United States General Accounting Office

GAO

Report to Congressional Requesters

June 1995

SPACE SHUTTLE

NASA Must Reduce Costs Further to Operate Within Future Projected Funds

GAO/NSIAD-95-118

GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-260706

June 15, 1995

The Honorable William S. Cohen
Chairman, Subcommittee on Oversight
of Government Management and
the District of Columbia
Committee on Governmental Affairs
United States Senate

The Honorable James A. Hayes
House of Representatives

As requested, we reviewed efforts by the National Aeronautics and Space Administration (NASA) to reduce operating costs for the space shuttle program. This report addresses (1) the extent to which shuttle operating costs have been reduced and what changes enabled the reductions; (2) the potential for further cost reductions; and (3) NASA's consideration of the impact, if any, of cost reductions on shuttle safety.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to other interested congressional committees, the Administrator of NASA, and the Director of the Office of Management and Budget. We will also provide copies to others on request.

Please contact me at (202) 512-8412 if you or your staff have any questions concerning this report. Other major contributors are listed in appendix II.

David R. Warren
Director, Defense Management
and NASA Issues

Executive Summary

Purpose

The space shuttle is the single most expensive program in the National Aeronautics and Space Administration's (NASA) budget. In fiscal year 1992, NASA set a goal of substantially reducing the costs to operate the shuttle to provide additional funding for other programs.

The current Chairman, Subcommittee on Oversight of Government Management and the District of Columbia, Senate Committee on Governmental Affairs; and the former Chairman, Subcommittee on Investigations and Oversight, House Committee on Science, Space, and Technology, asked GAO to review NASA's efforts to reduce funding requirements for shuttle operations. The specific objectives were to determine (1) how successful NASA has been in reducing funding for shuttle operations and what changes enabled the reductions; (2) if the potential exists for further reductions; and (3) whether NASA adequately considered the impact, if any, of the reductions on shuttle safety.

Background

The space shuttle has operated for about 14 years and is likely to be used well into the next century. Since it is the nation's only launch system capable of transporting people, the shuttle's viability is critical to other space programs such as the international space station. The shuttle has not lived up to its expectations to make space access routine and inexpensive. In fiscal year 1996, NASA spent about $3.2 billion of its $14.3-billion budget for shuttle production and operations. NASA's Office of Space Flight established a program to reduce shuttle funding requirements and operating costs beginning in fiscal year 1992.

Results in Brief

NASA has made substantial reductions in funding for shuttle operations and plans to make further cuts. However, these additional reductions in some cases are not yet defined. GAO's review showed that NASA reduced (1) cumulative funding for fiscal years 1992 through 1995 by 22 percent from the requirements projected at the time of the fiscal year 1992 budget and (2) actual annual operating costs by 8.5 percent between fiscal years 1992 and 1994—the equivalent of a 12.3-percent reduction after inflation.

Significant additional funding reductions are needed to achieve NASA's future budget projections for shuttle operations. At the time of the fiscal year 1996 budget request, program requirements still exceeded budget estimates by at least 10 percent in fiscal years 1996 through 2000, not including any of the "unresolved percentage reductions" shown in the budget request. Shuttle managers told GAO they were concerned about

their ability to achieve the needed additional reductions, but in February 1995, independent review teams recommended additional ways to reduce costs. NASA has not yet acted on all of the recommendations and does not have an estimate of the savings that may result from them. If NASA cannot reduce shuttle operating costs to match available funds in fiscal years 1996 through 2000, either NASA's budget must be increased or funding for other programs will have to be cut. On May 19, 1995, after completion of GAO's work, the Administrator announced plans for significantly reducing NASA's infrastructure. GAO did not evaluate the potential effect of these changes on shuttle costs.

NASA appears to have adequately considered safety while implementing cost reduction actions to date. However, because shuttle safety cannot be directly measured, it is difficult for NASA to know how much further it can reduce costs without affecting safety. In 1994, two outside review teams expressed concern about the planned size and pace of future cost reductions. However, two different review teams reported in February 1995 that additional reductions were possible without adversely affecting safety. Shuttle program managers have begun to more closely monitor trends in certain indirect safety indicators, such as the numbers of problems in flight and the number of mishaps during processing for flight.

Principal Findings

NASA Has Reduced Funding Requirements for Shuttle Operations

In its fiscal year 1992 budget, NASA estimated $13 billion in cumulative funding would be required to operate the shuttle between fiscal years 1992 and 1995. In the fiscal year 1995 budget, NASA reduced required funding for those years by a cumulative amount of $2.9 billion—22 percent. Reductions have resulted primarily from a combination of decreasing contract labor by increasing operating efficiency (about $1.6 billion), reducing program requirements ($388 million), decreasing the level of funding reserves ($458 million), and making other miscellaneous changes ($417 million). Between fiscal years 1992 and 1994, NASA reduced shuttle operations contract labor by 19 percent—from 19,556 direct equivalent persons to 15,902—by freezing designs, automating processes, eliminating unnecessary paperwork, and implementing other efficiencies. The primary reduction in requirements was a reduction in the planned annual flight rate from 10 to 7 flights. Although NASA planned to fly up to 10 missions a year, it never launched more than 8 in any given year. Other reductions included

decreasing the level of funding reserves available for unforeseen changes and experiencing lower than expected inflation rates.

NASA Has Reduced Actual Shuttle Operating Costs

To some extent, the reductions in funding requirements resulted from eliminating projected cost increases. NASA also reduced the actual operating costs from $2.8 billion in fiscal year 1992 to about $2.6 billion in fiscal year 1994 for the same number of flights—an 8.5-percent decrease. Because the costs decreased over the period, when inflation is taken into account, the 8.5-percent decrease equated to a 12.3-percent decrease in constant dollars.

Further Reductions Will Be Required to Meet Future Budget Projections

To meet its future budget targets, NASA must reduce shuttle operating costs by at least an additional $1.3 billion in fiscal years 1996 through 2000—an average of $250 million a year. For example, the fiscal year 1996 budget for shuttle operations was $258.5 million lower than the estimated funding requirements at the time the budget was submitted to the Congress. The gap between estimated funding requirements and future budgets will be even larger if future shuttle operations budgets must be reduced to compensate for "unresolved percentage reductions" shown in NASA's fiscal year 1996 budget request. NASA has not yet identified how it will accomplish these "unresolved target reductions," totaling $775 million for human space flight activities in fiscal years 1997 through 2000.

NASA's ability to resolve even the $1.3-billion projected shuttle operations funding deficit for fiscal years 1996 through 2000 is uncertain. Some officials are more optimistic than others that needed reductions can be achieved. In February 1995, two reviews reported their recommendations for further ways of reducing costs, but NASA has not acted on all of the recommendations and does not yet have an estimate of the savings expected to result from the reviews. An internal NASA workforce review recommended over 500 changes that, according to the team, will allow NASA to significantly reduce its shuttle labor force. An independent shuttle management review recommended that NASA restructure shuttle program management by consolidating operational activities under a single contractor, more clearly define operating requirements, and limit NASA's oversight of contractor activities.

NASA Considered Safety Implications in Shuttle Changes

All proposed changes to hardware or procedures have been approved through a formal review process that included reviews by independent NASA safety and mission assurance personnel. Some proposed changes were not implemented because the review panel concluded that safety risks were unacceptable. So far, NASA has targeted only noncritical hardware and processes—those which could not result in injury, damage, or loss of mission or life—for cost reduction efforts.

Two external and two internal studies of the safety implications of the cost reduction effort found no adverse safety impact resulting from the reductions. For example, a July 1994 General Research Corporation study concluded that reductions up to that point were a healthy "tightening up" of the program while protecting content and that no instances of safety compromise were found. An October 1994 internal NASA study of trends for 18 measures of shuttle performance that could provide indirect indications of any possible adverse impact of cost reductions concluded that all of the indicators had remained stable or improved.

Outside Review Groups Assess Possible Impacts of Further Reductions

The Aerospace Safety Advisory Panel, in its March 1994 report, and the General Research Corporation, in its July 1994 report, both expressed concern about the pace of future cost reductions. Both studies cited the difficulty of measuring the impact of the reductions on shuttle safety. The Aerospace Safety Advisory Panel stated that future reductions carry a higher probability of affecting safety. The General Research Corporation study concluded that the frequency and rate of budget and budget-driven change experienced by the program decrease the ability to assess impacts and risk. However, both the NASA workforce review and the independent management review team that reported in February 1995 concluded that additional reductions were possible without adversely affecting safety. According to the management review team, because the program has matured since the Challenger accident, shuttle processing requirements and safety oversight can be reduced.

NASA Monitoring Potential Safety Impacts at Higher Management Level

Because of the safety concerns, NASA, in November 1993, asked the General Research Corporation to recommend a system to help monitor the potential impact of funding reductions on safety. NASA did not adopt all of the recommendations, but it did develop its own system similar to the one suggested by the corporation. Although no new measurements are to be made, some data will be analyzed and reviewed at the highest level of shuttle management.

