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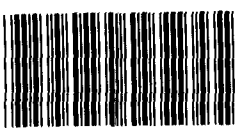
Report to the Chairman, Subcommittee on Investigations and Oversight, Committee on Science, Space, and Technology, House of Representatives

December 1992

NASA PROGRAM COSTS

Space Missions Require Substantially More Funding Than Initially Estimated



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National Security and
International Affairs Division

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December 31, 1992

The Honorable Howard Wolpe
Chairman, Subcommittee on
Investigations and Oversight
Committee on Science, Space,
and Technology
House of Representatives

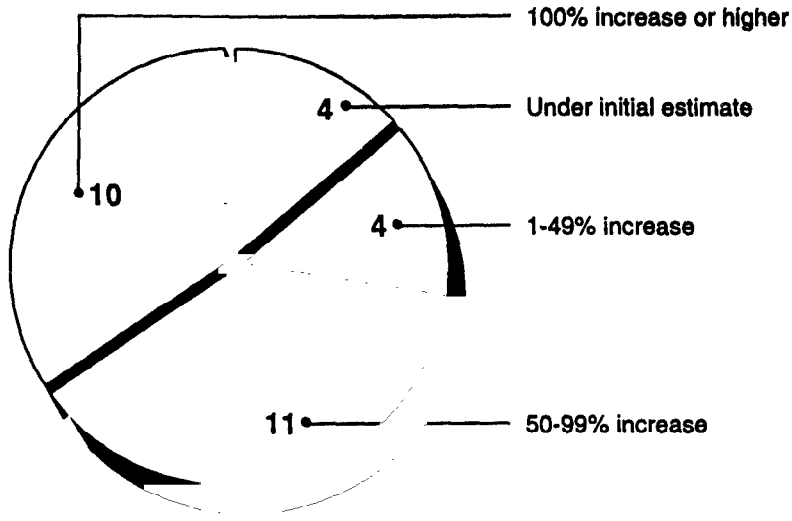
Dear Mr. Chairman:

This report responds to your request that we provide information on the National Aeronautics and Space Administration's (NASA) historical experience at estimating space program costs. The Subcommittee was concerned that at the time Congress is asked to authorize the start of new programs estimated to cost hundreds of millions or even billions of dollars, NASA may not have reasonably accurate estimates of their total funding requirements. Specifically, we reviewed the changes from initial to current estimates for major space programs initiated in the past 15 years and studied the reasons for those changes.

Results in Brief

Almost all of the 29 programs we reviewed required substantially more funding than the initial estimates provided to Congress. Figure 1 shows the extent that current cost estimates changed from initial estimates. Changes in estimates ranged from a 44-percent decrease to a 426-percent increase over the initial estimates. The median change was a 77-percent increase. (See app. I.)

Figure 1: Changes From Initial to Current Cost Estimates for 29 NASA Space Programs



Source: GAO compilation based on NASA documents.

General reasons NASA gave for differences between the initial and current estimates included insufficient definition studies, program and funding instability, overoptimism by program officials, and unrealistic contractor estimates. Specific reasons for changes in estimates included program redesigns, technical complexities, budget constraints, incomplete estimates, shuttle launch delays, and inflationary effects. As a result of these factors, the content and schedule of many programs changed substantially between the initial and current cost estimates. (See apps. II and III.)

Background

Initial cost estimates are generated during NASA's phased development process. In the preliminary analysis phase, proposed mission and scientific objectives are outlined. During this phase, the NASA field center responsible for the project identifies technical risks and prepares preliminary cost and schedule estimates. A more detailed cost estimate is developed in the definition phase as the mission is better defined. In this phase, preliminary designs, specifications, and management requirements are developed. Generally, once the definition phase is completed and the Administrator of NASA approves a new program, it is included in the

President's budget and submitted to Congress for authorization to start the detailed design and development phases. At this time, NASA normally provides Congress with an initial estimate of the program's cost.

