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Shuttle Fleet's Safe Return to Flight Is Key to Space Station Progress

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Highlights

Highlights of GAO-04-201T, a testimony before the Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate

NASA

Shuttle Fleet's Safe Return to Flight Is Key to Space Station Progress

Why GAO Did This Study

Since its inception, the International Space Station has experienced numerous problems that have resulted in significant cost growth and assembly schedule slippages. Following the Columbia accident and the subsequent grounding of the shuttle fleet in February 2003, concerns about the future of the space station escalated, as the fleet has been key to the station's assembly and operations.

In August 2003, the Columbia Accident Investigation Board drew a causal link between aggressive space station goals—supported by the National Aeronautics and Space Administration's (NASA) current culture—and the accident. Specifically, the Board reported that, in addition to technical failures, Columbia's safety was compromised in part by internal pressures to meet an ambitious launch schedule to achieve certain space station milestones.

This testimony discusses the implications of the shuttle fleet's grounding on the space station's schedule and cost, and on the program's partner funding and agreements—findings we reported on in September 2003. The testimony also proposes a framework for providing NASA and the Congress with a means to bring about and assess needed cultural changes across the agency.

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What GAO Found

Since the grounding of the shuttle fleet last February, the space station has been in a survival mode. Due to the limited payload capacity of the Russian launch vehicles—which the program must now rely on to transport crew and supplies to and from the station—on-orbit assembly is at a standstill and on-board research has been limited. Moreover, certain safety concerns on board the station cannot be corrected until the shuttle fleet returns to flight. For example, NASA has had to delay plans to fly additional shielding to protect the on-orbit Russian Service Module from space debris—a risk that increases each year the shielding is not installed.

To date, NASA has not fully estimated the increased costs and future budget impact incurred due to the grounding of the space shuttle fleet. However, it projects that additional costs of maintaining the space station while the shuttle fleet is grounded will reach almost $100 million for fiscal years 2003 and 2004. It has also identified a number of factors that will affect costs—including the need to extend contracts to complete development and assembly of the station. Delays in completing the assembly of the station—which will be at least 2 years—are likely to incur significant additional program costs. At the same time, partner funding is uncertain, which may result in NASA paying a larger share of certain program costs.

Although the full impact of the shuttle fleet's grounding on the space station is still unknown, it is clear that the station's future is dependent on the shuttle fleet's return to flight. NASA must carefully weigh this future against the risks inherent in its current culture. As we reported early this year, NASA's organization and culture has repeatedly undermined the agency's ability to achieve its mission. The Columbia Accident Investigation Board similarly found that NASA's history and culture have been detrimental to the shuttle fleet's safety and that needed improvements at NASA go beyond technical enhancements and procedural modifications. The cultural change required for NASA to consider the numerous technical and administrative recommendations made by the Board could be the agency's greatest challenge to date.

In an effort to help NASA as it undergoes this change—and the Congress as it assesses NASA's future corrective actions—we have provided a framework for establishing appropriate operating principles and values and program direction, securing and maintaining a sufficient and skilled workforce, establishing proper performance targets, and ensuring adequate monitoring.

Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the challenges facing the International Space Station in the wake of the Columbia accident. The grounding of the shuttle fleet this past February escalated concerns about the future of the space station—which, since its inception, has experienced numerous problems that have resulted in significant cost growth and assembly schedule slippages. The shuttle fleet has been key to the station's assembly and operations, and without it, the program must rely on Russian launch vehicles to transport crew and supplies to and from the station. As requested, my testimony today will discuss the implications of the shuttle fleet's grounding on the space station's schedule and cost and on the program's partner funding and agreements—findings we reported on to the full Committee in September 2003.[1]

