONS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Launch operations.....................	297,800	301,600	287,800	215,300
Payload and launch support............	44,200	55,600	51,200	49,700
Total..............................	342,000	357,200	339,000	265,000

OBJECTIVES AND STATUS

Launch and landing operations provides for the launch preparations and the launch and landing operations of the Space Shuttle and its cargo. The orbiter, external tank, solid rocket boosters, main engines, and payloads are checked out, integrated, and launched from KSC at Cape Canaveral, Florida. The SRB's are retrieved from the Atlantic Ocean after separation from the Shuttle. Space Shuttle landing support is furnished at KSC and contingency landing sites as required. The major facilities used for launch and landing operations include: the launch control center, orbiter processing facility, vehicle assembly building, mobile launcher platforms, SRB processing and storage facility, payload processing facilities, launch pads, and the Shuttle landing facility.

Funding for launch and landing operations provides the propellants, ground support equipment, and manpower required to accomplish the integration and processing of the Shuttle and its payloads. Under launch operations, manpower is provided to process, integrate, and check out the orbiter, ET, solid rocket motors/boosters and the SSME into the proper launch configuration preparatory to each flight. Support manpower is also included to conduct the SRB retrieval operations, engineering support, logistics, central data system support, facility and equipment modifications, and the maintenance and operation of the ground systems, structures and equipment. Funding for payload and launch support provides for the processing and integration of the payloads, procurement of spares for ground support equipment, propellants for launch operations and base support (excluding SRB propellants), and Shuttle operations at the Dryden Flight Research Facility.

During **FY 1983**, KSC successfully processed the first four Shuttle operational launches and landings. During FY **1984**, KSC will process seven to eight launches; the first landing planned at KSC's Shuttle landing facility is among these and will be the first of five KSC landings planned for the fiscal year. The STS flight rate is planned to increase to **24** per year **by FY 1989**, twenty of which may be from KSC and the remainder from Vandenberg. The first flight from Vandenberg is planned for late **1985.**

The contracting philosophy for the operations era has been directed toward the consolidation of contracts to strengthen the STS launch function. Clear contractor responsibility is provided through reducing the interfaces that exist today. NASA is placing more emphasis on the contractor's approach to the job and an overall reduction of many of today's approval requirements, detailed instructions, and daily serial involvement in the work. These changes are expected to achieve cost reductions and to provide the contractors with incentives to achieve future economies while maintaining safety of flight.

To this end, a base operations contract (BOC) was awarded in early FY **1983** to establish a single on-site, consolidated support contractor to provide institutional support to the KSC organizations. The Shuttle processing contract (SPC) was awarded in late **FY 1983** establishing one consolidated contractor for launch and landing activities and operation of related ground systems at both KSC and Vandenberg. There are plans to incorporate a consolidated cargo processing contract (CPC).

CHANGES FROM FY 1984 BUDGET ESTIMATE

The launch and landing operations decrease of **$16.3** million is primarily due to a reduction in the NASA requirement to fund launch and landing support services provided by the DOD Eastern Space and Missile Center. Additional savings were realized by a reduction of two flights in the mission model through **FY 1984** and downgrading the Dryden Flight Research Facility to a contingency landing site. Offsetting these savings somewhat is an increase in the manpower required to provide supply support to payload operations and additional funding to improve KSC's information processing capability for a multi-flow, operational environment.

BASIS OF FY 1985 ESTIMATE

Launch and landing operations funding in FY **1985** provides for manpower and support necessary to process the eleven planned launches. This includes manpower to process the build-up of the SRB's, mate the boosters and tanks, process the orbiter, integrate payloads into the orbiter either vertically or horizontally, mate the orbiter, process and check out the integrated flight elements through launch, retrieve the SRB's for refurbishment, and support landing of the orbiter and its return when required from alternate landing sites. Funding also supports the sustaining engineering, logistics, launch processing system, and ground operations and facility and equipment maintenance, modification and operation. Projected savings due to BOC and SPC efficiencies have been included in the estimate.

Payload and launch support funding provides: propellants for launch operations and base support, spares for the ground support equipment (such as MLP crawler shoes and magnetic tapes for the launch processing system), 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 multi-mission payload support equipment--and the payload support areas--such as 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.

OFFICE OF SPACE TRACKING AND DATA SYSTEMS — SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate	Page Number
	(Thousands of Dollars)				
Space network........................	104,300*	294,700	259,100	386,500	SF 3-4
Ground network.......................	242,920*	231,500	249,300	223,600	SF 3-9
Communications and data systems.... ...	138,280*	159,800	165,600	185,600	SF 3-19
Total..............................	485,500	686,000	674,000	795,700	
Distribution of Program Amounts by Installation					
Marshall Space Flight Center..........	2,500	13,000	13,500	17,400	
Goddard Space Flight Center...........	327,264	355,600	352,700	434,800	
Jet Propulsion Iaboratory.........	99,553	97,200	95,900	106,600	
Ames Research Center..................	4,550	6,600	6,500	8,700	
Headquarters...	51,153	213,600	204,900	228,200	
Johnson Space Center.................	480	---	500	---	
mtal..............................	485,500	686,000	674,000	795,700	

* Prior to FY 1984, these programs were in Research and Development.