Estimates provided to Congress by NASA typically can include costs for development, mission operations and data analysis, launch services, tracking services, and construction of program-unique facilities. After a program is authorized to begin the detailed design and development phases, NASA provides Congress with updated information on programs through Project Status Reports. These biannual reports document the initial estimates and track the costs, schedules, performance, and progress of NASA's major programs.

Developing estimates in the preliminary analysis and definition phases is difficult because there is often a great deal of uncertainty involved. Margins for uncertainties are built into the estimates in the form of reserves so that a program's budget better reflects potential resource needs. Reserves are established to fund significant changes in the definition or scope of the project, new requirements, engineering changes, schedule slips, increases in technical or management complexity, and known issues whose cost impact is uncertain. The level of reserves varies from program to program and depends on the level of uncertainty and risk of the particular program. NASA considers a reasonable level of reserves to range from 10 to 35 percent of a program's development budget.

Scope and Methodology

To determine NASA's historical experience at providing Congress with accurate estimates when new program starts were requested, we compared the initial estimates provided to Congress with the current estimates for space programs that (1) were initiated between 1977 and 1991 and (2) had initial or current estimated development costs greater than $200 million—the threshold established for reporting programs to Congress through Project Status Reports. We identified 29 such programs, including planetary missions, space and earth science missions, manned missions and related programs, and other programs such as communications satellites. We did not review the National Launch System or National Aerospace Plane programs because NASA was not the principal agency funding and managing these programs. We also excluded from our analysis costs for program elements provided by other federal agencies or international partners. Initial estimates reflect the projected costs at the time a new program was first authorized by Congress. Current estimates reflect the latest estimate as of NASA's fiscal year 1993 budget request for

programs that were in development or launched, or the latest estimate prior to the decision to cancel programs. As agreed with NASA, we consistently used the highest estimates in our analysis where estimates were presented as ranges.

To determine the reasons for changes in the estimates, we collected information from NASA on each of the 29 programs, reviewed the Project Status Reports, and interviewed current and former officials at NASA headquarters, the Goddard Space Flight Center, the George C. Marshall Space Flight Center, and the Jet Propulsion Laboratory. In addition, we reviewed our prior reports on 11 of the programs. For the purpose of analyzing specific reasons for estimate changes, we judged a reason to be significant if it was related to a change estimated to cost at least $20 million—10 percent of the minimum cost for programs tracked in the Project Status Reports. To determine inflationary effects, we used NASA's inflation index to compare the initial and current cost estimates for the development portion of the program budget in fiscal year 1992 constant dollars.

As requested, we did not obtain official agency comments on this report. However, we discussed a draft of the report with officials from NASA's Office of the Comptroller and considered their comments in preparing the final report. NASA officials generally agreed with the facts in the report, but were concerned that readers not simply review the amounts of estimate changes without fully considering the reasons for the changes that are presented in the report. We conducted our work from February to November 1992 in accordance with generally accepted government auditing standards.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to interested parties upon request.

Please contact me on (202) 275-5140 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix IV.

Sincerely yours,

Mark E. Gebicke

Mark E. Gebicke
Director, NASA Issues

Contents

Abbreviations

ACTS	Advanced Communications Technology Satellite
AFE	Aeroassist Flight Experiment
ASRM	Advanced Solid Rocket Motor
ATP	Alternate Turbopumps
AXAF	Advanced X-ray Astrophysics Facility
COSTR	Collaborative Solar Terrestrial Research
CRAF	Comet Rendezvous Asteroid Flyby
EOS	Earth Observing System
EUVE	Extreme Ultraviolet Explorer
FTS	Flight Telerobotic Servicer
GAO	General Accounting Office
GGS	Global Geospace Science
GOES	Geostationary Operational Environmental Satellite
GRO	Gamma Ray Observatory
HST	Hubble Space Telescope
LANDSAT	Land Remote Sensing Satellite
NASA	National Aeronautics and Space Administration
NSCAT	NASA Scatterometer
OMV	Orbital Maneuvering Vehicle
SOHO	Solar and Heliospheric Observatory
TDRS	Tracking and Data Relay Satellite
TOPEX	Ocean Topography Experiment
TRMM	Tropical Rainfall Measuring Mission
TSS	Tethered Satellite System
UARS	Upper Atmosphere Research Satellite
XTE	X-ray Timing Explorer

