National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 2001 budget justifications provides information about major NASA programs that are either in the design and development phase or have not completed their initial operational phase. In several instances, information about programs which are not "major" but are of special interest has been included. The budgetary estimates are expressed in millions of dollars of *budget authority*.* Estimates of the FY 1999 and prior fiscal year budget authority are the "actual" amounts. The FY 2000 amounts are consistent with the FY 2000 initial operating plan. The amounts for FY 2001 and future fiscal years are expressed in "real year" economics, that is, they include an adjusting factor for the future inflation expected to be experienced. If the term "constant dollars" is used in the budget justifications, that phraseology indicates that the numbers do not include inflationary adjustments beyond the fiscal year referenced (e.g., "constant FY 1996 dollars").

The estimates provided below are intended to be comprehensive, including all related mission-unique costs, but there are limitations. The direct and indirect costs incurred by foreign governments or other federal agencies in support of these missions have not been included. The estimates of civil service costs have been included, but these estimates should be considered preliminary, and they will continue to be refined as the agency moves toward full cost accounting over the next several years.

* *Budget authority* is a term used to represent the amounts appropriated by the Congress in a given fiscal year; *budget authority* provides government agencies with the authority to obligate funds. The ensuing obligations, cost incurrence, and expenditures (outlays) can differ in timing from the fiscal year in which Congress provides the *budget authority* in an appropriations act.

X-33 Advanced Technology Demonstrator

The X-33 program will demonstrate, on the ground and on a flight demonstration vehicle, technologies and operations concepts that could reduce space transportation costs to one-tenth of their current level. The X-33 objective is to demonstrate technologies and operations concepts with the goal of reducing space transportation costs to one tenth of their current level. The X-33 program Phase II selection was made in July 1996 based on specific programmatic, business planning, and technical criteria. NASA selected the Lockheed Martin Skunk Works to lead an industry team to develop and flight test the X-33.

The X-33 is an integrated technology effort to flight-demonstrate key Single Stage To Orbit (SSTO) technologies, and deliver advancements in: 1) ground and flight operations techniques that will substantially reduce operations costs for an RLV ; 2) lighter, reusable cryogenic tanks; 3) lightweight, low-cost composite structures; 4) advanced Thermal Protection Systems to reduce maintenance; 5) propulsion and vehicle integration; and, 6) application of New Millennium microelectronics for vastly improved reliability and vehicle health management. X-33 will combine its results with the successes of the DC-XA, X-34 and complementary ground technology advances to reduce the technical risk of full-scale development of an operational RLV. The X-33 test vehicle will fly 13-15 times the speed of sound and will test the boundaries of current technology.

NASA is utilizing an innovative management strategy for the X-33 program, based on industry-led cooperative agreements. As a result of industry's leadership of the program, Government participants are acting as partners and subcontractors, performing only those tasks for which they offer the most effective means to accomplish the programÕs goals. The Government participants report costs and manpower to the industry team leader as would any other subcontractor. Every NASA center except the Goddard Space Flight Center has a negotiated role on the X-33 program. The Industry-led cooperative arrangement allows a much leaner management structure, lower program overhead costs and increased management efficiency

The X-33 program also funded refurbishment of rocket engine test stands at Stennis in FY 1997 ($2.3 million) and FY 1998 ($3.7 million) to enable testing of X-33 development and flight engines, as well as other future advanced space transportation engines. Civil Service estimates below are for the X-33 cooperative agreement only.

A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
COOPERATIVE AND TASK AGREEMENTS	560.7	239.1	111.6							911.4
OTHER X-33 ACTIVITIES	269.3	38.2								307.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	830.0	277.3	111.6							1218.9
(ESTIMATED CIVIL SERVICE FTEs)	(739)	(280)	(161)	(22)	(8)	(8)	(8)	(7)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	59.2	21.4	13.8	2.1	0.8	0.9	0.9	0.8		

Alternate Turbopump Development

Funding to begin development of an alternate design for the two turbopumps driving the Space Shuttle's Main Engine was initiated in FY 1987. The development of a new high-pressure oxygen turbopump and hydrogen fuel turbopump was undertaken to improve the safety, reliability, producibility, and maintainability of the current turbopumps. After an initial period of design and development, problems experienced in early development testing and accompanying increased costs resulted in suspension of the fuel turbopump's development, while development activities concentrated on the oxygen turbopump. Although further development problems were encountered with the oxygen turbopump, their successful resolution led to Congress agreeing in Spring 1994 to resumption of the fuel turbopump's development. The first flight of the oxygen turbopump occurred in 1995, and the initial flight of the fuel pump is currently planned for late 2000, rescheduled from late 1997 due to development problems. The budgetary estimate of $965.8 million includes not only the funding required for the design, development, and extensive testing of these two types of turbopumps, but also the funding needed to produce the flight turbopumps for installation into the main engines for the four-orbiter fleet.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	697.2	34.8	21.3	2.9	1.0					757.2
IMPLEMENTATION	143.3	22.1	20.0	18.8	4.4					208.6
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	840.5	56.9	41.3	21.7	5.4					965.8
(ESTIMATED CIVIL SERVICE FTEs)	(539)	(22)	(15)	(7)	(2)					
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	30.0	1.9	1.3	0.6	0.2					

Super Lightweight Tank

The objective of the Super LightWeight Tank (SLWT) is to provide the Space Shuttle with 7,500 pounds of additional performance of payload capability. The weight reduction objective was achieved by selectively substituting high-strength, low-density, aluminum-lithium alloys, redesigning certain structural components, and reducing thermal protection thickness. The new SLWT physically and functionally replaced the existing External Tank (ET) with no launch processing impacts and without detriment to the other Shuttle system elements. NASA was given congressional approval to proceed in January 1994. The External Tank Project Office at the Marshall Space Flight Center in Alabama manages the SLWT, and Lockheed Martin is the ET prime contractor. The first flight of the SLWT (STS-91) was on June 2, 1998. The aluminum-lithium material is a specialty metal produced to rigorous specifications and accordingly costs more than the aluminum used at present. The development cost estimate is slightly higher than the FY 1999 estimate, as an additional $0.9M in residual development work was required in FY 1999 and FY 1999.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT COST	126.7	1.1	0.5							128.3
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	126.7	1.1	0.5							128.3
(ESTIMATED CIVIL SERVICE FTEs)	(231)									
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	17.1									

Checkout and Launch Control System (CLCS)

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50%, and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground databus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the Orbiter Processing Facility were developed, the final applications for the Hypergolic Maintenance Facility, the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL), and hardware testing for SAIL. The Titan delivery will provide support for completion of development and the start of validation testing for application software used for Shuttle Orbiter power-up testing. The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch-related application software. The Delta and Saturn phases include completion of all launch application development, completion of software certification and validation, and a complete integrated flow demonstration. Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project. By the end of FY 2002, Operations Control Room-1 will be fully operational, followed by certification. The first Shuttle launch using the CLCS is scheduled for FY 2002 with full implementation to be completed one year later.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT COSTS	62.9	50.0	39.8	40.0	32.4	8.0				233.1
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	62.9	50.0	39.8	40.0	32.4	8.0				233.1
(ESTIMATED CIVIL SERVICE FTEs)	(154)	(113)	(125)	(125)	(101)	(40)				
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	12.3	9.5	11.2	11.5	9.7	4.0				

TDRS Replenishment Spacecraft Program

The Tracking and Data Relay Satellite (TDRS) Replenishment Spacecraft program ensures sufficient spacecraft will be available to continue Space Network operations into the next century. The program provides three additional TDRS satellites and ground terminal modifications through a fixed price, commercial practices contract with Hughes Space and Communications Company. This innovative approach has deleted or greatly reduced Government specifications and documentation requirements, allowing the contractor to substitute commercial practices; this has resulted in efficiencies in both cost and development lead time.