Recommendations

GAO recommends that the Administrator (1) identify any significant unresolved cost reductions in future budget requests so that the Congress can provide oversight and make informed decisions and (2) request an independent organization, such as the National Research Council, to review significant cost reduction actions in future years, in the context of safety tradeoffs.

Agency Comments

NASA concurred with the two recommendations and stated that it had already begun implementing them. (See app. I for a copy of NASA's comments.)

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Abbreviations

GAO	General Accounting Office
NASA	National Aeronautics and Space Administration

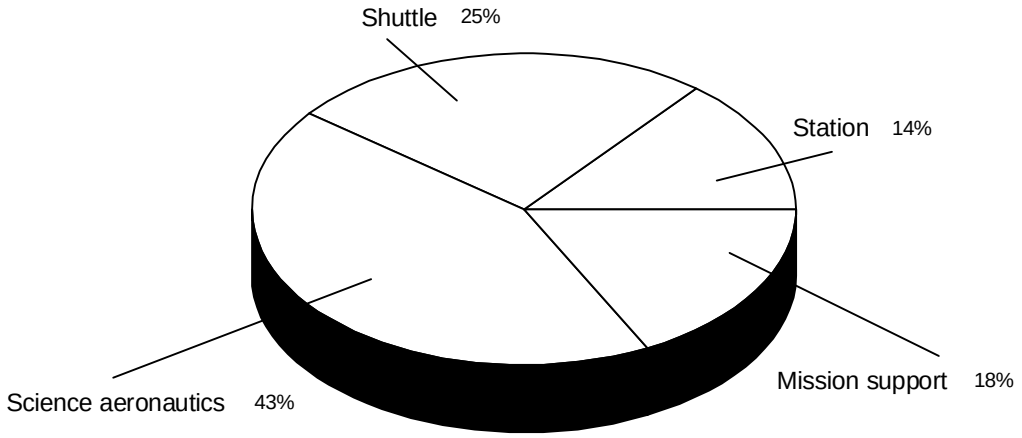
Introduction

The space shuttle has operated for about 14 years and is likely to be used into the next century. It is the only U.S. launch system capable of carrying people to and from space, and its viability is critical to other space programs, especially the international space station. The shuttle—the world's first reusable space transportation system—consists of a reusable orbiter with three liquid fueled main engines, two partially reusable solid rocket boosters, and an expendable external fuel tank. The shuttle is used primarily when human space activities are required.

Shuttle Cost History

The shuttle is the single most expensive program in the National Aeronautics and Space Administration's (NASA) budget. It is estimated to consume about one fourth of NASA's $14.3 billion fiscal year 1996 budget (see fig. 1.1).

Figure 1.1: NASA's Fiscal Year 1996 Budget



Originally intended to make space access routine and inexpensive, the shuttle has not lived up to its expectations. NASA initially planned up to 60 missions a year. Prior to the January 1986 Challenger accident, NASA reduced the target flight rate to 24 per year and after the accident, to 16 per year. After shuttle flights resumed, the target rate was reduced to 10 per year.[1] The budgets for fiscal years 1994 and 1995 supported eight

[1]Although NASA planned for higher flight rates, it never launched more than eight flights in a given year.

flights per year. Reductions in flight rates were based on more realistic estimates, national policy, and funding constraints. As the number of flights decreased, the average cost of operating the shuttle increased significantly. A June 1976 estimate placed the average cost of 572 flights at about $53 million each (in 1995 dollars).[2] In its fiscal year 1995 budget to the Congress, NASA estimated the eight flights planned for fiscal year 1995 would cost an average of $336 million each (in 1995 dollars), an increase of about 534 percent over the 1976 estimate. According to NASA, the cost increase was due primarily to the reduction in the number of flights.

Cost Reduction Goals

In response to tight fiscal constraints, the Deputy Associate Administrator for Space Shuttle, in January 1991, established a program to reduce shuttle funding requirements[3] and operating costs.[4] The goal was to reduce recurring shuttle costs by 3 percent in fiscal years 1992 and 1993 without compromising flight safety. In August 1991, the Space Shuttle Director extended the 3-percent per year reductions through fiscal year 1996. The cumulative reductions would total 15 percent by fiscal year 1996.

In May 1992, the Acting Deputy Administrator implemented a coordinated review of all NASA programs. The objective was to identify additional areas where program costs could be reduced by increasing efficiency, eliminating work no longer required, and prioritizing work that was not mandatory to safely accomplish the flight manifest. The review resulted in an initial target for these additional reductions in shuttle costs of about 8 percent per year between fiscal years 1994 and 1998.

Even further reductions to shuttle funding requirements were directed in fiscal years 1994 and 1995. The Space Shuttle Operations Office first asked shuttle element project managers to identify possible reductions. NASA reduced funding estimates based on these recommendations; however, further reductions would be required based on the funding that would be available. The shuttle program office allocated the remainder of the reductions to each project based on its share of the budget. Project managers were challenged to find further ways to reduce funding requirements.

[2]The June 1976 estimate was $16.07 million in 1975 dollars. To make it comparable with current estimates, we added an allowance for the inflation that occurred between 1975 and 1995 using a factor supplied by NASA.

[3]Funding requirements are estimates of the funding needed to accomplish the planned program in any given time period.

[4]Operating costs are the actual costs to accomplish the program in any given year.

Initially, NASA measured its shuttle funding reductions by comparing the projected funding requirements in the fiscal year 1992 budget request to the projected funding requirements in the budget requests for subsequent years. When NASA submitted its fiscal year 1995 budget to the Congress, NASA began tracking reductions in shuttle operating costs from one year to the next.

Changes in Shuttle Budget Structure

Prior to fiscal year 1995, NASA included space shuttle funding requirements in the Space Flight, Control, and Data Communications category of its budget. Shuttle costs were divided between two lines: shuttle production and operational capability and shuttle operations. Shuttle production and operational capability included nonrecurring or investment costs such as those to modify and improve flight hardware and ground facilities and produce reusable hardware such as liquid fueled main engines. Shuttle operations included recurring costs such as those for production of expendable flight hardware, mission training and support at Johnson Space Center, and shuttle processing and support at Kennedy Space Center.

Beginning in fiscal year 1995, NASA moved shuttle funding to a new appropriations category entitled "Human Space Flight." Again, shuttle funds were included in two lines that closely parallelled the previous budget lines. Nonrecurring costs were included in a line entitled "Safety and Performance Upgrades" and recurring costs were included in a line entitled "Shuttle Operations." Other costs totaling about $243 million in fiscal year 1995 that were formerly included in the shuttle operations line were moved to other budget lines. Payload operation costs were included in a separate line within the Human Space Flight category. Research operation support—support to civil service staff and physical plants at field centers where shuttle operations activities are performed and at NASA headquarters—was moved to a new category entitled "Mission Support."

Objectives, Scope, and Methodology

The Chairman, Subcommittee on Oversight of Government Management and the District of Columbia, Senate Committee on Governmental Affairs, and the former Chairman, Subcommittee on Investigations and Oversight, House Committee on Science, Space, and Technology, asked us to review NASA's efforts to reduce shuttle funding requirements. Our specific objectives were to determine (1) how successful NASA has been in reducing shuttle operating costs and what changes enabled the reductions; (2) if the potential exists for further funding or operational cost reductions; and

(3) whether NASA adequately considered the impact, if any, of cost reductions on shuttle safety.

To evaluate how successful NASA has been in reducing shuttle operating costs, we compared budgets for fiscal years 1992 through 1995 and visited NASA Headquarters and three NASA field centers. In addition, we judgmentally selected cost estimates for five shuttle projects, one directorate, and two operations for detailed review to determine how NASA had achieved the reductions. The budgets of these eight elements constituted an average of 85 percent of NASA's total operating budget for the shuttle. Our analyses were all based on recurring operations costs and, for consistency, we adjusted all of the estimates to reflect the new budget structure. We also discussed efforts to reduce costs with NASA and contractor project managers, business managers, and cost and budget analysts to determine how costs had been reduced for the eight elements.

To determine the potential for further reductions, we reviewed NASA's plans for achieving further reductions and discussed items the agency may have considered but rejected. We also reviewed reports of outside groups and independent assessments of potential reductions and discussed the findings with the outside organizations and with NASA officials.

To evaluate whether NASA adequately considered safety in reducing shuttle operating costs, we reviewed NASA's procedures for evaluating the safety implications of the cost reductions. We discussed specific reductions with safety, reliability, and quality assurance personnel at the project, program, and headquarters levels. We also reviewed independent safety assessments and discussed the findings with NASA officials.

We conducted our audit work at

- Marshall Space Flight Center, Alabama;
- Johnson Space Center, Texas;
- Kennedy Space Center, Florida; and
- NASA Headquarters, Washington, D.C.