Changes in the Total Estimated Cost of 29 NASA Space Programs

The total estimated cost for most space programs we reviewed changed significantly between the initial estimates provided to Congress and the current estimates. Table I.1 presents the changes in the National Aeronautics and Space Administration (NASA) estimates in then-year dollars and the status of the 29 programs.[1]

Table I.1: Initial and Current Program Cost Estimates

Then-year dollars in millions

Program	Initial estimate	Current estimate	Dollar change	Percent change	Status
Tethered Satellite System (TSS)	50	263	213	426	Launched
X-ray Timing Explorer (XTE)	100	373	273	273	Development
Galileo (Mission to Jupiter)	455	1,639	1,184	260	Launched
Advanced X-ray Astrophysics Facility (AXAF)[a]	2,050	6,022	3,972	194	Development
Alternate Turbopumps (ATP)	372	1,053	681	183	Development
Hubble Space Telescope (HST)[b]	617	1,682	1,065	172	Launched
Extreme Ultraviolet Explorer (EUVE)	120	322	202	168	Launched
Geostationary Operational Environmental Satellite (GOES) I-M[c]	691	1,787	1,096	159	Development
Aeroassist Flight Experiment (AFE)[d]	159	387	228	143	Canceled
Gamma Ray Observatory (GRO)	317	677	360	114	Launched
Advanced Solid Rocket Motor (ASRM)[e]	1,699	3,250	1,551	91	Development
NASA Scatterometer (NSCAT)	135	255	120	89	Development
Mars Observer (Mission to Mars)	536	994	458	85	Launched
Orbital Maneuvering Vehicle (OMV)[d]	440	814	374	85	Canceled
Tracking and Data Relay Satellite replacement (TDRS-7)	300	532	232	77	Development
Land Remote Sensing Satellite (LANDSAT-D)	311	538	227	73	Launched
Collaborative Solar Terrestrial Research (COSTR)	400	673	273	68	Development
Tropical Rainfall Measuring Mission (TRMM)	290	468	178	61	Development
Ulysses (Mission to the Sun)	292	460	168	58	Launched
Magellan (Mission to Venus)	556	856	300	54	Launched
Flight Telerobotic Servicer (FTS)[d]	317	485	168	53	Canceled
Advanced Communications Technology Satellite (ACTS)	496	656	160	32	Development
Ocean Topography Experiment (TOPEX)	438	520	82	19	Launched
Freedom (Space Station)[f]	25,120	28,935	3,815	15	Development
Global Geospace Science (GGS)	568	649	81	14	Development

(continued)

[1]Then-year dollars reflect the estimated purchasing power of the dollar in the year that an expenditure will occur. These estimates are adjusted for projected inflation to show Congress and others the amounts that may have to be appropriated to complete a program. In NASA's Project Status Reports, these inflation-escalated amounts are referred to as real-year dollars.

Then-year dollars in millions

Program	Initial estimate	Current estimate	Dollar change	Percent change	Status
Upper Atmosphere Research Satellite (UARS)	814	790	-24	-3	Launched
Comet Rendezvous Asteroid Flyby (CRAF)/ Cassini (Mission to Saturn)[a]	3,593	3,351	-242	-7	Canceled/ Development
Endeavour (Space Shuttle)	2,100	1,800	-300	-14	Launched
Earth Observing System (EOS)[a,g]	21,085	11,744	-9,341	-44	Development

Note: Estimates are current as of NASA's fiscal year 1993 budget request. Estimates may include costs for development, implementation, operations, data analysis, launch and tracking services, and construction of facilities through the end of the program. NASA estimates do not include civil service personnel costs.