These satellites will incorporate Ka-band frequencies, where space research has a primary allocation, into the high data rate services provided via the high gain, single access antennas. The single access services at S-band and Ku-band will be retained, remaining backward compatible with the existing, first generation TDRS satellites. These satellites will also provide an enhanced multiple access service with data rates up to three megabits per second. The first spacecraft remains on schedule for launch in the third quarter of 1999.

The estimates do not include costs for use of government facilities and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification for the program within the Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
SPACECRAFT DEVELOPMENT AND GROUND TERMINAL MODIFICATIONS	412.9	66.7	17.7	14.5	57.7	6.5				576.0
LAUNCH SERVICES	76.7	30.2	14.0	40.5	67.8	37.0				266.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	489.6	96.9	31.7	55.0	125.5	43.5				842.2
(ESTIMATED CIVIL SERVICE FTEs)	(178)	(37)	(43)	(42)	(42)	(42)	(7)			
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	12.0	3.1	3.8	3.9	4.0	4.2	0.7			

Chandra X-ray Observatory

The Chandra X-ray Observatory (CXO, formerly the Advanced X-ray Astrophysics Facility, AXAF) is the third of NASA's Great Observatories, which include the Hubble Space Telescope and the Compton Gamma Ray Observatory. CXO observes matter at the extremes of temperature, density and energy content. With its unprecedented capabilities in energy coverage, spatial resolution, spectral resolution and sensitivity, CXO is providing unique and crucial information on the nature of objects ranging from nearby stars to quasars at the edge of the observable universe. The AXAF program was restructured in 1992 in response to decreasing future funding projections for NASA programs. The original baseline was an observatory with six mirror pairs, a 15-year mission in low-Earth orbit, and shuttle servicing. The restructuring produced AXAF-I, an observatory with four mirror pairs to be launched into a high-Earth orbit for a five-year lifetime, and AXAF-S, a smaller observatory flying an X-Ray Spectrometer (XRS). A panel from the National Academy of Sciences (NAS) endorsed the restructured AXAF program. The FY 1994 AXAF budget was reduced by Congress, resulting in termination of the AXAF-S mission. The Committees further directed that residual FY 1994 AXAF-S funds be applied towards development of a similar instrument for flight on the Japanese Astro-E mission. Astro-E is scheduled to be launched by Japan in February 2000. In December 1998 NASA announced that AXAF had been renamed the Chandra X-ray Observatory, in honor of the late Indian-American Nobel laureate, Subrahmanyan Chandrasekhar. CXO was launched successfully by the Space Shuttle and an Inertial Upper Stage on July 23, 1999.

The budgetary estimates provided below encompass: the early development of the mirror technology; the design and development phase; establishment of a mission-unique science center and preflight ground system development, followed by a five-year period (1999-2008) of mission operations and science data analysis; the purchase of the IUS and integration activities; the average cost (including recurring costs for improvements and upgrades) of an FY 1998 Space Shuttle flight; mission-unique tracking and data support costs; and, the construction of the X-Ray Calibration Facility. The estimates below also include a pro forma distribution of the average costs of a Space Shuttle. They do not include the amounts being contributed by international participants, or for the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
ADVANCED TECH DEVELOPMENT	54.2									54.2
DEVELOPMENT	1,469.7	42.0	4.1							
UPPER STAGE	73.9	3.3								77.2
MISSION OPERATIONS	169.9	11.0	5.2	3.6	3.7	3.8	3.7	3.3	15.2	219.4
DATA ANALYSIS		44.5	55.2	55.5	57.2	55.2	53.9	49.1	155.1	525.7
STS LAUNCH SUPPORT	268.0	114.9								382.9
TRACKING & DATA SUPPORT	1.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	3.0
CONSTRUCTION OF FACILITIES	17.7									17.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	2,054.9	215.9	64.7	59.3	61.1	59.2	57.8	52.6	170.4	1,280.1
(ESTIMATED CIVIL SERVICE FTEs) - SSE ONLY	(1,528)	(129)	(33)	(28)	(15)	(15)	(15)	(15)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	96.9	10.1	2.5	2.2	1.1	1.2	1.2	1.3		

Space Infrared Telescope Facility (SIRTF)

The purpose of the Space Infrared Telescope Facility (SIRTF) mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. SIRTF is the fourth of NASA's Great Observatories, which include the Hubble Space Telescope, the Compton Gamma Ray Observatory, and the Advanced X-Ray Astrophysics Facility. The funding plan provided below reflects a dramatic restructuring of the SIRTF design concept carried for many years. Rather than simpl "descoping" the "Great Observatory" concept to fit within a $400 million (FY94 $) cost ceiling imposed by NASA, scientists and engineers have instead redesigned SIRTF from the bottom-up. The goal was to substantially reduce costs associated with every element of SIRTF -- the telescope, instruments, spacecraft, ground system, mission operations, and project management. The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. SIRTF is planned for launch on a Delta launch vehicle during FY 2002.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out prior to FY 96. A more detailed exposition of the progra goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
ATD	79.9									79.9
DEVELOPMENT	70.2	119.7	123.4	117.6	25.6					456.5
MISSION OPS					4.4	7.0	7.3	7.4	23.2	49.3
DATA ANALYSIS					33.9	61.8	61.2	64.0	237.6	458.5
TRACKING & DATA SUPPORT					tbd	tbd	tbd	tbd	tbd	tbd
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	150.1	119.7	123.4	117.6	63.9	68.8	68.5	71.4	260.8	1044.2
(ESTIMATED CIVIL SERVICE FTEs)	(63)	(40)	(32)	(18)	(10)	(4)	(4)	(4)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		3.4	2.9	1.7	1.1	0.5	0.5	0.5		

Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)

The TIMED mission is the first science mission in the Solar Terrestrial Probes (STP) Program, and is part of NASA's initiative aimed at providing cost-efficient scientific investigation and more frequent access to space. TIMED is being developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the National Center for Atmospheric Research will provide instruments for the TIMED mission.

TIMED will be ready for launch in May 2000 aboard a Delta II launch vehicle co-manifested with JASON, an Earth Science mission. However, due to Jason's inability to meet the May launch date, the TIMED spacecraft is now scheduled for a fall 2000 launch. TIMED began its 36-month C/D development period in April 1997. The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from April 1996 to April 1997. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	81.6	41.8	21.4							144.8
MISSION OPERATIONS			0.7	2.0	1.0					3.7
DATA ANALYSIS			1.9	9.2	7.7	6.5	2.8	0.3		28.4
LAUNCH SUPPORT	13.1	11.5	6.1							30.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	94.7	53.3	30.1	11.2	8.7	6.5	2.8	0.3		207.6
(ESTIMATED CIVIL SERVICE FTEs)		(24)	(24)	(3)	(3)	(3)	(3)	(3)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		2.0	2.0	0.3	0.3	0.3	0.3	0.3		

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) was requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the Kuiper Airborne Observatory, which was retired in October, 1995. The SOFIA will be accommodated in a Boeing 747 and will feature a 2.5-meter infrared telescope to be provided by the German Space Agency (DARA). SOFIA will conduct scientific investigations at infrared and submillimeter wavelengths. The initial science flights for SOFIA was scheduled to occur in October 2001; however, delays in development of the German telescope assembly have caused science operations to slip until November 2002.