We conducted our work between October 1993 and March 1995 in accordance with generally accepted government auditing standards.

NASA Has Reduced Shuttle Operating Costs, but Additional Cuts Are Needed

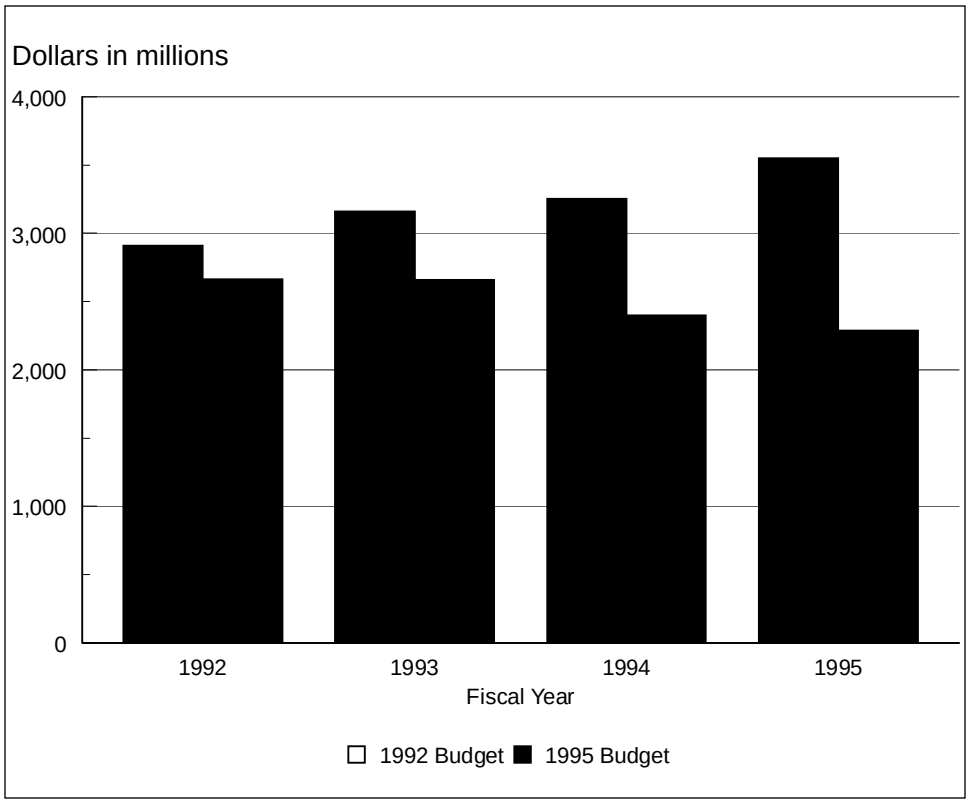
Over the past 3 years, NASA has substantially reduced shuttle funding requirements and operating costs. To achieve future budgets, NASA will have to reduce projected shuttle funding requirements by at least another 10 percent between fiscal years 1996 and 2000. Reductions may be even larger, depending on how NASA allocates "unresolved percentage reductions" for fiscal years 1997 through 2000. Agreement about the likelihood of achieving the projected shuttle operating cost reductions was not universal. Consequently, in 1994, NASA initiated two independent reviews aimed at identifying additional ways of reducing shuttle operating costs. Both groups reported their change recommendations in February 1995, but as of the end of March 1995, NASA had not acted on all of the recommendations and did not have an estimate of the savings expected to result from the changes.

NASA Has Reduced Projected Funding Requirements for Shuttle Operations

Between fiscal years 1992 and 1995, NASA reduced projected shuttle operations funding requirements by 22 percent.[1] In its fiscal year 1992 budget request, NASA projected that annual appropriations required to fund shuttle operations would increase from about $3 billion in fiscal year 1992 to about $3.6 billion in fiscal year 1995. By the time the President submitted his fiscal year 1995 budget request, shuttle operations funding requirements for those years had been reduced by a total of about $2.9 billion from the levels estimated in the fiscal year 1992 budget (see fig. 2.1).

[1]We adjusted all estimates to conform to the structure of the fiscal year 1995 budget.

Figure 2.1: Estimated Shuttle Funding Requirements



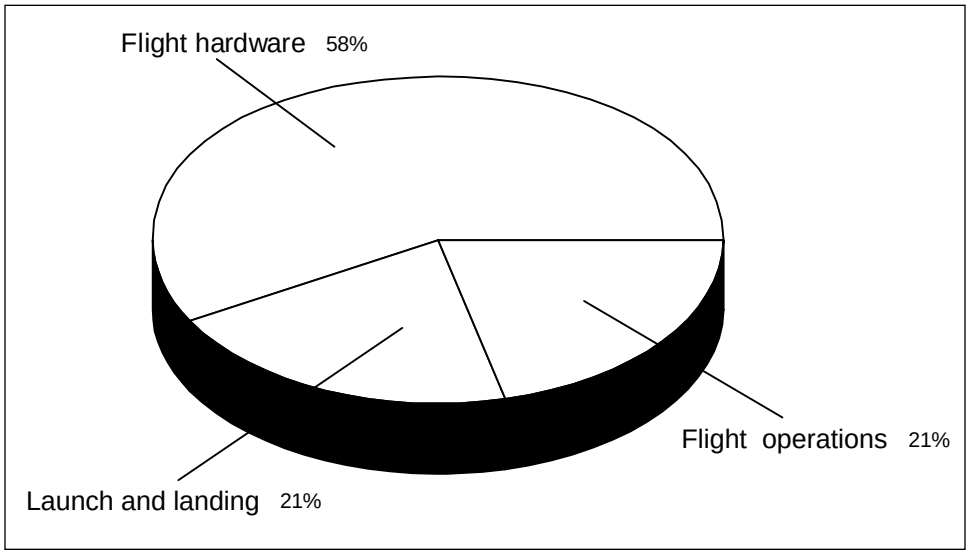
NASA achieved the reductions primarily by making operations more efficient and reducing the planned number of shuttle flights and funding reserves. Using a reasonable methodology, NASA allocated the cost reduction amounts to four categories, which have some interrelationship. Increased efficiency, which translated primarily into reductions in the contractor labor force, accounted for over half of the total reductions. Reduced program content—primarily eliminating some flights between fiscal years 1992 and 1995—accounted for another 13 percent of the reductions. Reduced management reserve funding accounted for another 16 percent, and other miscellaneous changes accounted for the remaining 15 percent.

Increased Efficiency

NASA reduced shuttle operations funding requirements by $1.6 billion through increasing efficiency. The most significant reductions occurred in the production of flight hardware such as the external tank, space shuttle main engines, redesigned solid rocket motor, solid rocket booster, orbiter,

and orbiter spare parts and ground support equipment. Other reductions were about equally spread between launch and landing, which is primarily the processing activities at Kennedy Space Center that ready the shuttle for its next flight, and flight operations at Johnson Space Center, which include mission control, crew training, systems engineering, and other similar activities (see fig. 2.2).

Figure 2.2: Reductions in Projected Shuttle Funding Requirements



Efficiency reductions included a large number of individual changes to each of the shuttle projects and activities. Examples included decreases in some contract fees, reduced material prices, and decreased stockage levels for some spare parts. Decreases in shuttle contractor labor constituted the single largest reduction. The labor reductions were made possible by such actions as freezing the design of major hardware components, reorganizing and combining work tasks, automating some tasks, eliminating unnecessary administrative work, and closing some facilities.

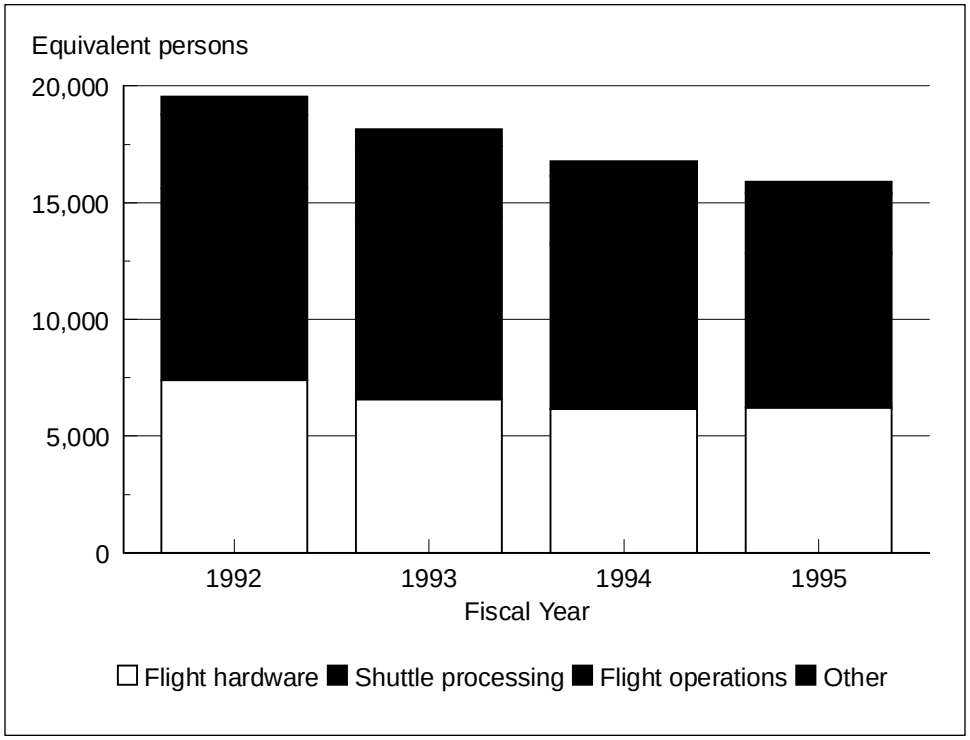
From fiscal years 1992 to 1995, NASA reduced shuttle contractor labor by 3,654 people,[2] a reduction of about 19 percent (see fig. 2.3).[3] The largest

[2]Labor is measured in "equivalent persons." One equivalent person is equal to the number of hours one person could be expected to work in a year less adjustments such as for federal holidays.

