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# GAO

Report to the Chair, Subcommittee on Government Activities and Transportation, Committee on Government Operations, House of Representatives

November 1992

# SPACE SHUTTLE

# Status of Advanced Solid Rocket Motor Program

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**National Security and**
**International Affairs Division**

B-248285

November 17, 1992

The Honorable Barbara Boxer
Chair, Subcommittee on Government
Activities and Transportation
Committee on Government Operations
House of Representatives

Dear Madam Chair:

As you requested, we have reviewed the status of the National Aeronautics and Space Administration's Advanced Solid Rocket Motor program. Our primary objectives were to (1) assess the extent to which the need for the program has changed and (2) determine the reasons for cost growth and schedule slippage.

Unless you publicly announce this report's contents earlier, we plan no further distribution until 30 days after its issue date. At that time, we will send copies of the report to the Administrator, NASA, and appropriate congressional committees. Copies will also be made available to others on request.

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

Sincerely yours,

Mark E. Gebicke

Mark E. Gebicke
Director, NASA Issues

# Executive Summary

## Purpose

The Advanced Solid Rocket Motor is one of the National Aeronautics and Space Administration's (NASA) most expensive and controversial programs. Two reusable solid rocket motors are attached to the space shuttle to provide most of the thrust needed to lift it into orbit. The advanced motor is being designed to replace the current motor, which is a redesigned version of the motor that caused the January 1986 Challenger accident.

The Chair of the Subcommittee on Government Activities and Transportation, House Committee on Government Operations, requested that GAO review the program's status. The specific objectives were to (1) assess the extent to which the need for the program has changed and (2) determine the reasons for cost growth and schedule slippage.

## Background

On January 28, 1986, the Space Shuttle Challenger exploded shortly after liftoff. The Presidential Commission established to review the circumstances of the accident concluded that it was caused by a faulty design of the solid rocket motor field joint—the area where segments of the motor are joined together during assembly operations at the launch site. The motor was redesigned to prevent a similar occurrence, and production of the redesigned motor began in August 1987.

At about the same time, in the 1988 NASA authorization act, the Congress approved the agency's plan to develop a new, advanced solid rocket motor to replace the redesigned motor and improve the shuttle's performance and safety. The development program involves constructing and equipping a manufacturing facility at the Tennessee Valley Authority's former Yellow Creek nuclear plant site near Iuka, Mississippi. It also includes constructing and modifying facilities at other NASA locations. The Congress appropriated about $1.2 billion for the program through fiscal year 1992.

In its fiscal year 1993 budget submission, the administration proposed terminating the advanced motor program. The President's budget message, however, suggested that the executive branch would consider continuing the program if the Congress increased NASA's total fiscal year 1993 budget allocation above the $15 billion requested. The Congress rejected the administration's proposal to terminate the program and appropriated $14.3 billion for NASA, including $360 million to continue developing the advanced motor and constructing facilities. Further, the Congress expects NASA to propose sufficient fiscal year 1994 funding to achieve a December 1998 first launch date.

## Results in Brief

The advanced motor program was justified on the basis that it would enhance the shuttle's safety and reliability and increase its lift capability by about 12,000 pounds. While these are still the expected results of the program, the need for the advanced motor has diminished since the program was initiated. The new motor may not be used for either of the two payloads that were projected to need the additional lift capability. In addition, two advisory groups have questioned whether NASA should develop a new motor when the existing redesigned motor has proven safe and reliable.

Between January 1988 and July 1992, the advanced motor's estimated development cost increased by about 95 percent—to $3.25 billion—primarily as a result of expanding the development scope, increasing construction costs, and adding cost reserves. The schedule for the first ASRM flight has slipped by over 2-1/2 years because of delays in awarding the development contract, funding constraints, and a redesign of the building where propellant is mixed and cast. Program officials said the program's costs will exceed $3.25 billion because the fiscal year 1993 funding level will cause NASA to further stretch out the development schedule.

## Principal Findings

### Advanced Motor Is Being Designed to Enhance Shuttle Safety

The advanced motor program was intended to enhance the shuttle's safety and reliability through design improvements and the use of automated production. For example, the advanced motor's propellant design and thrust should reduce the possibility of having to abort a mission and return the shuttle to its launch site because of a failure in one of the three liquid-fueled main engines. Also, NASA expects that using automated production processes will reduce the amount of human error in manufacturing the motors.