The budget estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the costs of preliminary design studies carried out in previous years, the amounts being contributed by the international participants, or costs for the use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	97.1	58.2	39.0	33.9	31.0					259.2
[CONSTRUCTION OF FACILITIES INCLUDED ABOVE]		[7.0]								
MISSION OPERATIONS						42.4	38.3	39.4	CONT.	CONT.
TOTAL EXCLUDING CIVIL SERVICE COSTS	97.1	58.2	39.0	33.9	31.0	42.4	38.3	39.4		
(ESTIMATED CIVIL SERVICE FTEs)		(75)	(78)	(60)	(48)	(40)	(40)	(40)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		5.1	7.0	5.7	5.2	4.8	5.0	5.3		

Relativity Mission/Gravity Probe-B

The development of the Relativity mission began in 1993, after many years of studying mission design alternatives and developing the advanced technologies required for this mission to verify Einstein's theory of general relativity. The award of the spacecraft development contract was made in 1994. The scheduled launch date is September 2001, using a Delta II launch vehicle. This launch date reflects an eleven-month slip from the original baseline date for launch of the Relativity Mission.

The estimates provided below include funding for the experiment development activities, a minimum of 16 months of mission operations, and the launch services. These estimates are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from FY 1985-87, but they do provide the amounts for the Shuttle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**BTC**	**TOTAL**
DEVELOPMENT	388.2	46.5	37.7	13.8						486.2
MISSION OPERATIONS				1.0	1.0	1.0				3.0
DATA ANALYSIS				8.0	5.2	3.1				16.3
LAUNCH SUPPORT	24.1	14.8	12.2							51.1
TRACKING & DATA SUPPORT						TBD				
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	412.3	61.3	49.9	22.8	6.2	4.1	0.0			556.6
(ESTIMATED CIVIL SERVICE FTEs)	(98)	(9)	(10)	(8)	(4)	(2)	(1)	(1)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	6.3	0.8	0.9	0.8	0.4	0.2	0.1	0.1		

The Explorer Program

The Explorer program consists of small to mid-sized spacecraft conducting investigations in all space physics and astrophysics disciplines. The program provides for frequent, relatively low-cost missions to be undertaken as funding availability permits within an essentially level overall funding profile for the program. The funding profile provided below covers the design and development phase, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	**FY 99**	**FY 00**	**FY 01**	**FY 02**	**FY 03**	**FY 04**	**FY 05**	**BTC**	**TOTAL**
*Far Ultraviolet Spectroscopy Explorer	143.9	20.2	13.4	14.4	12.0					203.9
*Imager for Magnetospause-to-Aurora Global Explorati	78.8	50.8	6.3	7.1	7.1	2.5	1.0	1.0		154.6
*Microwave Anisotropy Probe	48.5	39.4	32.4	19.5	3.7	2.6	0.7			146.8
*SWAS, TRACE, WIRE	211.9	14.8	5.0	5.5	2.8	2.4	1.0			243.4
*HESSI, GALEX, TWINS (New SMEX)	18.8	60.9	42.2	27.1	9.6	7.3	4.3	2.3	7.2	179.7
*STEDI (SNOE, TERRIERS, CATSAT, CHIPS & IMEX)	36.3	13.7	15.3	8.5	2.5	0.7				77.0
*HETE-II	9.2	11.1	4.7	1.5						26.5
*Planning & Future Developments		6.8	28.4	95.8	162.9	208.1	249.6	314.7	CONT	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		217.7	147.7	179.4	200.6	223.6	256.6	318.0	CONT	
(ESTIMATED CIVIL SERVICE FTEs)	(2,081)	(246)	(232)	(204)	(187)	(202)	(241)	(241)	CONT	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		22.7	21.7	19.8	19.1	21.3	26.4	27.5	CONT	

*Tracking estimate is not included

Far Ultraviolet Spectroscopic Explorer

Development of the Far Ultraviolet Spectroscopy Explorer (FUSE) began early in FY 1996. The FUSE mission is to conduct high-resolution spectroscopy in the far ultraviolet region. Major participants include the Johns Hopkins University, the University of Colorado, and University of California, Berkeley. Orbital Sciences Corporation was selected by JHU as the spacecraft developer. Canada provided the fine error sensor assembly, and France provided holographic gratings. GSFC provided management oversight of this Principal Investigator-managed mission. FUSE launched successfully in June 1999 aboard a Delta-II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	106.5	13.9								120.4
LAUNCH SUPPORT	37.1	0.7								37.8
MISSION OPERATIONS		3.3	6.0	5.0	3.2					17.5
DATA ANALYSIS	0.3	2.3	7.4	9.4	8.8					28.2
TOTAL	143.9	20.2	13.4	14.4	12.0					203.9

Imager for Magnetopause-to-Aurora Global Exploration

Development of the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) began in FY 1997. The IMAGE mission will use three-dimensional imaging techniques to study the global response of the Earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the Earth controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute has been selected to develop the IMAGE mission. IMAGE is scheduled for launch in February 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	58.7	25.8								84.5
LAUNCH SUPPORT	20.1	25.0	1.7							46.8
MISSION OPERATIONS			0.2	0.4	0.1					0.7
DATA ANALYSIS			4.4	6.7	7.0	2.5	1.0	1.0		22.6
TOTAL	78.8	50.8	6.3	7.1	7.1	2.5	1.0	1.0		154.6

Microwave Anisotropy Probe

Development of the Microwave Anisotropy Probe (MAP) began in FY 1997. The MAP mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the MAP instruments in cooperation with Princeton University. MAP will launch in November 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	40.9	18.3	17.7	10.4						87.3
LAUNCH SUPPORT	7.6	21.1	14.7	4.7						48.1
MISSION OPERATIONS				1.0	0.9	0.8				2.7
DATA ANALYSIS				3.4	2.8	1.8	0.7			8.7
TOTAL	48.5	39.4	32.4	19.5	3.7	2.6	0.7			146.8

Mars Surveyor Program

The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The first mission in this program, the Mars Global Surveyor mission, was approved as a new start in FY 1994. The follow-on Mars Surveyor 98 Climate Orbiter (MCO) and Polar Lander (MPL) were approved in FY 1995. In light of the failed MCO and MPL, the entire Mars Surveyor Program is undergoing major re-planning activity. Detail on the revised schedules and outputs will be provided once the re-planning is completed.

Funding also supports Mars Micromissions and Mars Telecom Network. Mars Micromissions will enhance the science return from Mars missions by utilizing micro-spacecraft launched as secondary payloads on commercial French Ariane-V geosynchronous transfer missions. Mars Telecom Network is designed to support Mars global reconnaissance, surface exploration, sample return missions, robotic outposts, and eventual human exploration by: 1) Developing a communications capability to provide a substantial increase in data rates and connectivity from Mars to Earth; (2) Developing an in-situ navigation capability to enable more precise targeting and location information on approach and at Mars.

Funding in the Future Missions budget line provides for Mars missions in the 2001 and beyond launch opportunities, and technologies required for these future Mars missions.

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
MARS GLOBAL SURVEYOR	207.5	13.0	15.6	9.5	9.1	4.2	2.8	2.2		263.9
98 MARS ORBITER/LANDER	262.8	27.2	5.6	10.4	7.3	3.5				316.8
MICROMISSION & TELECOM			6.0	35.0	33.0	87.0	146.0	137.0		
FUTURE MISSIONS (includes '01 and future Missions)	75.2	210.7	242.4	300.7	295.5	309.3	294.5	308.0	Cont.	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	545.5	251.0	269.6	355.6	344.9	404.0	443.3	447.2	Cont.	
(ESTIMATED CIVIL SERVICE FTEs)		(48)	(60)	(52)	(38)	(36)	(31)	(31)	Cont.	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		4.1	4.7	4.5	3.7	3.6	3.4	3.6	Cont.	