PROGRAM OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the Department of Defense (DOD), other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for sounding rockets, balloons, research aircraft, Earth orbital and planetary missions and deep space probes. The program includes support of the Space Shuttle and Spacelab flight programs. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmission from space vehicles; (e) transmission of commands from ground stations to the spacecraft; (f) communication 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. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions and, in the case of Shuttle missions, to insure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations, and by the first of a system of three tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational. The STDN will remain the primary Earth orbital support network until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to ensure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of selected STDN ground stations will be initiated. This is presently planned for the first half of 1985. Certain facilities of the STDN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS or to provide launch and Shuttle landing support. These remaining facilities, except for the launch and Shuttle landing support facilities, are to be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory (JPL). The consolidation, when completed, will provide a single network to support geosynchronous, highly elliptical, and planetary missions. The consolidated network will also support those spacecraft, now in low-Earth orbit, which are not compatible with TDRSS.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Space Flight, Control and Data Communications appropriation includes the Space Network, Ground Network and Data Processing and Communications elements of the program, and provides funds for: (a) the cost of TDRSS service; (b) operations and maintenance of the tracking, data acquisition, mission control and data processing facilities; and (c) the engineering services and procurement of equipment to sustain and modify the various systems to support continuing, new, and changing flight project requirements. The Research and Development (R&D) appropriation includes the Advanced Systems program element and provides funds for the investigation and development of advanced tracking and data acquisition systems and techniques.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The current estimate for FY 1984 is $12.0 million below the budget estimate and represents a reduction ($10.0 million) in the payment to the Federal Financing Bank (FFB) consistent with the FY 1984 HUD-Independent Agencies Appropriations Conference Agreement, and the application of a portion of the general appropriation reduction ($2.0 million) to this program.

Within the initial operating plan level of $688.2 million, adjustments were made primarily to accommodate the impact on the program resulting from the failure of the Inertial Upper Stage (IUS) vehicle to properly deploy the first Tracking and Data Relay Satellite to geosynchronous orbit in April 1983. These adjustments are addressed in more detail in subsequent sections of the program justification.

SPACE NETWORK

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Tracking and data relay satellite system (TDRSS)......................	41,000	242,900	204,300	319,900
Space network operations..............	42,500	31,800	31,300	40,800
Systems engineering and support.......	20,800	20,000	23,500	25,800
Total..............................	104,300	294,700	259,100	386,500

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth orbital spacecraft. The TDRSS itself will consist of a three-satellite system in geosynchronous orbit and a single ground terminal located at White Sands, New Mexico. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communication links interconnect the NASA elements of the network and any remotely located user facilities.

The FY 1985 request includes funding for: repayment of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; payments to the TDRSS contractor for continuing TDRS production, TDRSS services and for maintenance and operation of the White Sands Complex; manpower and services necessary to operate and maintain the other NASA elements of the network; and systems engineering, engineering analyses and other support services to the network elements, such as mission planning, logistics, and documentation.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system......	41,000	242,900	204,300	319,900

OBJECTIVES AND STATUS

The Tracking and Data Relay Satellite System (TDRSS) objective is to provide communication services between the user spacecraft and ground facilities. The Tracking and Data Relay Satellites (TDRS) provide space-to-space communications to and from the user satellites and relay these communications to the ground via a single ground terminal which is interconnected with the other elements of the Space Network. From their position in geosynchronous orbit, the TDRS can provide nearly a six-fold increase in the orbital coverage provided by the existing complex of ground stations and can accommodate extremely high user data rates ranging up to 300 megabits per second. These capabilities will provide tracking, command, telemetry, and communication services to the flight missions of the Shuttle era.

The TDRS-1 was launched in April 1983, and the Inertial Upper Stage (IUS) booster failed to deliver the TDRS spacecraft into the correct orbit. In late June, the mission was recovered through a complex sequence of maneuvers, and the spacecraft was placed into its nominal orbit. Since that time, the spacecraft has supported subsequent Shuttle missions, including Spacelab-1, while continuing the test and checkout of the TDRSS spacecraft and ground terminal. Recently, the spacecraft has experienced failures of the Ku Band forward link that provides communication from TDRSS to the user spacecraft. The cause of these failures is currently under review.

The launches of TDRS-B and C have been delayed while modifications are being made to the IUS to rectify the causes of the anomaly experienced during the first launch. Current plans anticipate launch of the second TDRS in late 1984 with the third launch following in early 1985. These launches will complete the operational constellation of three TDRS's. Production of TDRSS spacecraft continues with TDRS-B having completed testing and been placed in storage. TDRS-C has completed environmental tests and is being prepared for storage: (some modifications to these spacecraft may be necessary as a result of the TDRS-1 problem) TDRS-D, first of the ground spares, begins environmental testing this spring. The TDRS B-F will have the C-band modification for Government communication use. Principal agencies that plan to use C-band are DOD, NASA and U.S. Information Agency (USIA).

CHANGES FROM PY 1984 BUDGET ESTIMATE

The decrease in FY 1984 of approximately $38 million resulted from the restructuring of the TDRSS loans with the Federal Financing Bank (FFB) and the schedule impact of the IUS anomaly. The extended borrowing period resulting from loan restructuring will reduce the FY 1984 loan repayments to the FFB by approximately $11M. The schedule impact of the IUS anomaly reduced the TDRSS operations and associated award-fee funding requirements in FY 1984 by an estimated $27 million. Included in the group of deferred activities due to the schedule impact (in addition to award fees) are testing and some launch-related items.