You asked how the Congress can assess the cultural changes that the National Aeronautics and Space Administration (NASA) is considering as the agency proceeds with its efforts to safely return the shuttle fleet to flight. As you know, the Columbia Accident Investigation Board reported in August 2003 that in addition to technical failures, Columbia's safety was compromised in part by the shuttle program's fluctuating priorities and arbitrary schedule pressures to achieve certain space station milestones.[2] The Board characterized NASA's emphasis on maintaining the launch schedule to support construction of the station as a "line in the sand" and found evidence that structural inspection requirements for the shuttle were reduced and other requirements were deferred in order to meet an ambitious schedule. NASA's recent revision to its return to flight plan recognizes that to ensure safety in all its programs, a cultural change is needed across the agency. Today, I am proposing a framework intended to provide NASA and the Congress with a means to assess cultural change in the context of NASA's overall mission.

In summary, the grounding of the shuttle fleet last February has basically put the space station in a survival mode. Due to the limited payload capacity of the Russian launch vehicles, on-orbit assembly is at a standstill and on-board research has been limited. Moreover, certain safety concerns on board the station cannot be corrected until the shuttle fleet returns to

[1] U.S. General Accounting Office, *Space Station*: *Impact of the Grounding of the Shuttle Fleet*, GAO-03-1107 (Washington, D.C.: Sept.12, 2003).

[2] Columbia Accident Investigation Board, *Report Volume 1* (Washington, D.C.: Aug. 2003).

flight. NASA estimates that additional costs of maintaining the space station while the shuttle fleet is grounded will reach almost $100 million for fiscal years 2003 and 2004. However, significant additional program costs are likely to be incurred because completing assembly of the station will be delayed by at least 2 years. At the same time, partner funding is uncertain—which may result in NASA paying a larger share of certain program costs—and partner agreement on the final station configuration has been delayed by approximately one year.

While the space station's future is clearly dependent on the shuttle fleet's return to flight, NASA must carefully weigh this future against the risks inherent in its current culture. As we reported in January 2003, NASA's management challenges and risks reflect a deeper need for broad cultural change to eliminate organizational stovepipes and hierarchy, which have repeatedly undermined the agency's ability to achieve its mission.[3] The Columbia Accident Investigation Board similarly found in its August 2003 report that NASA's history and culture resulted in organizational practices that have been detrimental to the shuttle fleet's safety. The cultural sea change required for NASA to consider the numerous technical and administrative recommendations made by the Board could be the agency's greatest challenge to date. In an effort to help NASA as it undergoes a cultural change—and the Congress as it assesses NASA's future corrective actions—we have provided a framework for establishing appropriate operating principles and values and program direction, securing and maintaining a sufficient and skilled workforce, establishing proper performance targets, and ensuring adequate monitoring.

Background

In 1998, NASA and its international partners—Canada, Europe, Japan, and Russia—began on-orbit assembly of the International Space Station, envisioned as a permanently orbiting laboratory for conducting materials and life sciences research and earth observations under nearly weightless conditions. The International Space Station program has three key goals: (1) maintain a permanent human presence in space, (2) conduct world-class research in space, and (3) enhance international cooperation and U.S. leadership through international development and operations of the