### Advanced Motor May Not Be Used for Payloads Initially Identified

NASA had identified two specific payloads as needing the additional lift capability that the advanced motor could provide. These were the Advanced X-ray Astrophysics Facility and the laboratory modules for Space Station Freedom. Under NASA's current plan, however, the advanced motor may not be used for either payload. NASA has redesigned the x-ray observatory so that it will not need the additional lift to be provided by the new motor. In addition, NASA is considering alternatives to the shuttle for launching the space station's components. Even if NASA uses the shuttle to launch these components, the advanced motor will not be available in time for the planned 1997 launch of the U.S. laboratory module.

## Advisory Groups Question the Need for the Advanced Motor Program

The National Research Council and the Aerospace Safety Advisory Panel have concluded that the advanced motor program involves high technical and programmatic risks and should be reconsidered. These groups have cited uncertainties with the new design, potential improvements to the shuttle that would be more cost-effective, and the successful performance of the redesigned motor as reasons to question the need for the advanced motor.

## Current Shuttle Motor Demonstrates Reliability

The first shuttle equipped with the redesigned motor was launched in September 1988. Through October 1992, 26 shuttle missions had been successfully flown with the redesigned motor. During this period, according to NASA, there has been no evidence of significant safety or reliability problems with the motor. Also, the contractor for this program is implementing a series of improvements to further enhance the redesigned motor's safety and reliability.

## Program Costs Have Increased

In January 1988, NASA estimated that the advanced motor would cost about $1.67 billion to develop. In July 1992, the agency estimated that the development program would cost $3.25 billion, an increase of $1.58 billion, or about 95 percent. Motor development costs increased by $881 million (56 percent of the total increase), facility construction costs increased by $250 million (16 percent), and NASA increased contingency funding in the estimate by $450 million (28 percent).

## First Flight Schedule Has Slipped

Between January 1988 and July 1991, the schedule for the first ASRM flight slipped by 31 months—from July 1994 to February 1997. The launch was delayed by 11 months because of a delay in awarding the development contract. Funding constraints and a reestimate of the development program requirements caused further delays totaling 14 months. Redesigning the propellant mixing and casting building to conform to safety requirements caused another 6-month delay.

## Further Cost Increases and Schedule Slippage Expected

The estimated development costs will increase further because Congress appropriated $160 million less than what was required in fiscal year 1993 to maintain the existing development schedule. As a result, NASA will have to add about 22 months to the development schedule—delaying the first flight until December 1998. The program director stated that he could not yet quantify the cost impact of the stretch-out because the impact will depend in part on the amount of funding available in subsequent fiscal years.

## Recommendations

GAO is not making any recommendations.

## Agency Comments

As requested, GAO did not obtain agency comments on this report. However, GAO discussed the information in this report with program management officials and incorporated their comments where appropriate.

# Contents



**Abbreviations**

| | |
|---|---|
| ASRM | Advanced Solid Rocket Motor |
| GAO | General Accounting Office |
| NASA | National Aeronautics and Space Administration |
| RSRM | Redesigned Solid Rocket Motor |

# Introduction

The Advanced Solid Rocket Motor (ASRM) is being developed for the National Aeronautics and Space Administration (NASA) to enhance the safety, reliability, and performance of the space shuttle. Each launch relies upon two solid rocket motors and three liquid-fueled main engines to lift the spacecraft into orbit. The solid rocket motors provide about 80 percent of the required thrust. Once operational, ASRM is to replace the Redesigned Solid Rocket Motor (RSRM) on the remainder of the shuttle's planned missions.

## Background

On January 28, 1986, the Space Shuttle Challenger exploded shortly after liftoff. A Presidential Commission was established to review the circumstances surrounding the accident, determine its probable cause, and develop recommendations for corrective action. The Commission concluded that the accident was caused by a failure in the solid rocket motor field joint—the area where segments of the motor are joined together during assembly operations at the launch site. The failure was due to a faulty design that was unacceptably sensitive to a number of factors, such as the effects of temperature. After the accident, NASA redesigned the field joint to prevent a recurrence of the problem and made other changes in the motor's design. Production of the redesigned motors began in August 1987, and the first redesigned motor flew in September 1988.