[a]AXAF, Cassini, and EOS programs were being reevaluated by NASA at the time of our field work. The cost, schedule, and content of these programs may change significantly. For example, subsequent to NASA's fiscal year 1993 budget request, development and operations funding for EOS was capped at $8 billion—$3 billion less than the amount included in the table's current estimate.

[b]HST estimates do not include costs for mission operations and data analysis.

[c]GOES I-M estimates include costs for development and launch services. NASA manages the development and launch of the GOES weather satellites for the Department of Commerce. Commerce performs the mission operations, data analysis, and tracking services for operational weather satellites.

[d]Current estimates for AFE, OMV, and FTS were the latest prior to cancellation.

[e]The initial ASRM estimate includes costs for design, development, test, and evaluation. The current estimate also includes costs for the first six pairs of production rocket motors that NASA decided to include in the development program. The cost of additional production units is not included in the estimates.

[f]The initial estimate for space station Freedom reflects the estimated costs in NASA's fiscal year 1988 budget request at the time the program began the detailed design and development phases, consistent with the timing of the other initial program estimates in the table. NASA provided an initial estimate of $11 billion ($8 billion in 1984 dollars) to Congress in 1984 prior to completing the definition phase. The Freedom estimates only include costs for development, operations, launch and tracking services, and construction of facilities through fiscal year 1999. Other costs in the space station capital development plan, such as civil service personnel and definition were excluded because these cost are not included in the other NASA program estimates. NASA has estimated that it will cost about $2 billion or more annually to operate the space station between 2000 and 2027. In our testimony, Questions Remain on the Costs, Uses, and Risks of the Redesigned Space Station (GAO/T-NSIAD-91-26, May 1, 1991), we summarized our reasons for concluding that NASA's space station cost estimates were understated.

[g]EOS estimates only include costs through fiscal year 2000. The last satellite in the EOS program is scheduled for launch in 2012.

Estimates increased for 25 of the 29 programs. Increases ranged from 14 to 426 percent above initial estimates. These increases were above the reserves already included in the initial estimates to fund typical changes, problems, and delays. Decreases in estimates for the other four programs

ranged from 3 to 44 percent under the initial estimates. The median estimate change for all programs was an increase of 77 percent.[2] Estimates for nearly three-quarters of the programs increased by more than 50 percent, and one-third increased by more than 100 percent. Similar trends can be seen when only launched programs are considered. These programs provide a more complete picture of changes in estimates because their actual costs through launch are known and mission operations and data analysis costs are either known or can be better estimated. Of the 12 programs that were launched, current cost estimates ranged from 14 percent under the initial estimate to 426 percent over, with a median increase of 79 percent.

Estimates for four programs decreased over time. EOS and CRAF/Cassini estimates decreased as a result of major reductions in program content in response to funding limitations. The other two programs, UARS and Endeavour, stand out as programs that were successfully completed within their initial cost estimates. UARS program officials gave several reasons why the program was completed for slightly less than its initial cost estimate. First, they believed that UARS benefited from an experienced management team that had worked together on other programs. Second, extensive definition studies were performed, allowing for thorough understanding of requirements and early identification of risks. Third, UARS used an existing spacecraft design that reduced uncertainties for the spacecraft development and for the instruments that could be designed to a known interface. Finally, UARS officials said that stable funding contributed to the program's success.

According to NASA officials, Endeavour successfully met its initial cost and schedule estimates primarily because the contractor had prior experience building space shuttles. Furthermore, Endeavour was a production rather than a research program, which reduced the level of risk involved. Like UARS, the project team was also experienced, and the processes involved in producing the shuttle were well established. Finally, the fact that Congress appropriated all of the needed funding before the Endeavour production contract was awarded contributed to the program's stability.