[3]The analysis assumes that the contractor will make the reductions currently estimated for fiscal year 1995.

single reduction was in the shuttle processing contract at Kennedy Space Center.

Figure 2.3: Labor Reductions



The contractor that produces the shuttle's external fuel tank reduced its labor force by 300 people from a baseline of 2,328 people in 1992. The reductions were made possible by reducing the flight rate from 12 to 8 per year and freezing the tank's design, except for safety and efficiency changes. As a result, engineering and administrative personnel who were no longer required to process numerous design changes were released.

The redesigned solid rocket motor contractor reduced its labor force by almost 480 people between fiscal years 1992 and 1995 through more efficient operations. The reductions were achieved primarily by automating part of the process for mixing and casting the solid propellants, by constructing a new, more efficient facility for final assembly of motor segments, and by freezing the motor design, except for safety and efficiency changes.

Contractors responsible for launch and landing activities at Kennedy Space Center also found more efficient ways to operate. As a result, the largest of these contractors, the shuttle processing contractor, reduced its workforce by 1,421 people between fiscal years 1992 and 1995. The contractor reduced clerical and administrative personnel, programmers, planners, schedulers, and crafts labor by the highest proportion, and only about 19 percent of the reductions were of "hands-on," or touch labor. For example, the prime contractor analyzed work authorization documents to determine the value of multiple levels of review. If the reviews did not result in added value—such as increased safety or reliability—then one or more of the reviews were eliminated. Technical procedures were not changed and the areas affected were primarily support areas such as logistics, communications, and ground systems engineering.

Contractors performing mission operations and crew training activities also reduced their combined labor forces by almost 590 people between fiscal years 1992 and 1995 through increased efficiency. For example, the Mission Operations Directorate maintains a library of computer tapes containing flight software. Previously, storage and retrieval of the tapes were performed manually. The Mission Operations Directorate now uses an automated system to store and retrieve computer tapes instead of storing and retrieving the tapes manually. The Directorate also merged its software production facility with the Engineering Directorate's software development facility. The merger consolidated facility operations and sustaining engineering under a single contractor and permitted labor reductions.

Reductions in Flight Rates

Lowering the planned number of shuttle flights resulted in a cumulative reduction of $388 million[4] in operations funding between fiscal years 1992 and 1995. At the time of its fiscal year 1992 budget request, NASA planned for 38 flights between fiscal years 1992 and 1995 at a rate of up to 10 flights per year. Funding restraints imposed by several consecutive budgets, however, forced NASA to reduce its planned maximum flight rate to eight a year, which eliminated one flight each planned for fiscal years 1992 and 1993 and two flights each planned for fiscal years 1994 and 1995. Additional funding reductions in fiscal year 1995 caused NASA to reduce the planned number of flights for that year to seven.

[4]The reduction was offset somewhat by an increased cost for the super lightweight external tank, but the net effect was a reduction of $388 million.

Reduced Management Reserve

NASA also reduced the amount of funds it set aside as management reserves by $458 million, or 93 percent, between fiscal years 1992 and 1995. The shuttle program uses these funding reserves to cover unanticipated increases in program requirements not funded in the budget. For example, the external tank must be emptied and then refilled when a launch is rescheduled, which increases the cost for propellants because some of the liquid hydrogen and oxygen is lost during the process. Management reserves may be needed to cover the added costs.

In its fiscal year 1992 budget, NASA projected it would need $474 million in management reserves between fiscal years 1992 and 1995, or about 3.5 percent of the projected funding requirement for those years. Budgets for subsequent years include progressively less funding for reserves. For example, the management reserves budgeted for fiscal year 1995—$17 million—was less than 1 percent of estimated funding for that year.

According to NASA's Shuttle Resources Management Chief, reductions in the level of reserves were possible because the shuttle program's actual costs have been less than available funding in each of the past 5 years. Excess funds have been used to replenish reserves or carried over for use in succeeding fiscal years. The official acknowledged, however, that reduced reserves increase the level of schedule risk in the program. If funds are not available to quickly resolve problems, flights may have to be delayed.

Other Reductions

The remaining $417-million cost reduction resulted from a variety of other changes such as unrealized inflation. For example, in preparing its fiscal year 1992 budget request, NASA anticipated 5 percent inflation each year for the following 3 years. Actual price level increases were less than 5 percent; therefore, NASA did not need as much funding as previously estimated for shuttle operations.

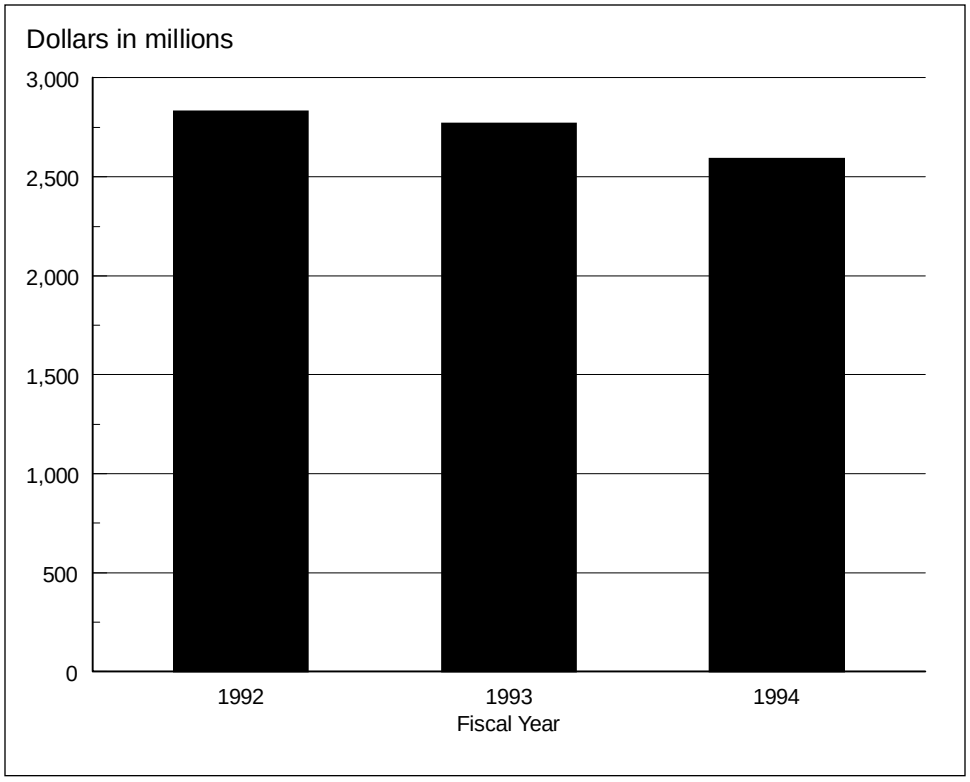
NASA Has Reduced Actual Shuttle Operations Costs

Another measure of NASA's shuttle operations cost reduction effort is changes in the actual costs to operate the shuttle from one year to the next. In that regard, NASA also reduced the actual cost to operate the shuttle between fiscal years 1992 and 1994[5] by 8.5 percent. Considering the general price level increases that occurred in the economy over this period, this reduction equated to a real decrease of 12.3 percent.

[5]Fiscal year 1994 is the latest year for which actual operating costs are known.

NASA processed the shuttle for flight eight times in each of these years.[6] As shown in figure 2.4, operating costs in fiscal year 1992 totaled $2,832.6 million, and in fiscal year 1994, these costs totaled $2,591.8 million, a reduction of $241 million, or 8.5 percent. After adjusting the fiscal year 1992 costs to reflect price level increases that occurred between fiscal years 1992 and 1994,[7] the reduction would be about $363.3 million, or about 12.3 percent, in constant fiscal year 1994 dollars.