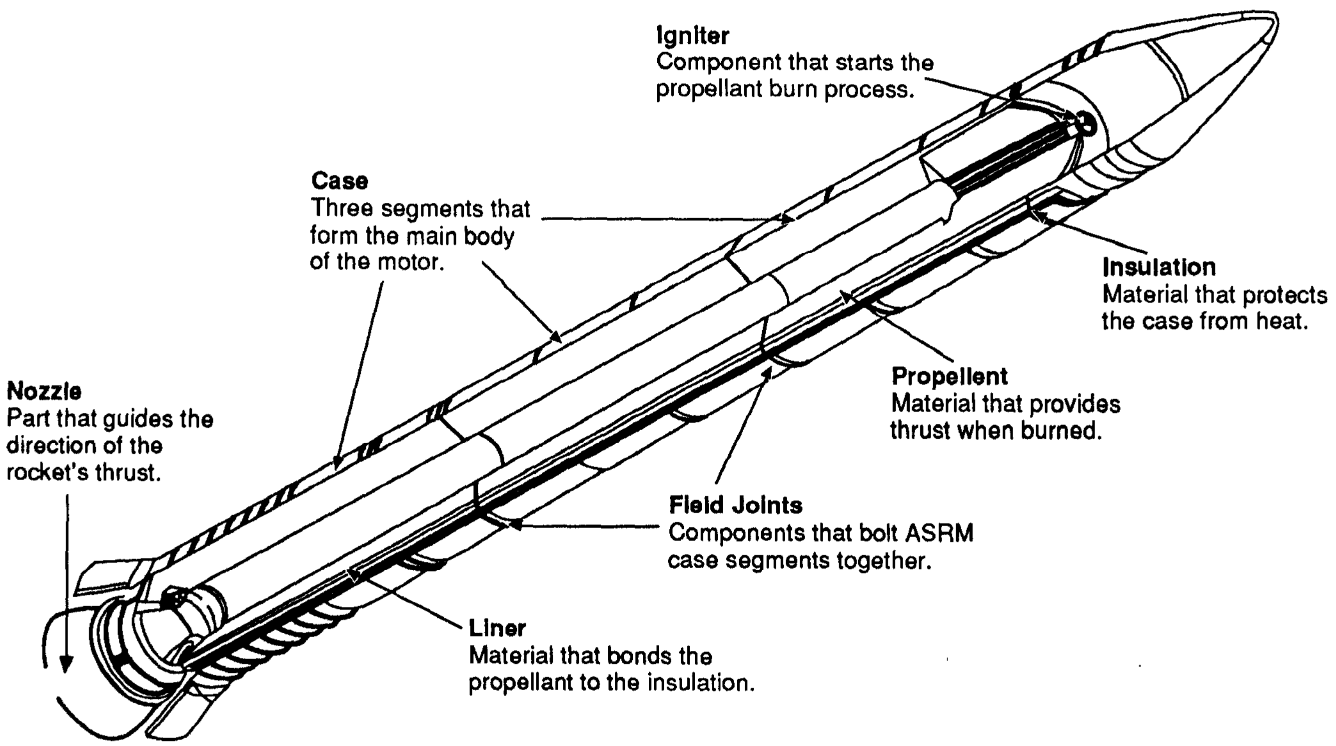
At the same time the motor was being redesigned, NASA prepared a plan for developing an entirely new and advanced motor to replace the redesigned motor. In the 1988 NASA authorization act, the Congress required NASA to issue a request for proposals to acquire ASRM on a competitive basis and stated that ASRM would increase the shuttle's performance and enhance flight safety. The program involves constructing and equipping a government-owned, contractor-operated manufacturing facility at the Tennessee Valley Authority's former Yellow Creek nuclear plant site near Iuka, Mississippi. It also includes constructing test facilities at the Stennis Space Center near Bay St. Louis, Mississippi, and modifying or expanding other facilities at Stennis; the Michoud Assembly Facility near New Orleans, Louisiana; and the Kennedy Space Center near Cape Canaveral, Florida. As of August 1992, NASA reported that the design was complete for about 90 percent of the facilities and that about 25 percent of the construction was complete. Figure 1.1 shows the status of the Yellow Creek manufacturing site.