Mars Global Surveyor

This mission will obtain a majority of the expected science return from the lost Mars Observer mission by flying a science payload comprised of spare Mars Observer instruments aboard a small, industry-developed spacecraft. Launch occurred in November 1996 on a Delta II launch vehicle, and MGS entered Mars orbit in September 1997. The funding estimates provided below do not include the previous expenditures on spare Mars Observer instruments or the amount recovered from the prime contractor after the Mars Observer failure.

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	130.7									130.7
LAUNCH SUPPORT	52.6									52.6
MISSION OPERATIONS	17.9	6.0	11.2	4.7	3.2	3.2	1.8	1.5		49.5
DATA ANALYSIS	6.3	7.0	4.4	4.8	5.9	1.0	1.0	0.7		31.1
TOTAL	207.5	13.0	15.6	9.5	9.1	4.2	2.8	2.2		263.9

98 Mars Orbiter/Lander

The '98 Mars Orbiter and Lander consisted of the Mars Climate Orbiter (MCO) and the Mars Polar Lander (MPL). MCO was intended to study the planet's weather for one Martian year, acquiring data to help scientists better understand the Martian climate. The MPL was to focus primarily on Mars' climate and water. The MPL mission would search for near-surface ice and possible surface records of cyclic climate change, and characterize physical processes key to the seasonal cycles of water, carbon dioxide and dust on Mars. MCO launched in December 1998 and MPL launched in January 1999; however, both missions failed upon arrival at Mars.

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	179.8	9.2								189.0
LAUNCH SUPPORT	83.0	7.7								90.7
MISSION OPERATIONS		9.4	3.6	8.9	6.4	3.5				31.8
DATA ANALYSIS		0.7	1.6	1.2	0.9					4.4
TRACKING & DATA SUPPORT		0.2	0.4	0.3						0.9
TOTAL	262.8	27.2	5.6	10.4	7.3	3.5				316.8

Future Surveyor Missions

The Mars Surveyor landers planned in future years -- 2001, 2003, 2005 and beyond -- will capitalize on the experience of the Mars Pathfinder lander mission launched in November 1996.

In light of the failed MCO and MPL, the entire Mars Surveyor Program is undergoing major re-planning activity. Detail on the revised schedules and outputs will be provided once the re-planning is completed.

(Budget Authority in Millions of Dollars)

	PRIOR	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	BTC	TOTAL
DEVELOPMENT	75.2	169.0	222.7	248.1	245.4	264.6	266.1	277.7	cont.	
LAUNCH SUPPORT		41.7	19.7	43.6	35.1	22.4			cont.	
MISSION OPERATIONS				8.0	11.8	19.9	20.4	17.2	cont.	
DATA ANALYSIS				1.0	3.2	2.4	8.0	13.1	cont.	
TRACKING & DATA SUPPORT										
TOTAL	75.2	210.7	242.4	300.7	295.5	309.3	294.5	308.0		

Discovery Missions

Discovery missions are planetary exploration missions designed with focused science objectives that can be met with limited resources. Total development costs are not to exceed $150 million in constant FY 1992 dollars, and development schedules are limited to three years or less.

The budgetary estimates provided below are the amounts included in the specific budget justification for this program within the Space Science section in the Science, Aeronautics and Technology appropriation. Under the specific mission descriptions, see below, other direct program cost elements are included: the development of the spacecraft and experiments, one year of mission operations, the launch services, and unique tracking and data acquisition services. They do not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**BTC**	**TOTAL**
NEAR	187.7	14.5	13.2	8.2						223.6
LUNAR PROSPECTOR	61.7	2.2								63.9
STARDUST	145.9	24.8	4.3	4.0	3.7	5.0	6.2	9.0	2.6	205.5
GENESIS	44.4	82.9	50.2	18.0	6.9	7.4	2.8	2.1	1.8	216.5
CONTOUR	0.4	8.8	51.8	45.6	21.1	3.7	3.0	1.8	8.1	144.3
FUTURE MISSIONS		28.7	86.7	163.5	225.8	223.3	263.4	283.1	CONT	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		161.9	206.2	239.3	257.5	239.4	275.4	296.0		
(ESTIMATED CIVIL SERVICE FTEs)		(20)	(19)	(17)	(17)	(16)	(16)	(16)	Cont.	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		2.3	2.0	1.9	2.0	1.8	1.9	2.2	Cont.	

Near-Earth Asteroid Rendezvous (NEAR)

The NEAR was approved as a new start in FY 1994 as one of the initial Discovery Program missions. The NEAR mission was conducted as an in-house effort at the Applied Physics Laboratory, with many subcontracted subsystems. The NEAR spacecraft will conduct a comprehensive study of the near-Earth asteroid 433 Eros, including its physical and geological properties and its chemical and mineralogical composition. The NEAR spacecraft was launched February 17,1996 on a Delta II launch vehicle. The original opportunity to rendezvous with the asteroid in January 1999 was lost when the spacecraft failed to fire its main engine properly. However, subsequent firing was successful, and NEAR will rendezvous with Eros in February 2000.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	124.9									124.9
LAUNCH SUPPORT	43.5									43.5
MISSION OPERATIONS	10.9	8.4	6.6	5.0						30.9
DATA ANALYSIS	8.1	5.9	6.4	3.0						23.4
TRACKING & DATA SUPPORT	0.3	0.2	0.2	0.2						0.9
TOTAL	187.7	14.5	13.2	8.2						223.6
(ESTIMATED CIVIL SERVICE FTEs)		(4)	(4)							
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		0.8	0.5							

Lunar Prospector

Lunar Prospector was selected as the third Discovery mission in FY 1995, and Phase C/D development started in the first quarter of FY 1996. The mission was designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. Ames Research Center managed the mission, and Lockheed Martin provided the spacecraft, instruments, launch and operations. Launch on a Lockheed Launch Vehicle-II (LLV-II) occurred in January 1998, and the mission has been completed successfully. Launch costs are included in the development cost.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	56.6									56.6
MISSION OPERATIONS	1.8	0.5								2.3
DATA ANALYSIS	3.3	1.7								5.0
TOTAL	61.7	2.2								63.9

Stardust

The Stardust mission was selected as the fourth Discovery mission in November 1995, with mission management from the Jet Propulsion Laboratory. The mission team completed the Phase B analysis, and Stardust was approved for implementation in October 1996. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to Earth for detailed analysis. The mission will also gather and return samples of interstellar dust that the spacecraft encounters during its trip through the Solar System to fly by the comet. Stardust is using a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, the spacecraft carries three additional scientific instruments. An optical camera will return images of the comet; the Cometary and Interstellar Dust Analyzer (CIDA) was provided by Germany to perform basic compositional analysis of the samples while in flight; and a dust flux monitor will be used to sense particle impacts on the spacecraft. Stardust was launched on the Med-Lite expendable launch vehicle in February 1999, and is operating well. Return of the samples to Earth is expected in January 2006.