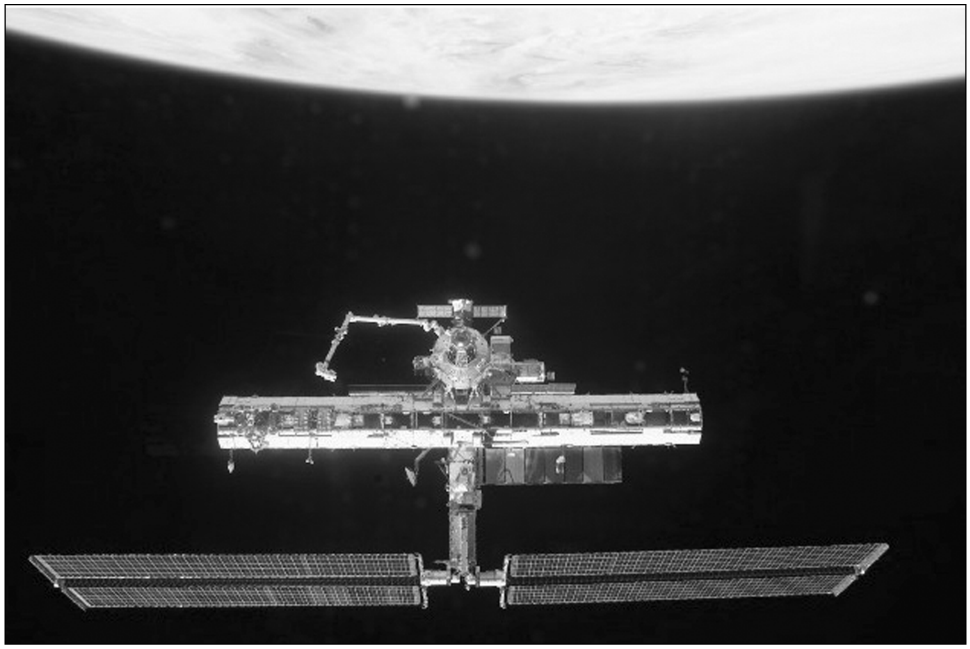
[3] U.S. General Accounting Office, *Major Management Challenges and Program Risks: National Aeronautics and Space Administration*, GAO-03-114 (Washington, D.C.: Jan. 2003).

space station. Each of the partners is to provide hardware and crew, and each is expected to share operating costs and use of the station.[4]

Since October 2000, the space station has been permanently occupied by two or three crewmembers, who maintain and operate the station and conduct hands-on scientific research. The space station is composed of numerous modules, including solar arrays for generating electricity, remote manipulator systems, and research facilities. The station is being designed as a laboratory in space for conducting experiments in near-zero gravity. Life sciences research on how humans adapt to long durations in space, biomedical research, and materials-processing research on new materials or processes are under way or planned. In addition, the station will be used for various earth science and observation activities. Figure 1 shows the International Space Station on orbit.

[4] In 1996, NASA and the Russian Aviation and Space Agency signed a "balance protocol" listing the services that each side would provide to the other during assembly and operations.

Figure 1: International Space Station On Orbit



Source: NASA.

Since fiscal year 1985, the Congress has appropriated a total of about $32 billion for the program. When the station's current design was approved in 1993, NASA estimated that its cost would be $17.4 billion.[5] By 1998, that estimate had increased to $26.4 billion. In January 2001, NASA announced that an additional $4 billion in funding over a 5-year period would be required to complete the station's assembly and sustain its operations. By May 2001, that estimated cost growth increased to $4.8 billion. In an effort to control space station costs, the administration announced in its February 2001 Budget Blueprint that it would cancel or defer some hardware and limit construction of the space station at a stage the administration calls "core complete."

In November 2001, the International Space Station Management and Cost Evaluation Task Force—appointed by the NASA Administrator—made a number of recommendations to get costs under control. NASA implemented most of the recommendations, and the task force reported in December 2002 that significant progress had been made in nearly all

[5] All amounts are stated in current-year dollars.

aspects of the program, including establishing a new management structure and strategy, program planning and performance monitoring processes, and metrics. NASA was postured to see results of this progress and to verify the sufficiency of its fiscal year 2003 budget to provide for the core complete version of the station when the Columbia accident occurred.

Grounding of the Shuttle Fleet Will Result in Additional Schedule Delays and Cost

With the shuttle fleet grounded, NASA is heavily dependent on its international partners—especially Russia—for operations and logistics support for the space station. However, due to the limited payload capacity of the Russian space vehicles, on-orbit assembly has been halted. The program's priority has shifted from station construction and research to maintenance and safety, but these areas have also presented significant challenges and could further delay assembly of the core complete configuration. While NASA maintains that its fiscal year 2004 budget will remain unchanged, the schedule delays that have resulted from the grounding of the shuttle fleet will come at a cost.