Figure 1.1: Yellow Creek Facility

## Description of ASRM

ASRM consists of six major components—the case, insulation, liner, propellant, nozzle, and igniter (see fig. 1.2). The motor is being developed to provide design improvements over the current motor. The proposed improvements include (1) fewer joints designed into the motor, (2) joints that remain closed during operation, (3) the elimination of asbestos insulation, and (4) a propellant design that minimizes the need to throttle down the main engines during ascent. The advanced motor is expected to provide the shuttle with about 12,000 pounds of added lift capability. (Some of these improvements are discussed further in ch. 2.)

Figure 1.2: ASRM Configuration




## President's Fiscal Year 1993 Budget Proposed ASRM Termination

The President's fiscal year 1993 budget submission proposed termination of the ASRM program. According to the accompanying budget message, much of the program's justification had eroded, and alternatives were available to offset the loss of ASRM's lift capability. To support the proposed termination, the budget message cited the safety and reliability of the existing redesigned motor, a reduced shuttle flight rate, and cost increases and schedule slippage that had already occurred in the ASRM program. The budget message noted that ASRM's total estimated cost had increased substantially and that the first scheduled shuttle launch using ASRM had slipped by more than 2-1/2 years. However, the message suggested that the executive branch would consider continuing the ASRM program if the Congress increased NASA's budget allocation for fiscal year 1993 above the $15 billion requested.

## Termination Would Increase Sunk Cost

Through fiscal year 1992, the Congress has appropriated about $1.2 billion for the ASRM program. NASA estimated that it would need about $300 million in new budget authority if the ASRM program was terminated in October 1992. This estimate included the costs associated with terminating the prime contract and halting efforts to integrate ASRM with other shuttle components and modify launch site equipment. The estimate assumed that all equipment and facilities that were 90-percent complete would be finished and all exposed facilities would be enclosed.

In addition to these direct costs of termination, NASA identified a number of indirect costs to be incurred if ASRM was terminated. They included costs associated with a program to eliminate asbestos from the redesigned motor and the costs for additional shuttle flights to support launching Space Station Freedom.

Terminating ASRM would also increase the complexity of assembling the space station. Without ASRM, equipment for use in the U.S., Japanese, and European laboratories would have to be sent up on flights separate from those carrying the laboratories. Astronauts would have to transfer the equipment from the shuttle to the laboratories and check out the integrated laboratory systems in orbit rather than on the ground. However, according to NASA, the additional assembly and verification activities should not be of major consequence since the agency would have 5 years to plan for them.

## Congress Rejected Termination Plan

The Congress rejected the administration's proposal to terminate the program in fiscal year 1993 and set NASA's fiscal year 1993 appropriation at $14.3 billion. The appropriation act provides $360 million for the ASRM program, including $195 million for motor development and $165 million for construction of facilities. The conference report accompanying the act stated that NASA is expected to propose sufficient fiscal year 1994 funding to maintain a December 1998 first launch of ASRM.

## Objectives, Scope, and Methodology

The Chair of the Subcommittee on Government Activities and Transportation, House Committee on Government Operations, requested that we review the status of the ASRM program. Our primary objectives were to (1) assess the extent to which the need for the program has changed and (2) determine the reasons for cost growth and schedule slippage.

We reviewed the program's budget submission documentation, cost estimates, obligation plans, legislative history, contract documentation, termination analyses, and project planning documentation. We then discussed cost, schedule, and performance issues with program management, engineering, quality assurance, and procurement officials at NASA Headquarters, Marshall Space Flight Center, and Johnson Space Center. We also discussed the rationale for continuing the ASRM program with representatives of the National Research Council, Aerospace Safety Advisory Panel, and Congressional Research Service.

To assess cost and schedule issues, we relied on official program estimates as well as discussions with NASA and contractor officials. To assess the performance of RSRM, we reviewed contractor reliability assessments and discussed their content with NASA and contractor officials.

We performed our review from February 1992 through October 1992 in accordance with generally accepted government auditing standards. As requested, we did not obtain written comments on a draft of this report; however, we discussed its contents with program management officials and incorporated their comments where appropriate.