Figure 2.4: NASA Reduced Actual Shuttle Operating Costs



Additional Cuts Will Be Needed to Achieve Future Shuttle Budgets

To achieve future shuttle budgets, NASA must continue reducing shuttle funding requirements because the purchasing power of funds available for shuttle operations is expected to decline through the end of the century. Shuttle officials estimate that current funding requirements exceed projected budgets by about $1.3 billion in fiscal years 1996 through 2000,

[6]NASA processed eight flights in fiscal year 1992, but launch of one of the flights was delayed by about 3 weeks into the next fiscal year.

[7]We used the gross domestic product deflator for fiscal years 1992 through 1994 to calculate price level changes.

even after the impact of cost reduction measures to date has been considered.

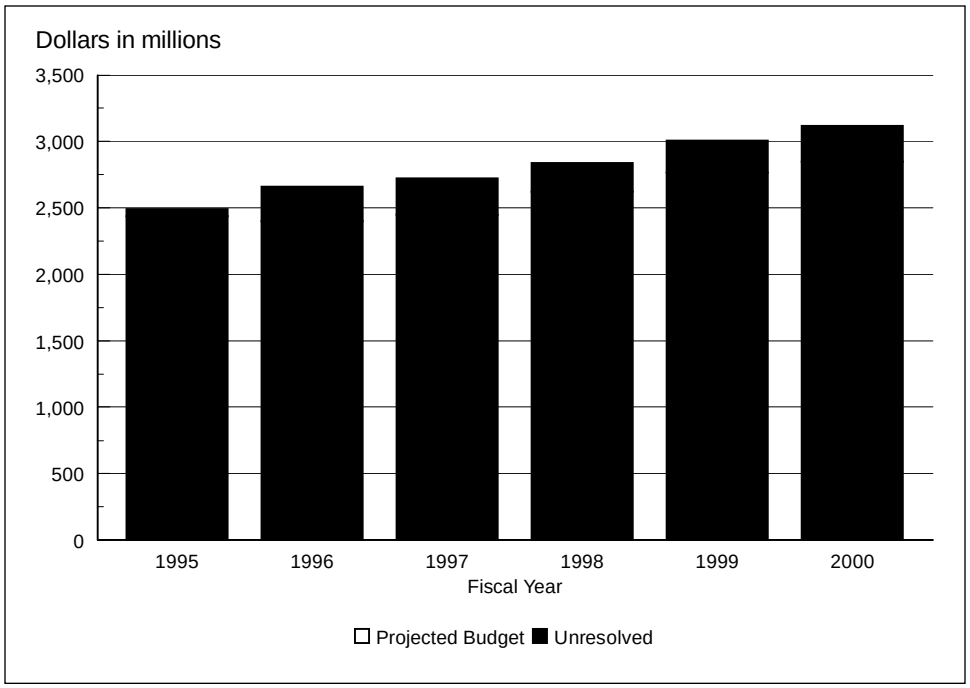
In addition, NASA's fiscal year 1996 budget documents show that NASA expects to reduce human spaceflight costs by another $775 million in fiscal years 1997 through 2000. This reduction is a portion of a $4-billion general reduction to NASA's projected budgets for those years. The reduction was identified in February 1995 when NASA submitted its fiscal year 1996 budget to the Congress. NASA has not yet determined how the reduction will be allocated. If the shuttle program absorbs a portion of the reduction, the shuttle operations funding deficit will increase even further in those years.

NASA estimates that in fiscal year 1995, it will have to reduce shuttle operating costs by $75.3 million below the fiscal year 1994 level. NASA officials told us that they will make the reductions by decreasing the planned number of flights from eight to seven, reducing contractor labor forces even further, consolidating some small contracts, and using funds carried over from prior years. As of February 1995, officials were still projecting a $54.1-million funding deficit for shuttle operations in fiscal year 1995. Officials told us that they were confident they could resolve the deficit by finding additional efficiencies in shuttle operations.

Achieving the reductions that are needed in fiscal years 1996 through 2000 is less certain, however. For example, at the time NASA submitted its fiscal year 1996 budget, it estimated that shuttle operations would cost $258.5 million more than the amount budgeted for that year. NASA estimates that funds available for shuttle operations will rise slightly in fiscal years 1997 through 2000. The increases, however, will not be sufficient to cover forecasted price level increases.

The estimated shuttle operations funding requirements, the funding levels projected to be available in fiscal years 1996 through 2000, and the projected funding deficits for those fiscal years are shown in figure 2.5. The amounts are based on fiscal year 1996 budget documents and do not reflect any impact in available funding that may result from the $775-million general reduction to the human spaceflight budget.

Figure 2.5: Program Requirements Versus Likely Budgets



To achieve the projected budgets, NASA must reduce funding requirements for shuttle operations by an additional 10 percent between fiscal years 1996 and 2000. NASA currently estimates the shuttle program will require a cumulative amount of about $14.3 billion to operate during this time period, but it projects that only about $13.1 billion will be available in its budgets, leaving a funding deficit of about $1.3 billion. The deficit averages about $250 million a year, or about 10 percent of the shuttle operations budget.

NASA officials and outside reviewers agreed that the shuttle program is more efficient than it has ever been, but future efficiencies will be more difficult to achieve. NASA's Administrator has stated that NASA can reduce shuttle funding requirements below current levels. The Administrator and other agency officials point out that NASA had achieved all of the necessary reductions through fiscal year 1994. In addition to achieving the necessary reductions each year since fiscal year 1992, NASA estimated that the shuttle program spent $83 million less than the amount shown in the cost plan in fiscal year 1994. The $83-million underrun will help achieve reductions necessary in fiscal year 1995. The Chief of Shuttle Resources Management told us shuttle managers also hope to underrun the cost plan for fiscal year

1995, thereby generating savings to be applied to the unresolved shuttle funding gap in fiscal year 1996.

Some of the shuttle managers we interviewed told us that, in their view, the only way to achieve significant further reductions was to reduce program requirements, primarily the numbers of flights. According to the Administrator, NASA cannot safely operate the shuttle at fewer than six flights a year. NASA has already reduced the shuttle program to seven flights a year, and eliminating another flight will not be enough to resolve all of the projected $1.3-billion deficit. According to NASA, although it can safely reduce the flight rate from the current seven flights a year to six, there would be a reduction in efficiency, a loss of schedule and surge flexibility, and a serious problem meeting space station assembly and operation requirements.

According to a December 1994 report by the National Academy of Public Administration,[8] the amount that can be saved from reducing the number of shuttle flights depends upon whether the reduction is for a single year or for several consecutive years. Reducing the number of flights in a single year would reduce costs by about $50 million. If, however, the reduction were for several consecutive years—essentially a reduction in the maximum flight rate—annual costs could be reduced between $90 million and $100 million because labor can be reduced to match the reduced flight rate.

Reducing the number of shuttle flights would increase the schedule risk associated with the assembly of International Space Station Alpha, which is projected to begin in fiscal year 1998. The current schedule requires three space station assembly flights in fiscal year 1998 and seven assembly flights in fiscal year 1999. Thus, as assembly of the station progresses, fewer flights can be eliminated without endangering the station assembly schedule.

Many of the shuttle managers we interviewed expressed uncertainty about achieving the cost reductions necessary to match available shuttle operating funds in fiscal years 1996 through 2000. Some of the managers stated they did not know how they would achieve the necessary reductions and still support the flight schedule. For example, the Kennedy Space Center Director wrote in June 1994 that significant funding gaps existed in shuttle operations and that the center could not achieve the

[8]National Academy of Public Administration, A Review of the Space Shuttle Cost, Reduction Goals and Procedures (Dec. 1994).

needed cost reductions and still support the projected flight rate. Similarly, the orbiter project manager told us that the project's ability to achieve the needed cost reductions in fiscal year 1996 and beyond was doubtful. If forced to absorb the reductions, the project manager said that timeliness of decisions and implementation of corrective actions would be adversely affected. He stated that key technical skills were already at the minimum levels required to sustain operations and that reducing the skills base further could affect the planned flight schedules.

In July 1994, the General Research Corporation, under contract to NASA, reported on its review of shuttle cost reductions.[9] The review team concluded that although reductions taken through the end of fiscal year 1993 represented a healthy tightening up of the program, there were no obvious, significant additional reductions that would be easy to achieve. The review did recommend that NASA consider several additional ways of reducing costs, such as combining the external tank, solid rocket booster, and redesigned solid rocket motor projects into a single propulsion project. However, the review team acknowledged that none of the recommended actions would individually resolve the difference between shuttle funding requirements and likely budgets. Also, the National Academy of Public Administration reported in December 1994[10] that most shuttle project managers believe that nearly all of the readily identifiable reduction opportunities have been accomplished and that further reductions will be much more difficult to achieve.