Program's Priority Has Shifted From Station Construction and Research to Maintenance and Safety

The space shuttle fleet has been the primary means to launch key hardware to the station because of its larger payload capacity. With the shuttle fleet grounded, current space station operations are solely dependent on the Russian Soyuz and Progress vehicles. Because the payload capacity of the Soyuz and Progress vehicles are significantly less than that of the U.S. shuttle fleet,[6] operations are generally limited to rotating crew and transporting food, potable water,[7] and other items to the station. The Russian vehicles are also used for logistics support.

On-orbit assembly of the station has effectively ceased. Prior to the Columbia accident, NASA had planned to assemble the core complete configuration of the station by February 2004. NASA officials estimate that assembly delays will be at least a "month for month" slip from the previous schedule, depending on the frequency of flights when the shuttles resume operations. Assuming a return to flight around fall 2004, the core complete configuration would not be assembled before early 2006.

[6] At about 36,000 pounds, the shuttle's payload capacity is roughly 7 times that of Russia's Progress vehicle and almost 35 times the payload capacity of its Soyuz vehicle.

[7] Potable water is a constraint to sustaining station operations. For example, crewmembers currently have a limit of two liters of water per day per crewmember.

While the space station crew's primary responsibility is to perform routine maintenance, the two crewmembers on board will conduct some research, according to an interim space station research plan developed by NASA. However, due to the grounding of the shuttle fleet and the station's reliance on the Russian vehicles, this research will be curtailed. For example:

- *Outfitting of U.S. research facilities halted*: Currently, 7 of the 20 planned research facilities are on orbit. With the fleet grounded, three major research facilities—which, according to NASA, complete the outfitting of the U.S. laboratory—could not be launched in March of this year, as planned.[8] At this time, it remains unknown when the full configuration of the 20 research facilities will be on board the station.
- *Existing hardware failures*: Because new and additional hardware cannot be transported, NASA has to rely more heavily on existing on-orbit science facilities—facilities that have already experienced some failures. For example, the refrigerator-freezers on board the station, which serve as the main cold storage units, have failed several times, according to NASA officials. A larger cold temperature facility was one of three facilities that had been planned for launch in March 2003.
- *Limited science material*: Currently, there are very limited allocations for science materials to be transported to or from the space station by the Russian Soyuz and Progress vehicles.[9] According to NASA officials, they plan to send about 93 kilograms (just over 200 pounds) of science material to the station on the next Progress vehicle scheduled for launch in January 2004. However, returning samples from investigations will be delayed until the shuttle fleet returns to flight because of the Soyuz's limited storage capacity.

NASA also cannot resolve known safety concerns on board the station while the shuttle fleet is grounded. For example, NASA has had to delay plans to fly additional shielding to protect the on-orbit Russian Service Module from space debris—a risk that increases each year the shielding is not installed. NASA is studying alternatives for launching and installing the debris protection panels earlier than currently planned. In addition, a failed on-orbit gyro—one of four that maintains the station's orbital

[8] The research facilities that were packed in a logistics module awaiting launch had to be removed from the flight module and serviced.

[9] Currently, science material is flown on a space and weight available basis. For example, if food or other life support items were not depleted between flights, science material might be transported.

stability and control—remains on board because the shuttle flight that was to carry a replacement gyro to the station and return the failed unit for detailed analysis was planned for March of this year—1 month after the grounding of the shuttle fleet.

Cost Implications Have Yet to Be Determined, but Increases Are Likely

To date, NASA has not fully estimated the potential increased costs and future budget impact incurred due to the grounding of the space shuttle fleet. However, it has identified a number of factors that will likely result in increased costs—including the need to extend contracts to complete development and assembly of the station.

NASA has requested $1.71 billion for fiscal year 2004 for the space station. The request is based, in part, on near completion of the hardware development for the U.S. core configuration and the transition to on-orbit operations. Soon after the Columbia accident, NASA stated that it would maintain budget requests at current levels until the shuttle returns to flight. NASA estimates the impact to the station program from the Columbia accident to be $22 million in fiscal year 2003 and up to $72 million in fiscal year 2004. NASA maintains that an assessment of total impact cannot be accomplished prior to the fiscal year 2006 budget submission in February 2005.