# Need for Advanced Motor Design Has Diminished

Although NASA still believes the advanced motor will provide advantages over the existing redesigned motor, the need for ASRM has diminished since the program was first authorized. For example, the advanced motor may not be used for launching either of the two specific payloads originally identified as needing the additional lift it is expected to provide. In addition, NASA advisory groups have questioned whether the redesigned motor, which has a known reliability, should be replaced with an unproven, albeit advanced, design.

## ASRM Originally Justified to Enhance Safety and Reliability

The ASRM program was intended to enhance the safety and reliability of the shuttle through improvements to the motor's design and the use of automated production processes. The proposed design improvements include field joints that close rather than open when the motor is ignited, welded case segments, an improved propellant, a redesigned nozzle, and asbestos-free insulation.

For example, the advanced motor's propellant design and thrust should reduce the possibility of having to abort a mission and return to the launch site if one of the shuttle's liquid-fueled main engines shuts down early in the launch. Equipped with the redesigned motor, the shuttle would have to return to its launch site if one of its three main engines shuts down in the first 2-1/2 to 3 minutes of flight. For some missions, ASRM would reduce this window of vulnerability by up to one-half, according to the ASRM project manager. Although it has never been attempted, NASA considers a return to launch site abort to be a high-risk procedure.

Also, ASRM's propellant is designed to burn in a way that will minimize the need to throttle down the shuttle's main engines during the period of maximum dynamic pressure—the period during launch where the aerodynamic forces on the shuttle are the greatest. According to NASA, this will eliminate the effects of approximately 150 failure possibilities. If one of these failures occurs during the throttle down process, an electrical or hydraulic lock-up could cause the throttle to stick, preventing the main engine from returning to full power. Without sufficient power, the shuttle would have to abort its mission.

The shuttle has never experienced a stuck throttle during this stage of flight, and the likelihood that this would occur is small, according to NASA. However, eliminating the effects of a stuck throttle is clearly beneficial and could potentially prevent the loss of a mission.

Automating production processes is expected to reduce human error in manufacturing shuttle motors. According to NASA, as many as half of the past solid rocket motor discrepancies resulted from human involvement in the manufacturing process. While these discrepancies were detected and appropriately addressed, NASA plans to automate a wide range of production activities on the advanced motor. These include mixing propellant, applying insulation and adhesives, and cleaning motor cases.

NASA considers propellant mixing to be the most advanced and important aspect of the automation strategy. Under the current plan, propellant would be continuously mixed and directly poured into the motor cases. The process would replace the current practice of batch mixing in which about 165 individual containers of propellant are mixed in separate facilities (to avoid large explosions) and then transported to be poured into the motor.

## ASRM May Not Be Used for Payloads Initially Identified

NASA stated that ASRM's additional lift capability will offer enhanced flexibility in designing payloads and initially identified two shuttle payloads requiring the added lift—the Advanced X-ray Astrophysics Facility and Space Station Freedom's laboratory modules. However, the x-ray observatory may no longer need ASRM, and the new motor will not be available in time to launch the space station's U.S. laboratory module.

Originally, NASA intended to launch the x-ray observatory on the shuttle using ASRM. Because of its weight, the observatory required ASRM's lift capability to achieve its orbit. However, NASA later decided to redesign the observatory and launch it on two separate missions. NASA plans to launch one component of the redesigned observatory on the shuttle and the other on an expendable launch vehicle. The shuttle-launched payload will require an elliptical orbit ranging from about 6,000 to 60,000 miles—a distance that the shuttle, even with ASRM, cannot attain. Therefore, NASA is planning to add propulsion stages to that payload, and ASRM will not be needed. According to the observatory project manager, the advanced motor would still be helpful because it would allow more flexibility in designing the observatory, but NASA is not relying on ASRM's availability to launch the observatory.

In addition, ASRM may not be needed to launch and deploy Space Station Freedom. In August 1992, the NASA Administrator established a team to assess the feasibility of completing the space station program using a new heavy lift launch vehicle derived from existing launch vehicles. All of the alternatives under consideration would provide for deploying the space station with a combination of the new heavy lift vehicle and the shuttle as currently configured without ASRMs. As a result, if any of the options are approved, the space station program will not depend on ASRM's availability. NASA plans to complete the study and make any recommendations by December 1992.