External Reviews Chartered to Identify Additional Reductions

In August 1994, the Administrator directed senior management to comprehensively review contractor and civil service workforces across the agency. NASA's primary objective for the review, known as the "Shuttle Workforce Review," was to develop a understanding of reductions that can be achieved while maintaining safety. In implementing the review, the Associate Administrator for Space Flight instructed the center directors to

- identify every function and person required to safely support the schedule,
- specify areas where changes to shuttle program requirements or plans can lead to savings without jeopardizing safety, and
- forecast the expected savings or cost avoidances to be achieved as a result of ongoing continuous improvement programs.

[9]General Research Corporation, Space Shuttle Budget Allocation Review (July 1994).

[10]National Academy of Public Administration, A Review of the Space Shuttle Costs, Reduction Goals and Procedures (Dec. 1994).

Twelve teams comprised of four to five members, most of whom were independent of the organization and associated management under review, were formed. Each team had representatives for major areas—such as engineering, management, and business—with significant experience related to functions of the organization being reviewed.

In February 1995, the teams reported that they had identified over 500 recommendations for further cost reductions. The recommendations were grouped into six categories:

- eliminating tasks such as all nonessential panels, work groups, and teams that are not value added;[11]
- reducing workforces such as engineering support contractor labor at Kennedy Space Center;
- improving processes such as adopting more efficient flight software development and verification processes;
- eliminating potential overlaps by actions such as consolidating responsibility for institutional activities at Kennedy Space Center;
- shifting some work such as contract administration support from contractors to civil service personnel; and
- making other changes such as closing redundant facilities.

Some of the recommendations require further coordination, but according to the teams, most recommendations can be accomplished during fiscal years 1996 and 1997. NASA does not yet have a firm estimate of the savings that may result from the recommendations, but according to the Office of Space Flight, implementing the recommendations will help reduce the funding gap in future shuttle budgets.

In December 1994, the Administrator established another independent team to review management of the shuttle program. The team, which consisted of aerospace executives, business leaders, and former NASA officials, was charged with evaluating the current processes and procedures for conducting shuttle operations at NASA's various field centers and recommending a new and more efficient operating structure.

In February 1995, the management review team reported its conclusion that significant additional reductions in cost will be difficult without a new and innovative approach.[12] This new approach must transition the current

[11]Not value added means the review did not increase the safety or reliability of the process.

[12]NASA, Report of the Space Shuttle Management Independent Review Team (Feb. 1995).

program to a more operational program and introduce cost-effective operations as a primary goal. To achieve this goal, the review team recommended that NASA (1) establish a clear set of program goals, placing a greater emphasis on efficient operations and payload integration; (2) redefine the management structure, separating development and operations and disengaging NASA from routine shuttle operations; and (3) provide the necessary environment and conditions within the program to pursue these goals. The review team also recommended that NASA consolidate all shuttle operations under a single prime contractor and provide incentives for the contractor to reduce operations cost while maintaining safety of flight and mission success. The team's report did not include any estimate of the savings that might result from its recommendations. NASA has not yet acted on the recommendations.

On May 19, 1995, the Administrator announced plans for significantly downsizing NASA's infrastructure to reduce the cost of agency operations. We did not assess the potential affect of these changes on the shuttle program. One potential action still being studied was to restructure the shuttle program and prepare it for contractor consolidation and privatization.

Conclusion

NASA has substantially reduced shuttle operating costs since it first began cost reduction efforts in fiscal year 1992. However, substantial additional reductions are needed to eliminate gaps between estimated funding requirements and projected budgets for fiscal years 1996 through 2000. While review groups have recommended additional changes to reduce costs, NASA has not acted on all of the recommendations and has no estimate of the savings that will result from the changes. The current funding gaps are not specifically identified in NASA's budget documents, but if they cannot be eliminated, NASA's future budgets will have to increase or funding for other programs will have to decline. Decreasing funds for other programs to eliminate the gaps could disrupt the balance between human spaceflight activities and science, aeronautics, and technology that NASA has sought to achieve.

Recommendation

We recommend that in future budget submissions, the Administrator specifically identify any significant unresolved reductions that remain so that the Congress can provide oversight and make informed budget decisions.

Agency Comments

In commenting on a draft of this report, NASA agreed with our recommendation. NASA indicated that the January 12, 1996, budget cuts were not specifically accounted for by program in the NASA budget submission, due to the late timing of the reductions. However, NASA intends to delineate the various programs' and institutions' share of these reductions in future budget inputs.

NASA Considers Safety Impacts of Cost Reductions

Although there are no direct measures of shuttle safety except for accidents such as the Challenger, there are some indirect indicators. To date, NASA appears to have given adequate consideration to safety in evaluating potential cost reductions. Therefore, only noncritical hardware and processes[1] have been changed, and all potential changes to hardware and processes were formally reviewed by appropriate groups, including NASA's safety and mission assurance organizations, before being implemented. Both internal and external reviews have concluded that the changes have not affected safety. Two groups have cautioned that further reductions on the scale planned by NASA could increase safety risks especially since the impact of changes is difficult to determine. However, both the NASA workforce review and the independent management review team reported in February 1995 that additional reductions were possible without adversely affecting safety. Because of its concern about the possibility that cost reductions could affect safety, higher level NASA managers recently began monitoring some potential, indirect safety indicators.

NASA Considered Safety Implications in Evaluating Shuttle Cost Reductions

NASA's commitment to safety is reflected in the processes it has to ensure that safety is adequately considered. Changes to hardware and processes are reviewed by multiple levels before being implemented. Neither highly critical components nor the processes that support them have been changed to achieve cost reductions. Several groups outside NASA have echoed the agency's commitment to a safe shuttle program. Trends in a number of indirect safety indicators remain stable or improve while operating costs are being reduced.

Potential Changes Reviewed by Appropriate Groups

NASA has an approved and defined shuttle program configuration that is used for a reference point for program planning and as a point of departure for controlling changes. Changes to it must be approved either by NASA or by the contractor, depending on the classification of the change. All configuration changes to flight hardware or software must be authorized by the space shuttle program or one of its projects. Changes that affect safety must be forwarded to the Space Shuttle Program for disposition.

The space shuttle configuration control structure consists of three levels. The Associate Administrator for Space Flight and the Deputy Associate

[1]Noncritical hardware and processes are those for which no injury, damage, or loss of mission or life would result from a failure.

Administrator for Space Shuttle provide strategic guidance, programmatic oversight, budget and procurement direction, and external advocacy for the program. The Director of Space Shuttle Operations manages the day-to-day operations of the program, including the integration of the various shuttle program elements. Project managers at Johnson and Kennedy Space Centers and at Marshall Space Flight Center manage the design, qualification, and manufacturing associated with their projects and control specifications and changes to them. At the contractor level, those charged with project implementation are responsible for design, development, manufacture, test, qualification, and certification of certain contract end items.

The ultimate controlling authority for all changes to the space shuttle program baseline is the Space Shuttle Program Requirements Control Board. The board has delegated authority to make decisions about certain changes to the baseline to other boards. The Mission Integration Control Board decides about changes to mission integration requirements such as those with impacts to standard launch or landing processes and flows. At the project level, a number of configuration control boards represent the controlling authority for changing baselines for the hardware elements, flight support equipment, payload ground support equipment, and launch and landing. Several other boards control changes in areas such as crew procedures.

Membership varies somewhat among the boards. Generally, members represent areas such as engineering, integration, NASA and contractor management and safety, reliability, and quality assurance. We reviewed the paperwork associated with several proposed changes and found that in all cases, the boards included a member of the safety, reliability, and quality assurance community.

All proposed changes to the baseline must be documented, evaluated, coordinated, and either implemented or disapproved. Changes proposed by the contractor must be documented and must provide, among other information, the impact of the proposed changes on safety, reliability, quality assurance, test, operations, and logistics. Baseline changes proposed by a NASA organization must include the same minimum data as changes proposed by the contractor. Engineering change proposals are submitted to the project office, which in turn submits the proposals to the appropriate configuration control board. Any changes affecting space shuttle program baselines or another project must be decided upon by the board.

In addition to the various control boards, there is a System Safety Review Panel that provides an independent review of proposed changes presented to the Program Requirements Change Board. The panel was established as a result of the presidential commission that investigated the Challenger accident and has been functioning since the shuttle program resumed flights. Its membership includes a number of mandatory members of the safety community from the centers, some projects, and the Department of Defense. In addition, prime contractors serve as advisory members, and safety representatives from NASA headquarters observe the panel's proceedings.

We reviewed several proposed cost reductions to determine if they were handled in accordance with applicable procedures. All of the changes we reviewed were processed in accordance with procedures. Some of these changes were approved while others were not approved because of safety concerns.