(Budget Authority in Millions of Dollars)

	PRIOR	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**BTC**	**TOTAL**
PHASE A/B	9.6									9.6
DEVELOPMENT	108.0	8.8								116.8
LAUNCH SUPPORT	28.3	12.5								40.8
MISSION OPERATIONS		1.0	1.0	1.0	1.0	1.2	1.2	1.3	1.0	8.7
DATA ANALYSIS		2.5	3.3	3.0	2.7	3.8	5.0	7.7	1.6	29.6
TOTAL	145.9	24.8	4.3	4.0	3.7	5.0	6.2	9.0	2.6	205.5

Genesis

In October 1997 NASA selected Genesis as the fifth Discovery mission. The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. It is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA; JPL will provide the payload and project management, while the spacecraft will be provided by Lockheed Martin Astronautics of Denver, CO. Due for launch in January 2001, it will return the samples of isotopes (oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert in August 2003. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
PHASE A/B	11.4									11.4
DEVELOPMENT	33.0	65.1	33.2	7.3						138.6
LAUNCH SUPPORT		17.8	17.0							34.8
MISSION OPS				2.0	1.2	1.4				4.6
DATA ANALYSIS				8.2	5.2	5.5	2.8	2.1	1.8	25.6
TRACKING & DATA SUPPORT				0.5	0.5	0.5				1.5
TOTAL	44.4	82.9	50.2	18.0	6.9	7.4	2.8	2.1	1.8	216.5
(ESTIMATED CIVIL SERVICE FTEs)		(5)	(4)	(4)	(4)	(4)	(4)	(4)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		0.5	0.4	0.4	0.4	0.5	0.5	0.5		

Comet Nucleus Tour (CONTOUR)

In October 1997 NASA selected CONTOUR as the sixth Discovery mission. CONTOUR's goals are to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. The spacecraft will leave Earth orbit, but stay relatively near Earth while intercepting at least three comets. The targets span the range from a very evolved comet (Encke) to a future "new" comet such as Hale-Bopp. CONTOUR builds on the exploratory results from the Halley flybys, and will extend the applicability of data obtained by NASA's Stardust and ESA's Rosetta to broaden our understanding of comets. The Principal Investigator is J. Veverka of Cornell University; the spacecraft and project management will be provided by the Johns Hopkins University Applied Physics Laboratory of Laurel, MD. Launch is expected in June 2002.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
PHASE A/B	0.4	8.8								9.2
DEVELOPMENT			34.9	26.0	8.2					69.2
LAUNCH SUPPORT			16.9	19.6	10.8					47.2
MISSION OPS					1.0	1.0	1.0	1.0	2.0	6.0
DATA ANALYSIS					1.1	2.7	2.0	0.8	6.1	12.7
TRACKING & DATA SUPPORT					TBD	TBD	TBD	TBD	TBD	TBD
TOTAL	0.4	8.8	51.8	45.6	21.1	3.7	3.0	1.8	8.1	144.3
(ESTIMATED CIVIL SERVICE FTEs)		(4)	(4)	(6)	(6)	(5)	(5)	(5)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		0.3	0.4	0.6	0.6	0.5	0.6	0.6		

Space Science Flight Validation Spacecraft

The Flight Validation (formerly called New Millennium) program is an advanced development effort started in FY 1996 to demonstrate how complex scientific spacecraft can be built for lower mission costs and have short development times, while still possessing considerable scientific merit. The Flight Validation program will enable the introduction of the latest technology advances into spacecraft for Space Science missions. The primary objectives of the program are to increase the performance capabilities of spacecraft and instruments while simultaneously reducing total costs of future science missions, thereby allowing more frequent flight opportunities even under tight budget constraints. In previous years, NASA and the Department of Defense have funded technology developments offering extraordinary promise, and the goal of this program is to move those technologies from the laboratory to space.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program to include development and launch of two small ($40-50 million each) and one medium ($100-150 million) system validations every four years along with two-to-three subsystem validations per year ($100-150 million). Launches are generally targeted for small expendable launch vehicles. The budget estimate below does not include the costs for the government facilities and general and administrative support used to carry out the research and development activities. Additional information on the Deep Space 1, Deep Space 2 and Space Technology 5 missions is provided later in this section. A more detailed description of the program goals, objectives and activities is provided in the budget justification narrative for the Space Science Supporting Research and Technology program.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEEP SPACE 1	140.9	13.8	4.9	5.8	0.6					166.0
DEEP SPACE 2	26.5	2.4	0.8							29.7
SPACE TECHNOLOGY 5		6.0	3.1	8.0	6.0	4.0	1.5			28.6
FUTURE MISSIONS INCLUDING PROGRAM COSTS	27.2	10.0	7.0	30.0	38.8	60.9	79.6	83.0	CONT	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		32.2	15.8	43.8	45.4	64.9	81.1	83.0	CONT	
(ESTIMATED CIVIL SERVICE FTEs)	(322)	(8)	(1)	(1)	(1)	(1)	(1)	(1)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	4.1	0.7	0.1	0.1	0.1	0.1	0.1	0.1		

Deep Space 1

Deep Space 1 was selected in FY 1996 as the first New Millennium Program mission. DS 1 launched in October, 1998 on a Med-Lite-class Delta launch vehicle. All technologies completed their validation by the end of FY 1999 and included solar electric propulsion, an advanced solar array, autonomous primary navigation, and a miniature imaging camera spectrometer. Given the opportunity to explore further, the DS 1 mission has been extended to validate twelve advanced technologies via an asteroid flyby and comet flyby. The supplemental technology development line below contains funding for crosscutting technology development efforts previously managed by the Office of Space Access and Technology.

(Budget Authority in Millions of Dollars)

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	95.2	4.1								99.3
SUPPLEMENTAL TECH DEV (included in Dev)	[14.9]									[14.9]
MISSION OPERATIONS		8.1	3.0	4.2						15.3
DATA ANALYSIS		1.5	1.9	1.6	0.6					5.6
LAUNCH SUPPORT	45.4									45.4
TRACKING & DATA SUPPORT	0.3	0.1								0.4
TOTAL	140.9	13.8	4.9	5.8	0.6	0.0	0.0	0.0	0.0	166.0

Deep Space 2

Deep Space 2 was selected in FY 1996 to develop and validate technologies and systems required to deliver multiple small packages to the surface and/or subsurface of Mars using direct entry. Technologies to be validated included power electronics, a microcontroller, flexible interconnects for system cabling and a sample/water experiment. DS 2 was attached to ("piggyback" on) the Mars 98 Lander, launched in January 1999. The probes were to have impacted Martian soil on December 3, 1999 but each failed to respond to communication efforts by NASA engineers.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2001	2003	2004	2005	BTC	TOTAL
DEVELOPMENT	26.2	1.4								27.6
SUPPLEMENTAL TECH DEV (included in Dev)	[3.3]									[3.3]
MISSION OPERATIONS		0.5	0.4							0.9
DATA ANALYSIS	0.3	0.5	0.4							1.2
ELV INTEGRATION (included in Dev)	[1.6]									[1.6]
TOTAL	26.5	2.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	29.7

Space Technlogy 5

Three very small satellites called the Nanosat Constellation Trailblazer mission were selected in August 1999 as Space Technology 5. Each Trailblazer spacecraft is about the size of a large birthday cake, they weigh about as much as a desktop computer and are smart enough to fly in formation far from Earth as they test new technologies. The mission will validate methods of operating several spacecraft as a system and test eight technologies in the harsh space environment near the boundary of Earth's protective magnetic field, or magnetosphere. The mission will be launched in 2003 as a secondary payload on an expendable launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	BTC	TOTAL
DEVELOPMENT		6.0	3.1	8.0	6.0	3.2				26.3
MISSION OPERATIONS						0.5	0.2			0.7
DATA ANALYSIS						0.3	1.3			1.6
LAUNCH SUPPORT										
TOTAL		6.0	3.1	8.0	6.0	4.0	1.5	0.0	0.0	28.6

Earth Observing System

Before the Earth Observing System (EOS) was authorized in November 1990 in the FY 1991 budget as a new start, EOS planning had been in progress for over eight years. The EOS is key to achieving the objectives set forth in the Earth science program plan and the overall goal and scientific objectives of the interagency U.S. Global Change Research Program. EOS is an international science program, drawing upon the contributions of Europe (ESA), Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing comprehensive measurements of the nature of global climate change.