Even if NASA uses the shuttle equipped with ASRM to launch station components, the motor will not be available in time to launch the U.S. laboratory module. NASA previously planned to launch the laboratory on the first ASRM-equipped shuttle in February 1997.[1] However, according to the program director, the new motor will not be available until December 1998 (see ch. 3).

Because ASRM will not be available in time to launch the U.S. laboratory module, NASA will have to add one shuttle flight to the station assembly schedule, if the shuttle is used for deploying the station. The one additional flight will be needed to transport equipment to be installed inside the laboratory module. According to the ASRM program director, the advanced motor would be available in time to launch the Japanese and European laboratory modules. Using ASRMs would allow NASA to launch these components fully outfitted with equipment.

## ASRM's Comparative Advantage Over the Current Motor Is Questioned

While the new design features and automated manufacturing processes hold the potential for a more reliable and safer motor, ASRM's design is as yet unproven, and its reliability will not be known for a long time. As a result, two NASA advisory groups have recommended that the agency reconsider its decision to develop the advanced motor. According to these groups, the advanced motor's high technical and programmatic risks, together with the redesigned motor's proven performance, make development of the advanced motor unnecessary.

### Advisory Groups Question Decision to Continue ASRM's Development

Both the National Research Council and the Aerospace Safety Advisory Panel have questioned whether ASRM will be safer and more reliable than RSRM and have recommended that the program be reconsidered. According to the Research Council, NASA should rely on RSRM since it has proven to be reliable.

[1]According to the space station program manager, the launch date for the U.S. laboratory module could slip by about 6 months due to fiscal year 1993 funding constraints.

The Research Council also stated that it believes the ASRM program contains high technical and programmatic risks. For example, in a 1991 report,[2] the Research Council questioned the design of the ASRM field joint and welded factory joint. According to the Council, the ASRM field joint is more complex and more difficult to analyze than the field joint in the current motor. The Council also said that welding the factory joints introduces the possibility of stress cracks occurring after final inspections but prior to launch. NASA believes that limited test results show that the welded area is resistant to stress cracking, but the agency agrees that further analysis and testing are required.

In 1989, the Aerospace Safety Advisory Panel also questioned the need for the new motor since many other elements of the shuttle system could be replaced or modified to contribute more to improving safety.[3] For example, Panel officials told us that NASA could better use ASRM development funds to restore the main engine alternate fuel turbopump development. This improvement would increase the main engine's safety, efficiency, and life expectancy, according to NASA officials.

The Panel also questioned whether NASA could have as high confidence in ASRM as it does in RSRM until the ASRM has flown as many times as the current motor. Under the current schedule, NASA will launch the RSRM-equipped shuttle about 75 times before ASRM is available. On the basis of the current expected shuttle flight rate of eight missions a year, NASA would not have equivalent confidence in ASRM's reliability until at least 9 years after it is first launched.

## RSRM Is Performing Well

When ASRM was first approved, NASA had no actual flight experience with the redesigned motor. Through October 1992, RSRM has successfully flown 26 times. Since the January 1986 Challenger accident, NASA has enhanced its safety organization and increased the number of quality assurance inspections. Following each launch, the solid rocket motors are disassembled and inspected. To date, these inspections have identified no major design problems, according to NASA.

Another measure of the motor's quality is the number of problem reports generated during preflight inspections. A problem report is written when

[2] The Space Shuttle Advanced Solid Rocket Motor, Quality Control and Testing, National Research Council, 1991.

[3] Annual Report, Aerospace Safety Advisory Panel, March 1989.

any characteristic of the RSRM motor violates engineering requirements. According to NASA, these reports have decreased from 470 with the first RSRM flight set down to only 20 with the 26th flight set.

One recent problem with the redesigned motor occurred on September 18, 1992, when a field joint seal leaked during a preflight pressure check. NASA determined that a piece of filler had become dislodged and creased an O-ring seal. Although the joint contains two additional O-rings and other safety features to prevent hot gases from escaping, NASA disassembled the motor segments and installed new filler and O-rings. NASA is now considering a number of manufacturing, packaging, and inspection changes to ensure that the filler will stay in place.