[2]A median is the middle value in a set of ordered values, where half the values lie above the median, and half below. Due to the diversity of the cost data we reviewed, we believed that a median was a more appropriate measure of central tendency than an average.

Reasons for the Changes in Cost Estimates for Major Space Programs

NASA officials identified both general and specific reasons why initial estimates provided to Congress changed over time. According to these officials, general reasons for the initial estimates' being far lower than the eventual cost of the programs included insufficient definition studies, program and funding instability, overly optimistic assumptions by program officials, and unrealistic contractor estimates. Based on information provided by NASA and our prior reports, we organized the specific reasons for the estimate changes in the 29 programs into 6 categories: program redesigns, technical complexities, budget constraints, incomplete estimates, shuttle launch delays, and inflationary effects. These factors often resulted in programs whose content and schedules changed substantially between the initial and current cost estimates.

General Reasons for Changes Between Initial and Current Estimates

Two NASA studies, conducted over a decade apart, emphasized the importance of thorough definition studies. The first, NASA's Project Management Study in 1980, concluded that one of the most significant contributors to cost and schedule growth was inadequate definition of technical and management aspects of a program prior to NASA's seeking approval to proceed from the Office of Management and Budget and the Congress. The study recommended that sufficient funding be included in NASA budgets for thorough definition studies. The second study, NASA's Roles and Missions Report in 1991, documented the need for increased emphasis on technological readiness and requirements on the front end of a program. In response to this report, the NASA Administrator directed the agency to implement more rigorous definition studies. The purpose of the studies was to understand the full range and implications of a program's technical content in order to prepare an implementation plan that includes the cost, schedule, and performance contingencies necessary to make meaningful and reliable internal and external commitments.

NASA officials cited program and funding instability as another general reason for changing estimates. Space programs can take a decade or more to complete, often spanning changes in NASA management, presidents, and Congress. NASA officials stressed the difficulties in efficiently managing long-term programs in an environment where funding must be approved in an annual budget process and priorities can change or compete. Changing and competing priorities can result in unstable and inefficient funding profiles. The Advisory Committee on the Future of the U.S. Space Program also raised concerns about program and funding stability. The Advisory Committee's December 1990 report cited the lack of consensus on goals and management turbulence as general concerns about the Nation's space

program. The Advisory Committee further stated that Congress should provide program stability through consistent and adequate funding.

NASA officials also cited overoptimism as a reason why initial estimates are often significantly lower than current estimates. According to a former deputy administrator, optimism provides the "can do" attitude that enables scientists and engineers to meet the challenges and solve the unknowns intrinsic to NASA's work. However, if this optimism is not tempered by realism, it can lead the program team to underestimate technical challenges and overestimate its capabilities to solve them. NASA's 1980 Project Management Study noted that NASA should be realistic with itself, Congress, and the public in terms of the goals, capabilities, costs, schedule, and technical risks of a new project. More recently, the Advisory Committee on the Future of the U.S. Space Program also concluded that NASA must be more realistic in estimating the resources that will be needed to complete programs.

NASA officials stated that unrealistic contractor proposals and estimates also contribute to differences in initial and current estimates. According to these officials, competition drives proposal costs down and creates artificially low estimates. These proposals tend to be optimistic in assessing the actual complexity and cost of developing new technology. NASA recently rejected contractors' cost estimates for the development of the EOS data and information system because they were considered unrealistically low. A senior NASA official stated that by rejecting the proposals, NASA was sending a message to contractors that there is a new way of doing business at NASA and that the agency will no longer tolerate "low balling." In the official's opinion, contractor low balling of proposal estimates to buy into programs has been a costly problem for the agency.

Specific Reasons for Estimate Changes

Table II.1 summarizes the major reasons for changes in the estimates for the 29 programs we reviewed. The table illustrates the reasons that increased or decreased a program estimate by at least $20 million when the dollar impact of the reason could be determined. In cases where multiple events within a reason category sometimes increased the estimate and other times decreased it, the table indicates whether the predominant change was an increase or a decrease.