At its outset, the EOS program was based on the flights of two series of large platforms, in addition to platforms from Japan and ESA and instruments carried on Space Station Freedom. The initial estimates provided to Congress focused on the period through fiscal year 2000. The initial estimate of $18-21 billion included development, mission operations, data analysis, launch services, communications, construction of facilities and the amounts carried in the Space Station program for the polar platform's development. In the FY 1992 appropriations process, Congress directed NASA to modify the scope and cost of the program. The cost through FY 2000 was to be reduced by $5 billion, the FY 1993 funding level had to be reduced, and NASA was to examine the feasibility of using smaller platforms. In 1991, the program was restructured to employ five smaller flight series. In 1992, in response to the constrained budget environment, NASA further rescoped the program by implementing a common spacecraft approach for all flights after the first morning (AM-1) spacecraft, increasing reliance on the cooperative efforts of international and other government agencies, and adopting a build-to-cost approach for the first unit of a multiple instrument build. The estimated NASA funding through FY 2000 was further reduced to $8.0 billion in this effort.

In the FY 1995 budget process, the program cost estimate was further adjusted downward by approximately $0.9 billion, of which $0.3 billion reflected an accounting transfer for small business innovative research out of individual programs into a common NASA account, and $0.1 billion reflected the change to lower-cost launch vehicles. The further reductions in program funding were addressed in 1994 through a program rebaselining activity. A number of small spacecraft were introduced into the program flight plans. In addition, alterations were made in flight phasing and accommodations were provided for a follow-on instrument to the enhanced thematic mapper being flown in 1999 on Landsat-7. Funding for the science investigations and data analysis was separated from the algorithms being developed to convert the instrument data into information. This change recognized the close relationship to similar science investigations and data analysis funded in the Earth Science research and analysis account. (The amounts budgeted for EOS science are shown in the table below.) In addition, it was decided to incorporate the development funding for the Landsat-7 into the EOS program in light of the integral ties between the two activities.

In the FY 1996 budget process, the amounts reflected the related program costs for Landsat-7 activities previously funded by the Department of Defense.

The 1997 Biennial Review completed the shift in planning for future missions that began in the 1995 “reshaping” exercise. Emerging science questions drive measurement requirements, which drive technology investments in advance of instrument selection and mission design. Mission design includes such options as purchase of science data from commercial systems and partnerships with other Federal agencies and international agencies. The result is a more flexible and less expensive, approach to acquiring Earth science data.

The ESE recognizes that the pathways of global change research lead from specialized studies of fundamental processes to the integration of individual findings into interactive models of the global Earth system, which can eventually deliver reliable predictions of natural or human-induced environmental phenomena. Long, consistent time-series of global environmental measurements are needed to document changes in forcing parameters and corresponding variations in the state of the Earth system, as required to explore the range of natural variability and test mathematical models of the phenomena. While diagnostic studies based long time series of global measurements can reveal the nature of the underlying mechanisms, focused process studies are indispensable to identify and model the basic physical, chemical and biological processes involved. Understanding these component processes is crucial in order to achieve the goal of constructing reliable predictive models of the Earth system. For this reason, the ESE aims to achieve a proper balance between long-term systematic measurements of key forcing or response parameters, and specialized process research. NASA ESE is in the process of developing a science implementation plan, which will drive the selection of the EOS follow-on missions.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation except for the amount for the Space Station platform. The amounts below reflect the effects of the rescoping of the EOS program, the impacts of the ZBR, and the inclusion of the estimate for FY 2005. They do not include the costs of the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

Earth Observing System	Prior	1999	2000	2001	Subtotal Through FY 2000	2002	2003	2004	2005	Total Through FY 2004
MORNING (Terra)	1,176.6	36.0	6.2	3.1	1,221.9					1,221.9
AFTERNOON (Aqua)	630.3	113.1	92.8	42.9	879.1					879.1
CHEMISTRY	206.1	132.8	124.7	110.3	573.9	69.1	26.2	0.1		669.3
SPECIAL SPACECRAFT	372.3	116.0	120.4	86.7	695.4	32.2	15.8	13.8	13.5	770.7
QUIKSCAT	72.9	11.4	1.1		85.4					85.4
LANDSAT 7	422.3	17.0	9.6	1.4	450.3	1.7	1.7	1.9		455.6
EOS FOLLOW-ON	3.9	4.5	24.4	120.6	153.4	203.3	268.5	228.7	203.0	1,056.9
ALGORITHM DEVELOPMENT	436.2	116.8	121.7	82.1	756.8	70.4	56.9	53.9	52.6	990.6
TECHNOLOGY INFUSION *	168.5	89.0	74.5	89.1	421.1	74.2	53.4	93.3	115.8	757.8
EOSDIS	1,345.1	261.7	261.9	252.0	2,120.7	249.2	255.2	282.1	266.3	3,173.5
SUBTOTAL	4,834.2	898.3	837.3	788.2	7,358.0	700.1	677.7	673.8	651.2	10,060.8
PHASE B	41.0				41.0					41.0
SPACE STATION PLATFORM	104.0				104.0					104.0
EOS SCIENCE		46.4	60.3	59.2	165.9	65.6	66.0	66.9	69.5	433.9
LAUNCH SERVICES	278.0	4.2			282.2					282.2
CONSTRUCTION OF FACILITIES	96.7				96.7					96.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	5,353.9	948.9	897.6	847.4	8,047.8	765.7	743.7	740.7	720.7	11,018.6
(ESTIMATED CIVIL SERVICE FTEs)	(3,616)	(610)	(608)	(689)		(720)	(716)	(741)	(741)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	250.8	51.9	54.1	63.4		70.2	73.2	79.4	83.2	

* In FY 01 Submit, Technology Infusion moved to R&T.

EOS New Millennium Program and Technology Infusion

The New Millennium Program (NMP) and Technology Infusion budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs. The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the government, private industries and universities. The first mission EO-1, has been selected to demonstrate innovative technology to produce Landsat data. The Space-Readiness Coherent Lidar Experiment (Sparcle) was the second EO mission. The project was terminated due to cost growth. However, the progress in the lidar technology development is still useful for future remote systems.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	TOTAL
EO-1 (INCLUDES LAUNCH SERVICES)	115.3	47.3	3.0	2.4					168.0
EO-2 SPARCLE (STS ATTACHED PAYLOAD)	7.3	4.1							11.4
NMP TECHNOLOGY & FUTURE FLIGHTS (INCLUDES LAUNCH SERVICES)	17.5	4.7	34.1	47.7	35.8	13.1	53.0	75.5	281.4
ADV. INFORMATION SYSTEMS TECH.		6.5	12.6	14.0	9.5	9.8	9.8	9.8	72.0
SENSOR & DETECTOR TECHNOLOGY	16.5	5.5	9.8	10.0	8.9	8.5	8.5	8.5	76.2
INSTRUMENT INCUBATOR	11.9	20.9	15.0	15.0	20.0	22.0	22.0	22.0	148.8
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	168.5	89.0	74.5	89.1	74.2	53.4	93.3	115.8	757.8
(ESTIMATED CIVIL SERVICE FTEs)	(126)	(98)	(15)						
CIVIL SERVICE COMPENSATION ESTIMATE	9.9	8.0	1.4						