BASIS OF FY 1985 ESTIMATE

Under the terms of the TDRSS service contract, loans were extended by the Federal Financing Bank (FFB) to the Space Communication Company (SCC), the owner-operator of the TDRSS, for program development. Under the terms of the loan agreement and assignment, NASA repays these loans directly to the FFB. In addition, NASA will make payments to SCC for TDRSS services, for continued spacecraft production, for maintenance and operation of the White Sands Ground Terminal and other support to be provided during the year. Current planning provides for launch of the initial four spacecraft (TDRS-1 and B through -D) using the IUS and the launch of TDRS-E using the Centaur/STS upper stage. The activities associated with integrating the TDRS with the Centaur/STS upper stage will be initiated in FY 1985.

Of the amount requested in FY 1985, $210 million is for loan repayments to FFB, $33 million for the impact of the IUS anomaly, $36 million for continuing TDRSS production and the balance of the request for TDRSS service payments, maintenance and operation of the White Sands Ground Terminal, TDRSS integration with the Centaur upper stage, and other changes and support activities. These estimates are predicated upon the successful launch and checkout of TDRS-B and TDRS-C in November 1984 and February 1985, respectively.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Space network operations.....	42,500	31,800	31,300	40,800

OBJECTIVES AND STATUS

The objective of Space Network Operations is to provide for the operation and maintenance of the associated NASA ground systems which, when combined with TDRSS, provide a full array of reliable tracking, telemetry, command, and communication services to user spacecraft in low-Earth orbit. Each of these NASA systems perform specific functions for the Space Network.

The NASA Ground Terminal (NGT) monitors TDRSS performance and provides fault isolation monitoring for the network. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft, and the Operations Support Computing Facility (OSCF) provides orbit determination, trajectory analysis, and position location for flight missions supported either via the Space Network or by the current Spaceflight Tracking and Data Network (STDN). The Bilateration Ranging Transponder System (BRTS) provides precision position location and orbit determination for the TDRS. The Simulation Operations Center (SOC) and the Compatibility Test Vans (CTV) provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission.

The individual elements are designed to function as an integrated operational system. Currently, the overall system is in an integration and test phase and is providing service to the user community on a limited basis. Effort is also continuing on achieving an operational configuration that is capable of supporting an expanded workload in the late 1980's.

CHANGES FROM FY 1984 ESTIMATE

The decrease of $.5 million is due to revised operational requirements for the Network Control Center.

BASIS OF FY 1985 ESTIMATE

The funding request provides for contractor personnel to operate the network systems 24 hours per day, seven days per week, and to provide requisite hardware and software maintenance. A contract has been competitively awarded to provide these operations and maintenance services. In addition, a variety of support services is provided in the areas of logistics, mission planning and documentation.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Systems engineering and support.......	20,800	20,000	23,500	25,800

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services and requisite hardware systems to implement and sustain the NASA elements of the Space Network. Engineering services are supplied primarily through the operations contract and a number of small, highly specialized engineering service contracts. Current emphasis is on the completion, test, and integration activities in preparation for the initial operations of the Space Network. Activities include test scenario design and development, system and subsystem level troubleshooting during simulations, end-to-end network testing, and operations procedure development.

CHANGES FROM FY 1984 ESTIMATE

The increase of $3.5 million is due to additional engineering and software support required for the Network Control Center, a high data rate switching capability for the NASA Ground Terminal and an additional transponder required for the Bilateration Ranging Transponder System.

BASIS OF FY 1985 ESTIMATE

Requested funding will provide for engineering support under the operations mission contract in the areas of systems engineering, performance and operations analyses, minor facility modifications, and network integration testing and interface verification. In addition, other contractors will supply sustaining engineering support, test equipment, and vendor maintenance for specialized equipment and subsystems within the Space Network. Design and analytical studies will be conducted on a wide array of items ranging from subsystem modifications to meet new mission requirements or to correct system deficiencies to the analysis of the radio frequency environment for potential impact on TDRSS and other network systems. Funds are also requested for continued software development for the NCC Full Operational Capability (FOC) and to complete procurement of replacement high data rate switching systems for the NASA Ground Terminal (NGT).

BASIS OF FY 1985 FUNDING REQUIREMENT

GROUND NETWORK

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation.......	6,000	8,100	8,600	6,300
Spaceflight tracking and data network operations..................	118,500	102,500	120,800	83,300
Deep space network systems implementation.........	44,300	38,100	38,100	37,100
Deep space network operations.........	61,300	66,500	65,500	76,800
Aeronautics, balloons, and sounding rocket support systems implementation............................	4,120	8,100	8,100	8,200
Aeronautics, balloons, and sounding rocket support operations............	8,700	8,200	8,200	11,900
Total...........................	242,920	231,500	249,300	223,600

The Ground Network includes the Spaceflight Tracking and Data Network (STDN), consisting of 15 geographically dispersed ground stations which support Earth orbital missions; the Deep Space Network (DSN) consisting of three stations approximately 120 degrees apart in longitude, for continuous viewing, which supports planetary and interplanetary flight missions; and support for Aeronautics, Balloon and Sounding Rocket (AB&SR) programs at the Wallops Flight Facility (WFF), the Dryden Flight Research Facility (DFRF), the Moffett Field Flight Complex (MFFC), and White Sands Missile Range (WSMC), as well as instrumentation support at the National Balloon Facility at Palestine, Texas.