The reasons for estimate changes were often interrelated. Consequently, the impact of one event may be indicated in several categories. For example, if budget cuts were handled by reducing program content, a

minus sign would appear in the program redesign category to indicate that the estimate decreased along with the program content. If NASA handled the budget cuts by stretching out the program over a longer period, a plus sign would appear in the budget constraint category to indicate that total estimated program costs increased if additional costs were incurred by contractors as a result of delays. Depending on the length of the stretch-out and the amount of funding shifted to future years, a plus sign might also appear in the inflationary effect category to indicate that the estimate also increased as a result of inflation. Each category is discussed in more detail in table II.1.

Table II.1: Reasons for Changes in Cost Estimates

Program	Program redesign[a]	Technical complexity	Budget constraint	Incomplete estimate	Shuttle delay[b]	Inflationary effect[c]
TSS		+		+	+	
XTE	+			+		
Galileo	+	+			+	+
AXAF	+	+	+	+		+
ATP	+	+				+
HST		+		+	+	+
EUVE	+			+		
GOES I-M	+	+				+
AFE	+		+	+		
GRO		+	+		+	+
ASRM	+	+	+			+
NSCAT	+					+
Mars Observer	+	+	+		+	+
OMV	_	+	+			+
TDRS-7		+	+	+		
LANDSAT-D	+	+				+
COSTR	+					
TRMM	+			+		
Ulysses	_		+	+	+	
Magellan	+	+			+	
FTS	_	+		+		+
ACTS	+		+		+	+
TOPEX		+				
Freedom	_	+	+			+
GGS			+			
UARS					+	
CRAF/Cassini	_		+	+		+
Endeavour						
EOS	_					+

[a]A plus sign (+) means increased cost estimate. A minus sign (-) means decreased cost estimate.

[b]Shuttle delays largely resulted from the Challenger accident and its effects on the space shuttle program.

[c]The inflationary effect was calculated on development costs only. It represents the sum of the inflation on the initial estimate and the program changes.

Program Redesign

Program redesign involves significant changes in requirements, spacecraft, instruments, launch vehicles, upper stage propulsion systems, trajectories, or operations. According to NASA's records, 15 estimates increased and 6 decreased as a result of major program redesigns.

XTE is an example where the estimated cost was driven up by adding new requirements to the program. XTE was originally designed to replace EUVE on the explorer platform during a space shuttle mission. However, funding problems led to delays that would have meant the mission to replace EUVE with XTE would not have occurred until the explorer platform was significantly older, increasing the risk to the XTE program. To avoid the delay, NASA added requirements for a dedicated platform to the program to be launched by an expendable launch vehicle, increasing development cost estimates by over $100 million.

Program redesign may also result when programs are restructured because of funding, technical, or schedule problems. For example, the cost estimate for the EOS program decreased when the program was restructured in response to directions from the Senate Committee on Appropriations. The Committee's report accompanying NASA's fiscal year 1992 appropriations bill directed NASA to reduce spending on the program by about $5 billion through the year 2000. To reduce the program's development and operations budget from $16 billion to $11 billion, and the total cost to $11.7 billion, NASA changed the number and type of satellites, reduced the number of instruments, and delayed the launch of some satellites. Further changes in the program and estimate will occur as NASA responds to directions in the Committee's fiscal year 1993 report to cap development and operations spending at $8 billion through 2000.

The Challenger accident also caused program redesigns that changed estimates. Some program estimates changed because transportation for the spacecraft switched from the shuttle to expendable launch vehicles. Others were affected by a safety decision to replace the liquid-fueled upper stage propulsion system with a solid-fueled system. For example, the Challenger accident and related upper stage change increased Galileo's cost estimates by about $480 million because of changes in both hardware and mission design. Among the required changes were (1) programming a longer trajectory to Jupiter because of the change to a less powerful upper stage, (2) replacing aging components, and (3) designing and developing thermal protection for the spacecraft because of longer exposure to radiation. Because the less powerful upper stage required a longer trajectory, mission times lengthened and operations costs increased.