In some cases, proposed cost reductions were not approved because of their potential adverse impact on safety. For example, the external tank project office directed the prime contractor to propose an engineering change that would eliminate nearly all of the x-ray inspections of tank welds done before tank proof testing. The change, if approved, would have reduced tank costs by about $3 million. The contractor's initial analysis concluded that 92 percent of the x-ray inspections of the welds done before proof testing could be eliminated because the weld process had never produced defects that were not otherwise identified. An analysis by NASA engineers, however, raised concerns that critical flaws could escape detection by other means and could cause a leak or burst either in proof testing or in flight. A leak or burst occurring during testing could lead to the loss of a facility and in-flight would likely be catastrophic. Consequently, the project configuration control board disapproved the change.

Only Noncritical Changes Considered

Through March 1995, NASA had targeted only noncritical hardware and processes for cost reduction changes. All of the project managers stated that neither highly critical hardware items nor processes would be considered in the future to accommodate reductions.

Shuttle hardware is categorized according to its criticality, or the potential effect of its loss. Hardware items are categorized according to the worst possible result of their failure to perform a required function within limits,

under conditions, and for the duration specified. Level 1 criticality could lead to the loss of life or vehicle, criticality 2 to the loss of a mission or the failure of a redundant item that could cause the loss of life or a vehicle, and all others are criticality 3.

Hardware functions are categorized according to the effect of loss of all redundancy for that particular function. Functional criticality includes the above definitions for levels 1, 2, and 3, plus an intermediate level between levels 1 and 2 and between levels 2 and 3. Criticality 1R relates to redundant hardware items that, if all failed, could cause the loss of life or vehicle. Criticality 2R failures are redundant hardware items that, if all failed, could cause the loss of mission.

None of the most critical hardware on the external tanks, main engines, redesigned solid rocket motors, solid rocket boosters, or orbiters has been changed to reduce cost. In some cases, redesign of hardware resulted in a coincidental cost reduction. For example, on the solid rocket booster, a single length of tubing replaced two pieces, which increased the safety and reliability of the part and decreased cost.

The Orbiter Logistics Office has not changed any program requirement to achieve cost reductions. The only changes implemented to date have involved delivery schedules and the length of time to effect repairs. Support levels for some highly critical items have been lowered. The logistics office considers the criticality of the hardware when buying spare parts or prioritizing repairs. However, such considerations do not impact safety. Neither has the Mission Operations Directorate considered changing any highly critical items or processes.

Key Shuttle Indicators Remain Stable or Improve

In October 1994, the Director for Safety and Risk Management of NASA's Office of Safety and Mission Assurance reviewed and reported on trends in 18 measures of performance in the space shuttle program since shuttle flights resumed. The analysis was in response to questions raised by the Congress and the Administrator concerning the existence and monitoring of indicators to gauge the safety and mission assurance of the shuttle program because of recent budget and personnel reductions. While these trends do not directly measure shuttle safety, they can provide indications of problems, according to a NASA safety official. A preliminary assessment of the indicators did not identify any adverse trends.

All elements of the space shuttle program track certain key performance indicators continuously. These indicators show trends that may be indicative of incipient problems when interpreted in the context of engineering and management judgment. Such trends are not, in isolation, used to judge shuttle safety, but according to the Safety and Mission Assurance officials, the trends can identify areas where further study may be warranted. Other processes, such as pre-launch assessment reviews, flight readiness reviews, mission safety evaluations, and management involvement provide for the assessment of overall shuttle safety.

The review analyzed trends in 18 different measures in 12 areas of shuttle operations, including launch attempts, processing, logistics, and problems reported prior to or during flight. Each trend was summarized graphically and the data interpreted. NASA's Safety and Risk Management Division selected the 18 indicators charted in this review. Some of the indicators selected were those highlighted by the report of the presidential commission on the Challenger accident.

One indicator reviewed was the number of launches attempted or scrubbed[2] over a period of time. This trend could provide an indication of shuttle processing quality and the effectiveness of pre-launch and flight readiness reviews in detecting potential problems. Between the resumption of shuttle flights and the end of 1991—just before the first round of reductions—the trend showed an average of 1.7 attempts per launch, excluding weather scrubs. Between 1992 and October 1994, the trend declined slightly, to an average of 1.6 attempts per launch. An increase in the number of scrubs over a period of time might have indicated that processing quality had declined, but a more thorough review would have been required to determine the reasons.

Another potential indicator of declining quality is the number of problems reported with the flight hardware elements during processing for any given flight. This trend could indicate system quality and reliability problems. Since 1991, the total number of problems for a given flight has remained well within established upper and lower control limits, with the exception of the first flight of a new orbiter and the first flight after the maintenance down period for other orbiters. Exceeding either limit would probably have warranted a more thorough review to determine the cause. Upper and lower control limits are periodically reviewed and adjusted to reflect improved performance.

[2]A scrub is a delay of 24 hours or more after the start of countdown for launch.

One indicator that concerned the presidential commission investigating the Challenger accident was overtime on the shuttle processing contract. Tracking the percentage of overtime provides insight into workloads that may have an effect on performance and schedule. Prior to the Challenger accident, overtime on this contract was between 20 percent and 26 percent. After the accident, additional labor was hired, and overtime rates dropped significantly, to about 13 percent. Despite a decrease in the number of labor hours expended to process each mission, overtime has not increased. Between September 1992 and January 1995, overtime decreased from 9 percent to 3 percent.

Outside Groups Have Concluded That Safety Has Not Been Adversely Affected

The Aerospace Safety Advisory Panel conducted an annual review of NASA between February 1993 and January 1994.[3] The panel recognized NASA's continued strong commitment to safety but stated that the impact on safety of organizational and budget changes will be significantly more difficult to assess. The panel noted that although the shuttle processing contractor had eliminated more that 1,200 positions since September 1991, reductions had been made without any apparent adverse impact on safety.

In 1994, the General Research Corporation reviewed shuttle cost reduction efforts to assess whether actual or planned cost reductions or functional changes across the program could have a significant impact on risk. The review team reported in July 1994 that the cost reductions through fiscal year 1993 were a healthy "tightening up" while protecting content and no instances of compromise were found.

Preliminary results from an internal study are also consistent with the outside reviews. The internal study, known as the Shuttle Workforce Review, was chartered in September 1994 to, among other objectives, identify any adverse consequences of cost reductions to date. In February 1995, the workforce review teams reported that the last 3 years of program reductions have not created any unacceptable safety holes.

Reviews Assess Risk of Continued Reductions

Both the Aerospace Safety Advisory Panel and the General Research Corporation expressed concern about the safety implications of future projected cost reductions. However, the shuttle workforce review and the independent management review team have concluded that further cuts are possible without jeopardizing safety.

[3]The Aerospace Safety Advisory Panel, Annual Report (Mar. 1994).

The Aerospace Safety Advisory Panel expressed concern that even though reductions already made to the shuttle processing contract had not adversely affected safety, comparable further reductions called for by the end of fiscal year 1995 could not be made without a higher probability of affecting safety. The panel recommended that NASA and contractor management remain vigilant and vocal in avoiding unacceptable impacts on safety as a result of cost reductions planned for fiscal year 1995 and beyond. The panel also indicated in a letter to the Associate Administrator for Space Flight that the key to monitoring the safety of the program is not just in reviewing metrics but fostering good communication with the managers throughout the system.

The General Research Corporation also found that safety had not been compromised by reductions made to date. The corporation, however, stated that the frequency and rate of budget and budget-driven change experienced by the program decreases the ability to assess impacts and risks. According to the review team, the program needs time to plan and implement changes prior to taking on additional reductions.

In February 1995, both the internal shuttle workforce review and the independent management review team recommended additional program changes to reduce costs. The workforce review made over 500 recommendations that, according to the teams, contained no significant safety impacts when taken individually. The management review team recommended a new program management structure. According to this team, as a result of the Challenger accident, NASA created a safety environment that is duplicative and expensive. Managers, engineers, and business people are reluctant to make decisions that involve risk because of the "fear of persecution," according to the management review team. As a result, a parallel and independent safety, reliability, and quality assurance element has grown to large proportions. According to the review team, to achieve significant cost reduction, NASA must restructure and streamline safety, reliability, and quality assurance throughout the shuttle program, maintaining only the necessary checks and balances. The management review also recommended that NASA review shuttle requirements with the goal of significantly reducing checkout and other requirements based upon operations experience.

NASA Monitors Potential Safety Indicators at Higher Levels

In 1994, NASA contracted with the General Research Corporation to develop and demonstrate a system of metrics to monitor the impact of changes on shuttle schedule, performance, and safety and recommend a system to improve the measurement of space shuttle program performance and risk. The task included identifying any key indicators that would provide broad performance metrics, standards for risk assessment, and a management analysis process. The corporation identified five areas that were key to assessing shuttle program performance—program management, logistics, engineering, flight crew preparation, and operations. The operations area was further broken down into personnel, hardware, and schedule.

Within each area, the corporation identified metrics that would indicate the overall status for each area. The corporation identified a total of 32 metrics distributed across the five areas. It also recommended potential sources for the data to be analyzed and provided a means for scoring each metric as being satisfactory, having minor weaknesses, having major weaknesses, or having major problems. In addition, arrows indicated whether the trend was improving, worsening, or remaining stable.