Funding for the ground network provides for operation and maintenance of the worldwide facilities, as well as engineering and procurement of equipment to sustain and modify network systems. The workload in FY 1985 includes ongoing support to Shuttle, Voyager, Dynamic Explorer, International Ultraviolet Explorer (IUE), and the International Sun-Earth Explorers, as well as preparation for support of such upcoming missions as Galileo, the Voyager-Uranus encounter, and the Venus Radar Mapper (VRM). Support will be provided to aircraft programs such as the F-16 and F-111, AV-8B, the forward swept wing, and the use of drones for aerodynamic and structural testing.

The FY 1985 budget request reflects a continuation of STDN ground station operations for six months into FY 1985 and then a planned phaseout of most of the ground stations after TDRSS is operational. This extension of STDN operations over previous plans is due to the rescheduling and delay of the TDRS-B and -C launches resulting from modifications that must be made to the IUS as a result of the problems experienced during the launch of TDRS-1. Three of the remaining STDN facilities will be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL). The consolidation will result in a single network to support geosynchronous, highly elliptical, and planetary missions. The remainder will be dedicated to support of launch and Shuttle landing operations and for scientific satellites such as IUE, IMP-8 and Nimbus 7.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Spaceflight tracking and data network systems implementation......	6,000	8,100	8,600	6,300

OBJECTIVES AND STATUS

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement and implementation of services to sustain network facilities and equipment to insure reliable tracking, command, and data acquisition support to ongoing scientific and applications satellite missions and the Space Shuttle, and to selectively replace obsolete equipment for reliable support in the TDRSS era. Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $0.5 million is for sustaining STDN systems and facilities for an extended period of time due to the delay in the station closure dates.

BASIS OF FY 1985 ESTIMATE

The FY 1985 request includes funds for the replacement of obsolete and difficult-to-maintain equipment at those facilities that remain after TDRSS is operational. These include facilities used for launch support at Bermuda, Merritt Island, Florida and New Smyrna Beach, Florida, and for orbital support from Greenbelt, Maryland. The requirement for support from these sites will continue for the foreseeable future. Equipment replacements and modifications are required in the network in FY 1985 to maintain a level of proficiency to support the continuing workload and to assure the reliability of the major systems. Accordingly, funds are required for equipment replacements and modifications to correct current deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network operations.................	118,500	102,500	120,800	83,300

OBJECTIVES AND STATUS

The primary function of the Spaceflight Tracking and Data Network (STDN) system is to support all NASA Earth-orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer (ISEE) missions. In addition, the network provides launch support to NASA automated planetary missions, and on a reimbursable basis, spaceflight missions of other nations, commercial firms, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of 15 geographically dispersed ground stations. These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew operations and safety, and other project-related purposes.

There are 12 STDN land stations located at: Fairbanks, Alaska; Goldstone, California; Greenbelt, Maryland (GSFC); Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Dakar, Senegal; Bermuda; Santiago, Chile; and Madrid, Spain. In addition to these 12 stations, three additional facilities supplement the STDN, primarily for Space Shuttle support. A small station is located at New Smyrna Beach, Florida, for support of Shuttle launch and landings. Also, two UHF/voice air-to-ground stations are located at Gaborone, Botswana and Yarragadee, Australia to provide additional voice coverage with the astronauts. An Air Force station in the Indian Ocean is occasionally used to provide additional Shuttle support.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $18.3 million results from the additional six-months of tracking operations for Shuttle support in FY 1984 brought about by the delay in the Tracking and Data Relay Satellite System reaching operational status (due to the IUS problems) thus requiring the ground stations to provide Shuttle and other support until the TDRSS is operational.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding requirements provide for the maintenance and operation of the STDN until phasedown begins in the April 1985 time period. This represents a planning assumption which is contingent upon the successful launch and checkout of the remaining two TDRS (-B and -C). Included in the funding request are the related logistics support, network planning, scheduling, engineering, documentation and software programming costs associated with the operation of the network.

The initiation of full TDRSS service will permit closure of several STDN stations in FY 1985--Ascension, Guam, Hawaii, Santiago, Dakar and Botswana--and the termination of Tracking and Data Acquisition activities at the Air Force Indian Ocean station and Yarragadee, Australia.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Deep space network (DSN) systems implementation.............	44,300	38,100	38,100	37,100

OBJECTIVES AND STATUS

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The DSN is responsible for receiving science and engineering data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging in distance to over 4.6 billion kilometers from Earth. After the Tracking and Data Relay Satellite System (TDRSS) becomes operational, the DSN will also support spacecraft much closer to Earth. The new set of spacecraft support requirements will include missions in highly-elliptical and synchronous Earth orbits which are not supportable by the TDRSS.

The systems and facilities required to support spacecraft at the limits of the solar system are highly specialized and include the use of large aperture antennas electronically configured in a phased array for optimum reception of the extremely weak radio signals. The antennas use ultrasensitive, cryogenically cooled receivers and powerful transmitters. Extremely stable hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the DSN complexes and the Network Operations Control Center (NOCC).