However, the considerable uncertainty about when the shuttle will return to flight, what the payload capability will be, and how many flights can be achieved each year greatly impact the total cost to the station program. NASA anticipates that by keeping a crew on board the station while the shuttle fleet is grounded and the continued development of space station hardware will incur additional costs. For example, NASA officials told us there are approximately 80,000 pounds of hardware at Kennedy Space Station ready for integration to the space station and another 106,000 pounds there being processed.

Uncertainty of the Shuttle's Return-to-Flight Date Delays Partner Agreements

While long-term plans are not well defined at this time, alternative funding may be needed to sustain the station—let alone achieve the station's intended goals. International agreements governing the space station partnership specify that the space agencies of the United States, Canada, Europe, and Japan are responsible for funding the operations and maintenance of the elements that each contributes, the research activities each conducts, and a share of common operating costs. Under current planning, NASA will fund the entire cost of common supplies and ground operations, then be reimbursed by the other partners for their shares.

Depending on contributions made by the partners while the shuttle fleet is grounded, the share that each partner contributes to the common operations costs may have to be adjusted and could result in NASA's paying a larger share of those costs. For example, the European Automated Transfer Vehicle is scheduled to begin flying in September 2004. If that vehicle takes on a larger role in supporting the station than currently planned, the European share of common operations costs could be reduced with the other partners paying more.

At the same time, NASA and its partners must develop a plan for assembling the partners' modules and reaching agreement on the final station configuration. Prior to the Columbia accident, options for the final on-orbit configuration were being studied, and a decision was planned for December 2003. NASA officials told us the process has been delayed, and NASA and its partners agreed on a program action plan in October 2003 that will ultimately lead to an agreement on the final on-orbit configuration in December 2004.

Proposed Framework for Guiding and Assessing Cultural Change

Clearly, the space station's future is dependent on the shuttle fleet's safe return to flight. In the past, we have reported on challenges facing NASA's shuttle program—especially in maintaining an adequate shuttle workforce.[10] In January 2003, we reported that NASA needed to shift its overall orientation from processes to results, organizational stovepipes to matrixes, management hierarchy and control to flatter structures and employee empowerment, and reactive behavior to proactive approaches. The Columbia Accident Investigation Board's report and recommendations similarly indicate that needed improvements to the shuttle program go beyond technical enhancements and procedural modifications. Specifically, the Board found that despite several schedule slippages and rapidly diminishing schedule margins, NASA remained committed to 10 shuttle launches in less than 16 months to achieve the space station's core complete status by February 2004—a target date set in mid 2001. According to the Board, this schedule-driven environment influenced managers' decisions about the potential risks to the shuttle if a piece of foam struck the orbiter—an event that had occurred during an October 2002 shuttle flight and one that was ultimately identified as the technical cause behind Columbia's breakup. The Board concluded that

[10] U.S. General Accounting Office, *Space Shuttle: Human Capital and Safety Upgrade Challenges Require Continued Attention*, GAO/NSIAD/GGD-00-186 (Washington, D.C.: Aug. 15, 2000).

cultural issues—including lapses in leadership and communication, a dogged “can do” attitude, and reliance on past successes—were critical factors that contributed to the accident.