Technical Complexity

Technical complexities inherent in the nature of NASA's work resulted in increases in many program estimates. NASA's work is highly experimental, often involving unique missions, long time frames, and technology that pushes the state of the art. In some cases, NASA or its contractors underestimated the technical challenges on a program. Technical complexities also arose from design problems or difficulties in the fabrication process. In other cases, technical problems were the result of poor contractor performance. These problems increased costs by causing additional design, development, fabrication, and testing. According to NASA, technical problems increased estimates for 16 of the 29 programs.

GOES I-M is an example of a program that experienced technical problems during development due to the complexity of the satellite design and poor contractor performance. NASA and the contractor underestimated the design complexities inherent in the requirements for a precisely controlled satellite capable of accurately pointing instruments. Technical problems were compounded by NASA's poor technical management of the program and its contractors. The inexperience of the instrument subcontractor's staff and the lack of technical guidance by the prime contractor also contributed to the significant problems and delays in the program.

Budget Constraints

Program cost estimates were affected when programs did not receive the level of funding requested. Budget constraints on particular programs were internally imposed by NASA or externally directed by the Office of Management and Budget or Congress. To offset near-term budget shortfalls, programs were often stretched out, pushing more of the funding requirements into the future and resulting in higher total costs. NASA officials attributed these higher costs in part to additional expenses incurred by contractors over the longer period. According to NASA, budget constraints significantly increased estimates for 12 of the 29 programs.

The AXAF program was a case where both internal and external budget constraints impacted program estimates. To provide funding for the Hubble Space Telescope and other projects, NASA cut the AXAF budget by about $25 million and $75 million in fiscal years 1991 and 1992, respectively. These cuts caused cost increases of about $90 million because the program had to be rephased. After rephasing, Congress reduced fiscal year 1992 development funding by $60 million and significantly reduced funding for fiscal year 1993. These latter budget cuts delayed the launch from early 1998 to mid-1999. The resulting stretch-out increased estimated future years' development costs by over $200 million.

Incomplete Estimates

Changes between initial and current estimates were caused, in part, by NASA not including all costs in its initial program estimates. According to NASA documents, 11 of the 29 initial program estimates lacked cost information on such elements as launch services or mission operations and data analysis. Excluding some costs from the initial program estimates meant that more complete estimates of total costs were not available to Congress when it authorized the program. According to NASA officials, some costs may have been excluded from initial program estimates because they were accounted for in separate budget categories. NASA officials also stated that although the initial program estimates may not have included all costs, congressional committees may have been informed of those other costs through hearings and other material that NASA prepared in support of its budget requests.

In most cases, excluding some costs from initial estimates did not have any significant near-term budgetary impact. Most launch, mission operations and data analysis, and tracking funds are budgeted in years following the fiscal year in which a program is initially approved. However, initially excluding certain costs dramatically changed some total program estimates. For example, the estimate for 15 years of operations and servicing costs for AXAF was not included in estimates until March 1992, even though the program was approved for a new start in fiscal year 1989. The additional costs increased the total program estimate by $3.2 billion.

Shuttle Delays

Estimates increased as program schedules stretched out due to launch delays. Table III.1 in appendix III shows that the launch date slipped for almost every program. However, according to NASA, only 9 of the 29 programs were significantly delayed due to launch vehicle problems; the others were delayed because of program redesigns, technical complexities, or funding constraints. All nine of these programs were affected by the Challenger accident in January 1986 and other shuttle problems. The accident caused some missions to be delayed by several years. For example, NASA estimated that the Challenger accident and other shuttle problems delayed the Hubble Space Telescope's launch by about 4 years and increased program costs by over $300 million.