The four major objectives for the DSN in the 1980's are as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive images at these great distances; (2) to consolidate the activities of the residual Spaceflight Tracking and Data Network (STDN) with the DSN after the TDRSS becomes fully operational in 1985; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits at altitudes that are beyond the support area of TDRSS); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the DSN, as it will be supporting many more spacecraft than in the past, and it will be working at extremely great distances (beyond the orbits of the known planets) by the end of the decade.

The next major planetary encounter will be of Uranus by Voyager-2 in 1986. This encounter will occur some 2.9 billion kilometers from Earth. At that time, Voyager-2 is expected to transmit the first high resolution images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of compound multiple antenna arraying (more than two antennas) during this Uranus encounter. In Australia, this will include the use of the 64-meter antenna of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). Further, the follow-on Neptune encounter by Voyager-2 in 1989 will require even greater antenna aperture. An expansion of the 64-meter antennas to 70-meter, along with compound multiple antenna arraying, will provide the increased signal capturing capability for our first look at this planet. In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support older near-Earth missions that are not compatible with the TDRSS. To support these older spacecraft in their extended mission phase, and to provide backup support to the TDRSS itself, existing 26-meter STDN antennas will be moved and colocated with the DSN facilities at Canberra and Madrid.

Upcoming deep space missions which will be supported by the network in the 1980's include the Jupiter orbiter and probe (Galileo), the International Solar Polar Mission (ISPM), and the Venus Radar Mapper (VRM). One or more of the Halley's Comet rendezvous missions will also be supported for the international community.

BASIS OF FY 1985 BUDGET

Funding in the FY 1985 request provides for continuing the reconfiguration of the ground network facilities into a consolidated, modern, and highly reliable network. The capabilities planned in the reconfiguration will provide for enhanced spacecraft-ground telecommunications and navigation precision while reducing overall maintenance and operations costs. Equipment required for this capability includes antenna monitor and control equipment, and receiving and data handling systems along with the necessary engineering and fabrication. Some equipment will be provided to augment the Parkes Antenna in Australia to properly handle and combine the signals received during the Voyager-Uranus encounter at that location.

In addition, funds are included for implementing a central signal processing center at each DSN complex. Instead of independent support facilities for each antenna, it will be possible to support all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized, shared maintenance and support facilities will also be provided.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager 2 at Uranus and Neptune. As the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for extremely sensitive receiving equipment as well as increased antenna aperture.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement of in-flight navigation accuracy.

Concurrent with these important engineering changes, FY 1985 funds will be required to maintain the high level of reliability for support of time-critical spacecraft maneuvers, as well as routine ongoing support. This will be accomplished through a continuing program of equipment and facility refurbishment and modifications to assure compatibility of existing equipment with the new systems being implemented in the network.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Deep space network operations.........	61,300	66,500	65,500	76,800

OBJECTIVES AND STATUS

The three Deep Space Network (DSN) complex locations--Goldstone, California; Canberra, Australia; and Madrid, Spain--are approximately 120 degrees apart in longitude and permit continuous viewing of planetary spacecraft. Each complex currently consists of one 64-meter and one 34-meter diameter antenna; an additional 34-meter antenna is being constructed both at Goldstone and Canberra.

A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field responsibility for the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operations of the Network Control Center at JPL.

The expected workload in 1985 on the DSN consists of the two Voyager spacecraft, the seven ongoing Pioneer spacecraft (Pioneer 6 - 11 and Pioneer Venus), Active Magnetosphere Particle Tracer Explorer, International Sun Earth Explorer-1 and -2, Helios-1, Nimbus-7, Design Engineer, Geosyncronous Operational Environmental Satellite, and the International Sun Earth Explorer-3 encounter with the Comet Giacobini-Zinner. Provision is also being made in the DSN to provide TDRSS emergency support.

The Voyager-2 spacecraft is on a trajectory for an encounter with Uranus in early 1986, and should provide the first detailed information on that distant planet. Voyager-1 is now about 2.8 billion kilometers from Earth on a trajectory that will take it out of the solar system. Of the older Pioneer spacecraft, Pioneer-10 is now beyond the orbit of Pluto and therefore is the first man-made object to leave the solar system. It now takes nearly eight and one-half hours for a radio signal, traveling at the speed of light, to make the round trip between Earth and Pioneer-10. The Pioneer-11 spacecraft, some 2.4 billion kilometers from Earth, continues to be tracked. The Pioneer-6 - 9 spacecraft are provided support during solar conjunctions and gravity wave experiments. The Helios-1 mission is continuing its orbit about the Sun.

The DSN facilities are also used on a noninterference basis for ground based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena.