Earth Probes

The Earth Probes program is the component of Earth Science that addresses unique, specific, highly focused mission requirements in Earth science research. The program is designed to have the flexibility to take advantage of unique opportunities presented by international cooperative efforts, small satellites and advanced technical innovation. Earth Probes complement the Earth Observing System by enabling investigations needing special orbits or other unique requirements. The missions are developed using short cycles of 1-3 years. The currently approved Earth Probes are the Total Ozone Mapping Spectrometer (TOMS), Triana, and Earth System Science Pathfinders (ESSP) missions. NASA has added the University Class Earth System Science (UnESS) pathfinder to the Earth Probes program. The Experiments of Opportunity funding will accommodate opportunities to provide flight instruments and technologies on non-Earth science missions, foreign or domestic, or on airborne experiments. The Lewis and Clark missions were transferred from the Office of Space Access and Technology when that office was dissolved. The LightSAR was cancelled in FY 1999; however, SAR studies will continue under the Technology Infusion Program. The SRTM is a reimbursable mission with the National Imaging and Mapping Agency (NIMA). In FY 2000 NASA has requested funding for costs associated with SRTM cost growth.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program. The budget estimates immediately below do not include the estimated costs incurred by the international collaborators, mission operations, science costs, related funding included in the Earth Observing System program, use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	TOTAL
TOTAL OZONE MAPPING SPECTROMETER (TOMS)	117.4	9.9	24.8	0.5					152.6
NASA SCATTEROMETER (NSCAT)	210.0								210.0
TROPICAL RAINFALL MEASURING MISSION (TRMM)	246.0								246.0
TRIANA	0.9	35.0	35.1	2.0	2.0				75.0
LEWIS & CLARK	130.4								130.4
(UNESS)			2.0	11.5	12.0	19.5	14.5	20.7	Continues
EARTH SYSTEM SCIENCE PATHFINDERS	37.8	62.3	94.5	105.9	125.6	120.7	108.2	121.6	Continues
LIGHTSAR/SAR DEVELOPMENT	12.0								12.0
EXPERIMENTS OF OPPORTUNITY	2.9	2.1	1.0	0.5	0.5	0.4	0.5	0.5	Continues
SRTM			6.2						6.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	757.4	109.3	157.4	120.4	140.1	140.6	123.2	142.8	
(ESTIMATED CIVIL SERVICE FTEs)	(905)	(110)	(121)	(73)	(54)	(55)	(52)	(51)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	61.6	9.3	10.8	6.8	5.4	5.7	5.7	5.8	

Total Ozone Mapping Spectrometer

The TOMS Earth Probes project is a follow-on to the Total Ozone Mapping Spectrometer (TOMS) instrument flown with such great success on the Nimbus-7 spacecraft in 1978. A TOMS instrument was also flown on the Russian METEOR spacecraft in 1991. The TOMS program consists of a set of instruments (flight models 3, 4, 5) and one small spacecraft. Flight model 3 was launched on the TOMS Earth probe spacecraft on July 2, 1996. Flight model 4 was launched on the Japanese ADEOS spacecraft on August 17, 1996. The ADEOS-I spacecraft failed on June 30, 1997. Flight model 5 has been completed, and was scheduled to fly as a cooperative mission with Russia in late 2000. However, Russia has indicated that it cannot meet that launch date. Presently, the Agency has completed its re-planning and will fly FM-5, as QuikToms, on a U.S. vehicle and spacecraft in August 2000.

(Budget Authority in Millions of Dollars)

	PRIOR	1999	2000	2001	2002	2003	2004	2005	TOTAL
DEVELOPMENT	117.4	9.9	24.8	0.5					152.6
MISSION OPERATIONS		2.7	3.2	4.4	2.7	2.7			15.7
SCIENCE TEAMS		0.9	1.0	1.1	1.1	1.0	1.1	1.1	7.3
SELV	16.7								16.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	134.1	13.5	29.0	6.0	3.8	3.7	1.1	1.1	192.3
(ESTIMATED CIVIL SERVICE FTEs)	(149)	(10)	(10)	(7)	(5)	(6)	(4)	(4)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	10.0	0.9	0.9	0.6	0.6	0.6	0.4	0.5	

Tropical Rainfall Measuring Mission

The Tropical Rainfall Measuring Mission (TRMM) was launched aboard the Japanese H-II vehicle November 27, 1997. The TRMM development began in FY 1992, after a four-year period of concept studies and preliminary mission definition. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. TRMM data will be useful to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but whose effects are felt globally. The observatory spacecraft was built in-house at the Goddard Space Flight Center. The Japanese built a critical instrument, the Precipitation Radar. Two other instruments are being developed with TRMM program funding, the Visible and Infrared Scanner and TRMM Microwave Imager. In 1992, two EOS-funded instruments were added to the payload, the Clouds and Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS). The budget estimates provided below include the costs of accommodating these two instruments on the TRMM observatory. The EOS Data and Information System will have a specific capability for disseminating TRMM data.

(Budget Authority in Millions of Dollars)

									TOTAL
DEVELOPMENT	246.0								246.0
EOS-FUNDED INSTRUMENTS/SCIENCE/DIS	[59.0]	[12.6]							[71.6]
MISSION OPERATIONS		10.9	11.0	9.7	2.2				33.8
SCIENCE TEAMS		14.3	14.4	19.4	8.8	0.6			57.5
RESEARCH & ANALYSIS-FUNDED SCIENCE	35.4								35.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	281.4	25.2	25.4	29.1	11.0	0.6			372.7
(ESTIMATED CIVIL SERVICE FTEs)	(706)	(22)	(22)	(20)	(17)	(6)	(6)	(6)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	47.5	2.7	2.3	2.3	2.0	0.9	0.8	0.8	

International Space Station

In FY 1983, NASA received approval to enter into a preliminary definition phase of a space station. A cost target was established at that time by President Reagan; this target provided guidance to the team undertaking the definition of what capabilities a space station could have for this amount of money. Due to the uncertainty of future inflation, the target was expressed in constant 1984 dollars. The target value of $8 billion was intended to cover the costs which would be incurred to perform the preliminary definition and the development of space station hardware and ground systems. The President also directed NASA to solicit the involvement of international parties in the space station.

After three years studying numerous design concepts, a final reference design was established by NASA and our international partners--Japan, Canada, and the member nations of the European Space Agency. Prior to requesting from the Administration and Congress the authority to proceed into the development phase, NASA undertook a comprehensive cost estimate. The resultant estimate of $14.5 billion (expressed in 1984 dollars for comparison purposes) was presented to the Administration in early 1987. After consideration, the Administration directed a National Research Council (NRC) review of the reference design and the cost estimate. The NRC reported back that the space station could be built in two phases, with the second phase adding the dual keel configuration, the co-orbiting platform, servicing capabilities, and additional solar dynamic power modules. The NRC included in its estimate of $21.0-25.0 billion (1984 dollars), a number of additional cost elements: operations, marginal Shuttle flight costs, a crew rescue vehicle, civil service salaries and expenses, facilities, and provision for additional testing and backup hardware. These estimates were furnished to the Congress in mid-1987 for their review prior to action on NASA's FY 1988 appropriation.

Over each ensuing year, Congress approved continuation of the Space Station Freedom program, but reduced each year's appropriations request. On several occasions, Congress directed NASA to redesign the Station to conform not only to the reduced appropriations request in that year but also to reduced projections of future funding availability for NASA's overall budget. In early 1993, President Clinton directed NASA to undertake a 90 day study of lower cost redesign options for the Space Station, and appointed an Advisory Committee on the Redesign of the Space Station. In June 1993, upon receiving the final reports and the Advisory Committee's recommendations, President Clinton selected an option (A) from the three options presented and directed NASA to execute the Space Station program for no greater than $2.1 billion per year. This figure encompassed not only the development and operational costs of the Space Station itself but also the costs for a program of precursor scientific research, the expenses for integrating the Space Shuttle and the Space Station and the development of experimental facilities and capabilities for the Space Station. The cap excluded the costs of civil service salaries and expenses, Space Shuttle operational flight costs, and performance improvements to the Shuttle.