Inflationary Effects

Inflation also increased cost estimates as program schedules were stretched out. Inflation affected program cost estimates to varying degrees, depending on the amount of funding shifted to future years, the

number of years funding was shifted, and the estimated rate of inflation. The inflationary effect category in table II.1 represents the change in the estimated development costs due to the effects of inflation on both the initial estimate and on costs added to the development effort after the initial estimate. Estimates for the development cost of 16 of the 29 programs increased by more than $20 million as a result of inflationary effects.

We analyzed inflationary effects only on the development portion of the program estimate because sufficient information was not available for the other cost elements, particularly on NASA's older programs, to reconstruct complete initial funding plans. The development cost is the major cost of most space programs, averaging 72 percent of the total cost for the 29 programs.

Launch Schedule Changes for Major Space Programs

Table III.1 presents the initiation dates and the changes in launch dates for the 29 programs we reviewed. Launch dates for most programs have slipped at least 1 year, with the Galileo program experiencing the longest slip—8 years. The average delay for the 12 programs that have been launched was 44 months.

Table III.1: Initial and Current Launch Dates

Program	Fiscal year initiated	Initial launch date	Current/actual launch date[a]	Launch slip (months)
TSS	1984	4/87	8/92	64
XTE	1990	10/94	4/96	18
Galileo	1978	10/81	10/89	96
AXAF	1989	10/95	4/99	42
ATP[b]	1986	10/91	10/94	36
HST	1978	10/83	4/90	78
EUVE	1984	10/88	6/92	44
GOES I-M[b]	1985	10/89	10/93	48
AFE (canceled)	1988	8/92	8/96	48
GRO	1981	10/85	4/91	66
ASRM[b,c]	1989	10/94	12/98	50
NSCAT	1985	10/88	1/96	87
Mars Observer	1985	8/90	9/92	25
OMV (canceled)	1987	8/91	4/95	44
TDRS-7	1987	10/91	10/95	48
LANDSAT-D	1978	1/81	7/82	18
COSTR:[d] Cluster	1987	7/93	10/95	27
SOHO		10/93	7/95	21
Geotail		4/92	7/92	3
TRMM	1991	1/97	7/97	6
Ulysses	1979	2/83	10/90	92
Magellan	1984	4/88	5/89	13
FTS (canceled)	1988	1/91	10/93	33
ACTS	1984	7/89	1/93	42
TOPEX	1987	10/91	8/92	10
Freedom[e]	1988	3/94	4/97	25
GGS:[d] Polar	1988	7/92	4/94	21
Wind		1/92	7/93	18
UARS	1982	10/89	9/91	23

(continued)

Program	Fiscal year initiated	Initial launch date	Current/actual launch date[a]	Launch slip (months)
CRAF (canceled)	1990	8/95	2/96	6
Cassini	1990	4/96	10/97	18
Endeavour[b]	1987	1/92	4/92	3
EOS[b]	1991	10/98	4/98	-6

[a]Current launch dates are as of NASA's fiscal year 1993 budget request. Current launch dates for canceled programs were the latest dates prior to cancellation.

[b]Launch dates for ATP, GOES I-M, ASRM, Endeavour, and EOS are for the first launch in a series.

[c]A current launch date was not estimated for ASRM at the time of NASA's fiscal year 1993 budget request because the program was proposed for termination. Congress rejected the proposal to terminate the program and directed NASA to maintain a first launch date of December 1998.

[d]COSTR and GGS involve multiple missions and spacecraft.

[e]The fiscal year initiated and the initial launch date for space station Freedom were established at the time the program began the detailed design and development phases, consistent with the timing of the fiscal year initiated and initial launch dates for the other programs in the table. NASA provided an initial launch date of March 1992 to Congress in 1984 prior to completing the definition phase. The launch dates are for the first element launch.

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