In addition to the activities associated with network modifications and the support cited above, the DSN operations workload includes preparation for the Galileo spacecraft (the mission to Jupiter) and Giotto (the reimbursable European Space Agency (ESA) mission to Halley's Comet). This support preparation requires thorough and complex testing, training, and engineering involving both hardware and software. These activities must be carried out simultaneously with the extensive ongoing DSN workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

In preparation for the Voyager-2 encounter with Uranus, an additional 34-meter antenna is being constructed at both Goldstone and Canberra. These antennas will be electronically combined with the other facilities at their respective complexes so as to further increase the receiver gain available at these two stations which are both key to capturing imaging and remote science data from Uranus. The DSN complex at Canberra, because of its southern hemisphere location, will have the best view of Voyager-2 at Uranus. At that location, an additional facility will be used at the time of encounter; that facility is the Australian 64-meter Radio Observatory at Parkes, which will be electronically combined with an array of DSN antennas. ESA is planning to use this same radio observatory facility in support of their Giotto mission to Halley's

Comet. The arrival of Giotto at Halley's Comet at a time close to the Voyager-2 Uranus encounter will require close coordination between NASA, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and ESA in order to assure success.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The decrease of $1.0 million is due to lower than projected costs in the operation of overseas stations.

BASIS OF FY 1985 ESTIMATE

The DSN operations funding provides for the maintenance and operation of the network facilities, control center, and the support and engineering effort associated with continuing operation of the network. Funds requested for FY 1985 are based upon the ongoing workload, including the Voyager missions, Pioneer-6 - 11 missions, Pioneer-Venus extended mission, Helios mission, the preparation required for the upcoming activities mentioned above, and the assumption of management and funding responsibility for the consolidated network. The transfer of STDN facilities and management responsibility for the consolidated network to JPL in early 1985 is the primary reason for the funding increase from FY 1984 to FY 1985.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Aeronautics, balloons and sounding rocket support systems implementation	4,120	8,100	8,100	8,200

OBJECTIVES AND STATUS

The objective of the Aeronautics, Balloons, and Sounding Rocket (AB&SR) Support Systems Implementation program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition, and range safety requirements of the aeronautical research conducted at the Wallops Flight Facility (WFF) in Virginia, the Dryden Flight Research Facility (DFRF) in California, the Moffett Field Flight Complex (MFFC) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops, the White Sands Missile Range, New Mexico; Poker Flats, Alaska; Palestine, Texas and other selected sites around the world.

BASIS OF FY 1985 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which generally require about the same level of support from year to year. To support these programs, WFF provides fixed and mobile instrumentation systems; namely, radar, telemetry, optical, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, and test and calibration equipment routinely replaced.

Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased replacement and refurbishment program is underway to insure reliable real-time data collection and handling support to meet current and future requirements.

Funds are also included in the budget request for implementation of a second directional UHF antenna system at the DFRF as a part of the overall effort to develop a capability to support two missions simultaneously in order to accommodate the increase in flight research activity of that facility. Telemetry data processing equipment will be replaced at MFFC and radar data processing equipment will be replaced at both DFRF and MFFC. At WFF, the major expenditure is for rehabilitation of the FPQ-6 radar which supports aeronautics and balloon research activities as well as rocket launches.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket support operations...........	8,700	8,200	8,200	11,900

OBJECTIVES AND STATUS

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautical programs conducted by the Wallops Flight Facility (WFF), the Ames Research Center (ARC) at its Dryden Flight Research Facility (DFRF), and Moffett Field Flight Complex (MFFC). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket program continues to be an active program with approximately 200 launches in FY 1983, the majority of which were conducted at WFF. In addition, there were over 45 large scientific balloon flights, along with approximately 130 smaller special purpose balloon flights during the same period. At WFF, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and storm dynamics studies. The year 1983 was very active with over 300 research missions conducted during that period. In addition to support of sounding rocket, balloons, and aeronautical programs, instrumentation at WFF will continue to be utilized to support the Shuttle orbital flights.

ARC operates aeronautical test ranges at DFRF and MFFC which provide radar, telemetry, optical, and communications support for the performance of aircraft research and development programs. A variety of programs are conducted at these facilities involving high performance aircraft, such as the F-111, F-14, F-16, F-104, F-8, and unique research vehicles such as the tilt-rotor research aircraft, quiet short-haul research aircraft, composite rotorcraft, X-wing aircraft, and drones for aerodynamic and structural testing. Over 400 aeronautical research missions were supported at DFRF and nearly 300 at MFFC during FY 1983. DFRF was the prime landing site for STS-5, -6, -7, -8 and -9. Tracking and data acquisition support of Shuttle orbital flights will continue in the future. The MFFC operations are funded through FY 1984 in the appropriation for Aeronautics programs. In late 1983, it was decided to transfer the management responsibility for MFFC from the Office of Aeronautics and Space Technology to the Office of Space Tracking and Data Systems.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, optical, communications, and data handling and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities. The effort funded represents a continuation of the baseline support provided to the aeronautics, balloons and sounding rocket program. The increase in funding level from FY 1984 to FY 1985 reflects the transfer of responsibility of the Moffett Field Flight Complex from the Office of Aeronautics and Space Technology to the Office of Space Tracking and Data Systems.

BASIS OF FY 1985 FUNDING REQUIREMENT

COMMUNICATIONS AND DATA SYSTEMS

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation	5,600	5,300	5,900	6,500
Communications operations............	45,700	59,700	64,600	68,200
Mission facilities....................	10,900	11,500	12,900	12,400
Mission operations....................	16,200	18,600	19,100	21,900
Data processing systems implementation	20,580	22,400	22,400	26,600
Data processing operations...........	39,300	42,300	40,700	50,000
Total.............................	138,280	159,800	165,600	185,600

OBJECTIVES AND STATUS

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Communication circuits and services are necessary to transmit data between the remote tracking and data acquisition facilities, launch areas, and the Mission Control Centers. Real-time information is crucial to determining the condition of the spacecraft and payloads for the generation of commands for spacecraft and payload control. Data received from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. Such support is mandatory for achieving mission objectives. Missions supported include Shuttle, NASA scientific and application missions and international cooperative efforts.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation......................	5,600	5,300	5,900	6,500

OBJECTIVES AND STATUS

The objective of the Communications Systems Implementation Program is to provide the necessary capability in NASA's Global Communications Network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major effort underway in the NASCOM is the procurement and implementation of a digital replacement voice and data message switching system at the Goddard Space Flight Center (GSFC).