In the Fall of 1993, with the U.S. playing the lead role, the international partnership invited the Russian Government to become a participant in the program. The Russians offered access to their Mir space station in the interim period between 1995 and the beginning of the international Space Station's assembly. The Congress and Administration agreed in late 1993 that the $100 million amount to be paid annually to the Russian Space Agency for hardware and services over the FY 1994-97 period was outside the $2.1 billion annual cap. Since late 1993, the U.S. and the newly expanded set of international partners have proceeded with the final design and hardware development for an international Space Station with significantly greater capabilities for research than those which would have been provided on Space Station Freedom, or the option selected in the redesign process.

The budgetary estimates provided below include the amounts for this program in several appropriation accounts. Previous budgets provided funding for Space Station in the Human Space Flight appropriation, and through FY 1997, related research and payloads were funded in the Science, Aeronautics and Technology appropriation. In the FY 1998 budget NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the program budget. The FY 2001 budget continues to reflect that consolidation by funding the total program budget in the International Space Station appropriation account. An estimate for an X-38-based crew return of the total content of the program budget. The FY 2001 budget continues to reflect that consolidation by funding the total program budget in the International Space Station appropriation account. An estimate for an X-38-based crew return vehicle (CRV) is included, with planned funding beginning in FY 2000. Phase 1 of that development is funded within the ISS budget. Phase 2 funding is provided within Aero-Space Technology programs, in the Science, Aeronautics and Technology (SAT) appropriation account, pending a decision on whether to proceed with an X-38-based crew return vehicle, in the context of broader decisions that NASA and the Administration will make regarding future space transportation architectures. Also included in the Space Station project cost estimate is Russian Program Assurance, funding implementation of contingency plans associated with mitigating past, and potential, shortfalls in Russian contributions. The FY 2001 budget proposes multi-year appropriations for the development of the Space Station.

The totals provide the current estimate for the costs to be incurred through the end of FY 2005. A comparison is also included to display annual funding changes from the FY 2000 budget estimate. The estimates do not include the amounts being contributed by the international partners, the $400 million contract with the Russian Space Agency, the costs of the non-program unique NASA facilities, Shuttle performance improvements and flight operations costs, and the general and administrative support used to execute the program. Additionally, the program is planned to achieve an average annual cost target of $1.3 billion when the Space Station becomes operationally mature.

The cost of Space Shuttle flights can be stated in two ways: marginal and annual average. The marginal cost of a given Shuttle flight ranges from $60 million to about $85 million, reflecting the reusable characteristics of the Space Shuttle. The annual average cost of an FY 2001 Shuttle flight is approximately $453 million. Using the annual average costs of the 30 Space Shuttle flights planned for the assembly sequence the present cost estimate for Space Station is approximately $13 billion, including flights for partner elements. An additional 7 Shuttle flights are planned for research and technology utilization purposes during the assembly period; at annual average costs, these utilization flights are estimated at $3 billion. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the budget justifications for the Space Station.

International Space Station *

(Budget Authority in Millions of Dollars)

	PRIOR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	TOTAL *
PROGRAM ELEMENTS		2,104.7	2,112.9	2,143.6	2,348.6	2,441.3	2,299.7	2,323.1	2,114.5	1,953.5	1,642.5	1,557.0	1,525.0	24,566.4
HUMAN SPACE FLIGHT **	10,234.1	2,104.7	2,112.9	2,143.6	2,348.6	2,441.3	2,299.7	2,323.1	2,114.5	1,858.5	1,452.5	1,327.0	1,275.0	34,035.5
INTERNATIONAL SPACE STATION	10,234.1	2,104.7	2,112.9	2,143.6	2,348.6	2,441.3	2,299.7	2,323.1	2,114.5	1,858.5	1,452.5	1,327.0	1,275.0	34,035.5
VEHICLE	8,234.1	1,765.9	1,559.4	1,618.8	1,694.2	1,604.8	1,183.9	890.1	442.6	345.7	94.7	37.1		19,471.3
OPERATIONS CAPABILITY	956.3	151.0	298.9	247.4	258.3	500.2	576.3	784.6	851.5	786.2	777.7	728.1	722.7	7,639.2
RESEARCH	121.0	187.8	254.6	277.4	196.1	226.3	336.5	394.4	455.4	451.6	535.7	540.8	552.3	4,529.9
RUSSIAN PROGRAM ASSURANCE					200.0	110.0	203.0	200.0	300.0	200.0	44.4	21.0		1,278.4
CREW RETURN VEHICLE								75.0	90.0	75.0				240.0
OTHER	922.7							(21.0)	(25.0)					876.7
SCIENCE, AERO & TECH ***									-	95.0	190.0	230.0	250.0	765.0
(ESTIMATED CIVIL SERVICE FTEs)		(1,283)	(1,441)	(1,934)	(1,852)	(2,204)	(2,136)	(2,385)	(2,328)	(2,294)	(2,148)	(2,035)	(1,915)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M) ****		85.9	102.6	139.6	144.1	180.5	177.6	205.6	204.4	201.0	191.8	197.7	197.0	

* Estimate total is through FY 2005 and reflects the Administration's FY 2001 budget request for International Space Station Multi-Year Appropriations

** The amounts shown have been restated to include the funds appropriated in FY 1997 and prior years to the Science, Aeronautics and Technology, Construction of Facilities, and Research and Development appropriations.

*** Funded in Aero-Space Technology programs for crew return capability, pending decision to implement an X-38-based vehicle, in the context of broader decisions on space transportation architectures; estimate does not assume alternate access to the ISS

**** Civil Service FTEs estimates for the International Space Station include research workforce at non-OSF centers

International Space Station

(Budget Authority in Millions of Dollars)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	TOTAL
FY 2000 BUDGET PROGRAM COST ESTIMATE	2,104.7	2,112.9	2,143.6	2,348.6	2,441.3	2,304.7	2,482.7	2,328.0	2,091.0	1,721.0	1,573.0		23,651.5
FY 2001 BUDGET PROGRAM COST ESTIMATE	2,104.7	2,112.9	2,143.6	2,348.6	2,441.3	2,299.7	2,323.1	2,114.5	1,953.5	1,642.5	1,557.0	1,525.0	24,566.4
CHANGE	+0.0	_	+0.0	_	_	-5.0	-159.6	-213.5	-137.5	-78.5	-16.0	+1525.0	+914.9
FY 2000 Appropriation: Reduced Request (CRV, ISS ops reserves)							-152.1						-152.1
FY 1999 Operating Plan revision: Transfer to Adv Prog						-5.0							-5.0
FY 2000 Operating Plan revision: Transfer to ELV, recission, transfer from X-38							-7.5						-7.5
FY 2000 request: Rephase/Re-estimate CRV							(-73.0)	-172.0	-60.0	-10.0	+30.0		-212.0
(Amount funded in SAT: Aero-Space Technology)									(95)	(190)	(230)	(250)	(765)
Vehicle make-work changes						+143.7	+106.1	+69.2	+15.6	+0.6	+8.0		+343.2
Operations rephasing						-54.0	+36.4	-3.9	-8.8	+0.4	-8.0		-37.9
Research rephasing/changes						+30.8	-50.3	+1.0	-13.8	-21.8	+2.7		-51.4
RPA rephasing						-45.3	-0.4	-5.9	+22.5	+24.0	+17.0		+11.9
Reserve reductions to offset changes						-75.2	-91.8	-60.4	-15.5	-3.2	-19.7		-265.8
Other Annual Funding Requirements (reserves)							+0.0	-41.5	-77.5	-68.5	-46.0		-233.5