The RSRM contractor is implementing a program to further enhance RSRM's safety and reliability. The improvements include upgrades to the propellant mixing and casting facilities, a new final assembly processing facility and operations center, and upgrades to the computer system. Many of these improvements are already completed, and all of them are expected to be in place by December 1994.

The Aerospace Safety Advisory Panel believes the contractor has vastly improved its manufacturing, test, and assembly operations. In 1991, the Panel noted that the contractor had made "impressive strides in the quality of industrial operations" and was continuing efforts to enhance its operations through additional automation and procedural upgrades.[4]

[4]Annual Report, Aerospace Safety Advisory Panel, March 1991.

# Program Cost Increases and Schedule Delays Will Likely Continue

The ASRM cost estimate has increased by about $1.58 billion since the program was authorized, and the schedule for the first flight has slipped by over 2-1/2 years. Program officials believe costs will increase further because the fiscal year 1993 funding level will cause NASA to further stretch out the program schedule.

## ASRM Costs Have Increased

In January 1988, NASA estimated that it would cost about $1.67 billion to develop ASRM. Through July 1992, the program's development cost had increased by about 95 percent to $3.25 billion (see table 3.1).

**Table 3.1: Changes in ASRM Program Cost Estimates**

| Estimate date | Total program estimate (billions) | Reasons for change | Cost increase (millions) |
|---|---|---|---|
| January 1988 | $1.67 | | |
| March 1990 | 2.46 | • Added six flight sets | $510 |
| | | • Added motor hardware | 20 |
| | | • Construction cost increase | 164 |
| | | • Schedule slippage | 101 |
| July 1990 | 2.50 | • Construction cost increase | 36 |
| March 1991 | 2.55 | • Construction cost increase | 50 |
| July 1991 | 3.00 | • Defined requirements | 250 |
| | | • Additional contingency funding | 200 |
| July 1992 | 3.25 | • Additional contingency funding | 250 |

Increases associated with motor development accounted for $881 million of the total increase. The most significant contributor to the development cost increase was NASA's decision to include the production of the first six ASRM flight sets in the development cost estimate. Also, NASA based the initial cost estimate on an insufficient amount of reusable motor hardware to support the flight and test program. In March 1990, NASA increased the estimate to cover the additional hardware. That same month, NASA also increased the estimate to account for a 1-year stretch-out in the development program. In July 1991, NASA again increased the development cost estimate to reflect a better definition of the requirements for the technical challenges associated with the advanced motor's design. This estimate was based on a detailed analysis of ASRM development tasks, whereas previous estimates were based on cost experience with other solid rocket motors.

The construction cost estimate increased by a total of $250 million when NASA reestimated the facility costs after the contract was finalized and added funding for the Stennis test facility and plant equipment. The initial cost estimate was based on the assumption that the development contractor would provide private financing for construction of facilities while subsequent estimates are based on government funding for construction. Since July 1991, NASA increased the contingency funding, or cost reserves, in the estimate by $450 million. Cost reserves had been largely depleted to cover changes in the program up to that time.

## Launch Schedule Has Slipped

Between January 1988 and July 1991, the schedule for the first ASRM launch slipped by 31 months—from July 1994 to February 1997. The slippage was caused by a delay in awarding the development contract (11 months), funding constraints and a reestimate of development program requirements (14 months), and a redesign to strengthen a wall in the propellant mix and motor cast facility (6 months). The wall had to be strengthened to conform to safety requirements.

## Further Cost Increases and Schedule Delays Are Anticipated

The ASRM development cost estimate will increase above $3.25 billion because the fiscal year 1993 funding level will cause NASA to extend the development program by about 22 months. This stretch-out will delay the first flight until December 1998. The program required $520 million in fiscal year 1993 to maintain its existing schedule, but was appropriated $360 million. As a result, much of the development activity planned for fiscal year 1993 will be performed later in the program. When development efforts are performed later than originally planned, the effects of inflation must be considered. In addition, certain fixed costs such as engineering support are incurred for a longer period of time.

The ASRM program director stated that he could not quantify the cost impact of the additional schedule slippage until the program's outyear funding profile is known. He believes adequate funding in fiscal years 1994 and 1995 will help to minimize the increases to the program's total development cost.

# Major Contributors to This Report

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Terry Wyatt, Evaluator

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