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $.6 million is attributed to the requirement for higher data rate transfer capability in the Deep Space Network for Galileo and Voyager.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and initiate procurement of a replacement digital voice and data message switching system at GSFC. Implementation will continue on the use of advanced digital techniques for Time-Division-Multiple-Access (TDMA) via satellite and on the use of fiber optic cables for high data rate distribution in support of Spacelab and Space Telescope.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Communications operations..............	45,700	59,700	64,600	68,200

OBJECTIVES AND STATUS

NASA's Global Communications Network (NASCOM) interconnects, by means of leased voice, data, and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations. The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditiously to users for analysis.

NASA's Program Support Communications (PSC) interconnects by means of leased voice, data, and wideband circuits the NASA Centers, Headquarters, and major contractor locations for the transfer of programmatic and administrative information. Marshall Space Flight Center (MSFC) operates the PSC and serves as its major switching control point.

In order to meet high data transfer rate requirements, NASA has implemented and will continue to use digital and other newly developed techniques in providing communications support. The continuing availability of new technology provides for the transmission of increasing amounts of data in a cost effective and highly reliable manner.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $4.9 million is directly attributable to the need to provide communications with the overseas tracking sites for Shuttle support longer than planned due to the delay in the Tracking and Data Relay Satellite System (TDRSS) becoming fully operational.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding requirements for Communications Operations will provide the circuits and service required to operate and maintain the NASA Global Communications Network. International communications satellites and cables will continue to be used to provide digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

In addition, funds are included for Program Support Communications (PSC) which provide for the circuits and facilities for programmatic and day-to-day operations such as facsimile, teleconferencing, data transmission, and computer-to-computer data sharing for NASA centers and Headquarters. In FY 1985, funds are required to implement the PSC Network gateway equipment which will provide direct connections to the network from all NASA centers and Headquarters. Funding increases in FY 1985 are due to programmatic requirements for additional dedicated data circuits for Spacelab payloads, Space Telescope, and the Space Transportation System management information system.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
	(Thousands of Dollars)			
Mission facilities....................	10,900	11,500	12,900	12,400

T AND STATUS

The Mission Facilities implementation program provides the systems capability for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control of the spacecraft and on-board experiments is carried out via the Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS).

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the transmission of commands. Four POCC's currently monitor and control numerous spacecraft. In addition, a new dedicated control center is being implemented to control the operations of the Space Telescope to be launched in FY 1986. Related Mission Support Systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC Interface Facility and a closed-circuit television and data communications system.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The increase of $1.4 million is for the rephased purchase of a computer system which will be used for equipment configuration control in the Multisatellite Operations Control Center (MSOCC) in support of low-Earth orbiting spacecraft.

BASIS OF FY 1985 ESTIMATE

The FY 1985 funding requirements will provide for the continuing development of the Space Telescope Operations Control Center. Two major activities, the Preliminary Operations Requirements and Test System (PORTS) and Payload Applications Software System (PASS), plus a test and validation effort will be underway to meet the FY 1986 launch date. The control center hardware installation will have been completed and integration testing with the spacecraft on the ground will be conducted. Also, the control center hardware and software will be interfaced to the worldwide tracking and data systems for contingency support. The off-line software which provides the high precision telescope pointing, manipulation of the cameras and spectrographs, pointing of the spacecraft antenna toward the TDRSS, and energy and momentum management of the vehicle itself, will require additional development and testing. Funds are also necessary to assure that the PORTS, PASS, and Data Capture Facility operate as an integrated system.

In addition, FY 1985 funds will provide for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO) and Cosmic Background Explorer (COBE) spacecraft, and for sustaining activities such as changes to interface devices and replacement of obsolete equipment.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Mission operations..................	16,200	18,600	19,100	21,900

OBJECTIVES AND STATUS

The Mission Operations Program provides for the operation of four Payload Operations Control Centers (POCC's), a Mission Operations Center, and the related software and support services necessary for the monitoring and control of 10 in-orbit spacecraft.

The POCC's, which are the control facilities for spacecraft/payload operations, contain all of the necessary equipment, software, and personnel needed to monitor, evaluate, and control the performance of spacecraft and experiments. Each POCC is operated 24 hours per day, seven days per week. For Shuttle launches with control center payloads, the POCC will issue commands and receive telemetry through the GSFC Shuttle Payload Interface Facility (SPIF). The SPIF will also process a variety of Shuttle-unique data and display these data to the POCC via closed circuit television.

CHANGES FROM FY 1984 ESTIMATE

The increase of $.5 million results from a better definition of software requirements for controlling the ISEE-3 spacecraft during the Giacobini-Zinner Comet rendezvous and the need to develop interactive TDRSS service schedules for control center user spacecraft.