NASA did not adopt all of the recommended metrics. Instead, the then Associate Administrator for Space Flight tasked the Deputy Associate Administrator to establish a team to review the recommendations. The team presented its recommendations to the Deputy Associate Administrator who then decided which metrics were key and should be tracked. From the original 32 metrics, the team recommended tracking in-flight anomaly history, space shuttle monthly cost rate, maintenance trend analysis report, total mishaps at Kennedy Space Center, orbiter system and line replaceable unit problem reports, waivers of the processing criteria, overtime for the shuttle processing contract, and errors in the Kennedy Space Center and shuttle processing contractor's structured surveillance system.

NASA currently tracks all of these trends as well as others. The difference is that the identified trends are singled out as key and are subject to a scoring system similar to the one the corporation suggested. The team also recommended parameters outside of which the metric would be coded as other than satisfactory.

One key difference between the system recommended by the contractor and the one NASA is considering is the level at which the trend data is reviewed and scored. The corporation recommended the analysis and

coding at the project level, and NASA believes that the project managers already track these metrics and many more. The Deputy Associate Administrator (Space Shuttle) believes that the purpose of the headquarters metrics is to supplement existing programmatic communications systems with a few key indicators of program health.

Conclusion

Except for accidents like Challenger, NASA has no direct measure of shuttle safety, but it has placed substantial emphasis and effort into considering the safety implications of cost reduction actions to date. However, the absence of any direct safety measure makes continued reductions progressively riskier. Nonetheless, because of NASA's declining budgets, pressure to cut costs will no doubt remain high. Some external reviewers have advised more caution in the cost reduction effort while others have recommended additional reductions, including eliminating what they view as duplicative and unnecessary safety, reliability, and quality assurance activities. Because of concern about the possible impact of the reductions on safety, NASA managers are more closely monitoring possible indirect indicators of safety problems. An independent assessment of proposed cost reduction approaches may prove helpful in the critical and complex task of balancing the need to reduce costs and the need to maintain safe shuttle operations.

Recommendation

Because the potential safety impact of cost reduction changes cannot be measured directly, we recommend that the Administrator request an independent organization, such as the National Research Council, to review significant cost reduction actions to be taken in the future. This organization could bring added objectivity because it would not be subject to the same cost reduction measures that all NASA employees are experiencing.

Agency Comments

In commenting on a draft of this report, NASA agreed that an independent entity should review the possible safety implications of the cost reductions. According to NASA, it has asked the Aerospace Safety Advisory Panel to undertake this effort.

Comments From the National Aeronautics and Space Administration

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

MAY 2 1995

Mr. Henry L. Hinton, Jr.
Assistant Comptroller General
General Accounting Office
Washington, DC 20548

Dear Mr. Hinton:

We have reviewed the GAO Draft Report, "Space Shuttle: NASA Must Reduce Cost Further to Operate Within Future Projected Funds." NASA concurs with the two GAO recommendations and has begun implementation. As your study indicated, the Space Shuttle program has been aggressive in identifying and implementing program efficiencies and cost reductions. NASA will keep the Congress fully informed of these events as we endeavor to meet the challenges of future budget targets.

Enclosed are NASA's comments to the GAO Draft Report. If we can be of further assistance, you may call Kristen Erickson at 358-1017.

Sincerely,

J. R. Dailey
Acting Deputy Administrator

Enclosure

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUBJECT: Draft GAO Report "Space Shuttle-- NASA Must Reduce Cost Further To Operate Within Future Projected Funds," Dated April 11, 1995 (GAO/NSIAD-95-118)

A. General Comments:

We appreciate the very substantial effort expended by the GAO to review NASA's actions to reduce operating costs for the Space Shuttle program. The GAO study is one of six major independent reviews of the Space Shuttle program that have been performed since July 1994. The five independent reviews, chartered by NASA, recommended improvements to our management structure and identified areas in which we might reduce costs. As GAO stated, throughout all of the review teams' recommendations, maintenance of Shuttle safety has not been compromised, and we have adequately considered safety while implementing cost reduction actions. We will continue to do this. Indeed, it is our number one priority for future implementation of all management and cost revisions.

The management improvement and cost-reduction studies have now been considered and are being integrated by the Office of Space Flight (OSF) Management Council. They will determine the best processes and infrastructure and the optimum timing and methods to implement the proposed recommendations. The NASA Administrator, Daniel S. Goldin, will review their recommendations and begin implementation as early as the spring of 1995. Further, Mr. Goldin has already tasked the Aerospace Safety Advisory Panel (ASAP) to review all proposed and implemented changes to assure him that safety is not affected as costs are reduced.

B. NASA's Comments to the GAO Recommendations:

1) GAO recommends that the Administrator identify any significant, unresolved cost reductions in future budget requests, since such funding gaps can disguise overall Agency funding problems and make congressional oversight difficult.

NASA agrees. This information has been provided to the Congressional Authorization Staff in a review of the FY 1996 budget submission. The January 12, 1995, budget cut was not specifically accounted for by program in the NASA budget submission, due to the late timing of the reductions. However, NASA intends to delineate the various programs' and institutions' share of this reduction in future budget inputs.

Until the final cost reductions and organizational changes are approved, NASA will not have a firm estimate of the savings that will result. As these savings are determined, we will be able to identify cost reductions each year as the NASA budget is submitted to Congress.

2) GAO recommends that the Administrator request an independent organization, such as the National Research Council (NRC), to review significant cost reduction actions in future years, in the context of safety tradeoffs.

NASA agrees that an independent entity should review the possible safety implications of our cost reductions, and in fact, the ASAP has already undertaken this effort.

The previous NASA funded NRC study was very valuable to NASA. However, their final recommendations were not available for over 2 years. In view of the Agency's direction to streamline operations and reduce costs, ASAP will perform safety oversight, resulting in the least disruption to the Shuttle program. The ASAP's knowledge of the program will expeditiously enable it to go directly to the civil service and contractor employees and their managers concerning any matter it wishes to investigate. In summary, the ASAP is on board, is strongly independent, and knows where to go and what to do. ASAP is certainly the best group to accomplish NASA and GAO objectives.

C. Other NASA Recommendations and Clarifications:

Now on p. 3.

1. Page 3, paragraph 1, insert the following after the next to last sentence. *It should be noted that the actual achieved flight rate only reached eight flights in calendar year 1992, so that the real reduction was from eight to seven flights.*

Now on p. 5.

2. Page 4, last paragraph, the reference made to an "August 1994 internal NASA study of trends for 18 measures of shuttle performance..." refers to a publication of the Safety and Risk Management Division, Office of Safety and Mission Assurance, entitled "Space Shuttle Trends." Editions of this document were published in May, August, and October 1994. On page 26, paragraph 3, reference is made to the same document but to the October 1994 edition. Both pages 4 and 26 should refer to the same edition of the document.

Now on p. 31.

2

Now on p. 10.

3. Page 7, paragraph 3, add the word *"target"* in front of "flight rate" in line 4, and in front of *"rate"* in line 6. Also add to the end of the fourth sentence *... but only eight flights were actually flown in calendar year 1992. That was the maximum flight rate achieved.*

Now on p. 23.

4. Page 19, paragraph 2, states "According to the NASA Administrator, NASA cannot safely operate the Shuttle at fewer than six flights a year." NASA can safely reduce to a minimum rate of six flights per year, but there will be a reduction in efficiency, a loss of schedule and surge flexibility, and a serious problem with Space Station assembly and utilization requirements.

Now on p. 28.

5. Page 24, paragraph 1, second sentence, should be replaced with the following statement. *The Headquarters-badged Director of Space Shuttle Operations manages the day-to-day operations of the program, including the integration of the various Shuttle program elements. In Washington, both the Associate Administrator for Space Flight and the Deputy Associate Administrator (Space Shuttle), provide the strategic guidance, programmatic oversight, budget and procurement direction, and external advocacy for the program.*

Now on p. 34.

6. Page 28, paragraph 1, insert the following statement after the first sentence. *ASAP also indicated in a letter to the Associate Administrator for Space Flight that the key to monitoring the safety of the program is not just in reviewing metrics but fostering good communications with the managers throughout the system.*

Now on p. 35.

7. Page 30, paragraph 2, delete the second and third sentence and replace with the following statements. *The corporation recommended the analysis and coding at the project level, and NASA believes that the project managers already track these metrics and many more. The Deputy Associate Administrator (Space Shuttle) believes that the purpose of the Headquarters metrics are to supplement existing programmatic communications systems with a few key indicators of program health.*

In summary, NASA agrees that sustantial effort has been made to reduce the Space Shuttle program funding, while maintaining safety as the top priority. In fact, during the course of the lengthy GAO study, NASA has identified and implemented several options to enable it to streamline operations.

3

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