BASIS OF FY 1985 ESTIMATE

The FY 1985 budget request includes funds to operate the POCC's and supporting facilities for the control of on-orbit missions. Also in FY 1985, POCC and Command Management software development activities will be increasing for both the Cosmic Background Explorer (COBE) and Gamma Ray Observatory (GRO) missions. Software to enable the POCC to work with the consolidated network will be developed and efforts will continue on SPIF software development.

Also included in the FY 1985 budget request are funds for software and related support services which include maintenance of a software library, coordination and display of launch data, computer-generated command sequences, equipment maintenance, logistics, documentation, engineering services and operation of a closed circuit television/data communications system.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation.....................	20,580	22,400	22,400	26,600

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 (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements, these systems determine spacecraft attitude and orbit, and generate on-board commands to the spacecraft subsystems. In support of spacecraft payloads, the systems process the data from science and applications experiments for subsequent transfer to the experimenters for analysis.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large systems viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth-orbiting spacecraft. The Image Processing Facility (IPF) is generating products for Landsat and Nimbus 7. The Spacelab Data Processing Facility (SLDPF) supported the Spacelab-1 mission very efficiently and will have mission unique changes made that are required to support Spacelabs-3 and -2. A new Flight Dynamics System to perform the computations required to determine spacecraft attitude and to execute spacecraft maneuvers was placed on line in mid-1983. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

BASIS OF FY 1985 ESTIMATE

The FY 1985 budget request will provide continued funding for phased replacement of the existing computation systems at the Goddard Space Flight Center which provide real-time support to NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control. These systems are approximately 18 years old. The system architecture of the existing equipment requires more extensive software development to meet new mission requirements. Replacement is needed because hardware and software maintenance is becoming more difficult and expensive, and more frequent outages are becoming a threat to spacecraft support.

The FY 1985 funding request provides for continuation of the phased replacement program for the command management system and the orbit computation system at GSFC. The orbit computation replacement system will have a complex task of not only supporting free flyer spacecraft, but also the Shuttle and the Tracking and Data Relay Satellite System (TDRSS). Maintaining the TDRSS position accuracy and user spacecraft's relative position determination will impose a significant demand on the orbit computation system resources.

In addition, funds are required to continue the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is necessary to handle the planned "Packet" telemetry concept and to assure support over the long mission lifetime of the Space Telescope. The "Packet" telemetry concept allows the scientific data of an experiment to be handled with minimum involvement by the ground system, thus minimizing ground data processing time as well as insuring faster delivery of data to the experimenters. FY 1985 funds are requested also to continue the development of a general purpose, multimission system to handle packet telemetry with the Gamma Ray Observatory (GRO) as its first user.

Funds are required in FY 1985 for the augmentation of the SLDPF to support missions such as ASTRO-1, -2, -3; Earth Observation missions; and Sunlab. These Dedicated Discipline Laboratory (DDL) missions will be flown more frequently than the earlier Spacelab missions, have a higher average data rate, and require quicker release of experiment data to the scientific community.

There is a continuing requirement to procure and maintain an adequate supply of spare parts to replace failure-prone and high-maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

	1983 Actual	1984 Budget Estimate	1984 Current Estimate	1985 Budget Estimate
		(Thousands of Dollars)		
Data processing operations...........	39,300	42,300	40,700	50,000

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to separate the information obtained from various scientific experiments aboard the spacecraft, consolidate information for each experimenter, determine spacecraft attitude, and correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft.

As part of the data processing activities, three facilities, the Image Processing Facility (IPF), the Telemetry On-Line Processing System (TELOPS), and the Spacelab Data Processing Facility (SLDPF), have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF, initially established to handle image data from the Landsat-1, has supported Landsat-2 and Landsat-3 and presently is processing residual data from these spacecraft as well as current data from the Nimbus missions. These spacecraft are being supported with an all-digital system using high density recorders and computer compatible tapes. This equipment has reduced the time required to provide data to users as well as the completion of processing of the ten-year Landsat data archive required for climate and meteorological studies.

The Telemetry On-Line Processing System (TELOPS) handles the non-image data. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Facility management, maintenance and operations, and software development support for the image and non-image data processing facilities are also provided. The operation of the Spacelab Data Processing Facility (SLDPF) is included along with software development and maintenance required for attitude determination, flight maneuvers, and mission simulations.

CHANGES FROM FY 1984 BUDGET ESTIMATE

The decrease of $1.6 million is due to lower than estimated mission unique and facility software costs and reduced maintenance and rental costs for Image Data Processing equipment.

BASIS OF FY 1985 ESTIMATE

The FY 1985 budget request includes funds to operate the Image Processing Facility (IPF) and the Telemetry On-Line Processing System (TELOPS).

Additional funds will also be required for operation of the SLDPF as the number of Spacelab missions increase and preparations are initiated for the support of the Dedicated Discipline Laboratory (DDL) missions. Increased funding for both the IPF and TELOPS is also required to meet the projected workload.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Earth Radiation Budget Satellite, Gamma Ray Observatory, and the Upper Atmosphere Research Satellite which will operate with the Tracking and Data Relay Satellite System. Complex software is required for spacecraft on-orbit and attitude control maneuvers and for the related data processing activities.