In its September 8, 2003, response to the Board’s findings,[11] NASA stated that it would pursue an in-depth assessment to identify and define areas where the agency’s culture can be improved and take aggressive action.” NASA indicated that it would take actions to achieve several goals:

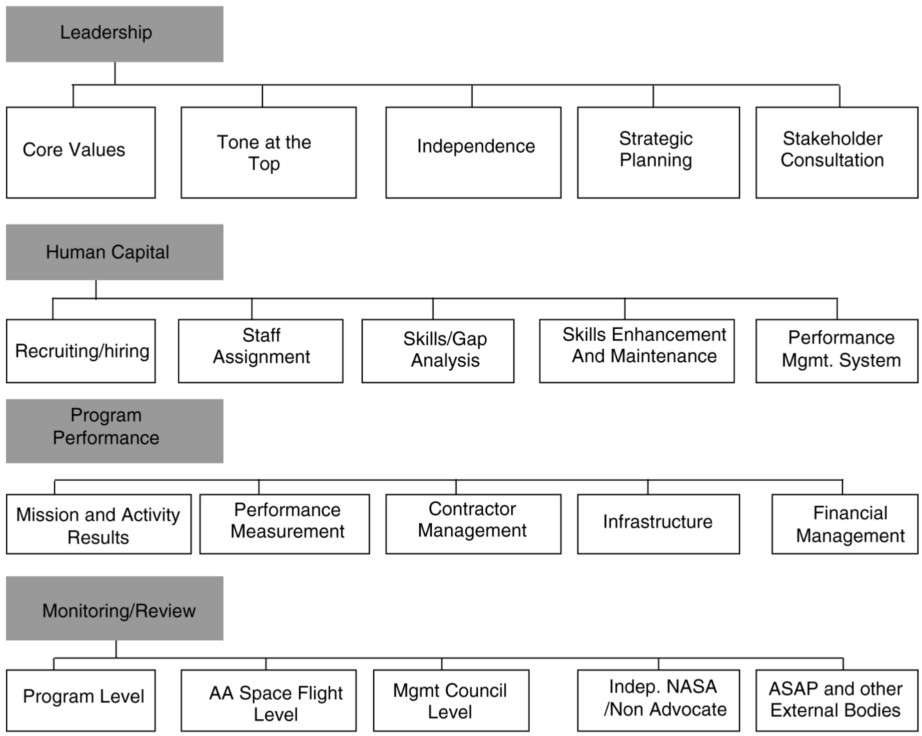
- Create a culture that values effective communication and remove barriers to the expression of dissenting views.
- Increase its focus on the human element of change management and organizational development.
- Ensure that existing procedures are complete, accurate, fully understood, and followed.
- Create a robust system that institutionalizes checks and balances to ensure the maintenance of the agency’s technical and safety standards.

Most recently, on October 15, 2003, NASA indicated that the agency is also assessing if cultural change is needed agency-wide. However, the agency offered no further details beyond its previous commitments.

As NASA works to change its culture, and as the Congress assesses the adequacy of NASA’s corrective actions, applying a framework could prove beneficial. Such a framework should recognize NASA’s operating principles and values, describe the direction of NASA’s programs, focus attention on securing and maintaining skills for its employees, provide safety targets, show key results, and acknowledge the importance of internal and external review. The following framework—similar in concept to GAO’s framework for ensuring the quality of its work—is anchored in four main areas: leadership, human capital, program performance, and monitoring and review.

[11] See NASA, *NASA’s Implementation Plan for Space Station Return to Flight and Beyond* (Oct., 2003).

Figure 2: Framework for Quality



Source: GAO.

- **Leadership:** The leadership anchor encompasses the agency's core values, including safety as NASA's highest priority; and the expectations that top management sets, such as stressing the importance of character, integrity, and support of safety assurance measures. This anchor also stresses the need to encourage staff to raise safety concerns, regardless of the staff member's formal organizational relationships or job responsibilities. Strategic planning and stakeholder consultation have importance only if championed by NASA's leadership. The leadership anchor helps address the question "What do we do?"
- **Human Capital:** Securing and assigning skilled staff, understanding short- and long-term skill deficiencies, establishing and maintaining skills, as well as assessing individual employee performance are major components of a comprehensive human capital anchor. NASA's efforts at developing a strategic human capital plan and legislative proposals related to human capital would be included in this anchor. The human capital anchor helps address the question "Who will do it?"

- **Program Performance:** While the primary focus of program performance is often related to mission-related activities, such as flight processing and major modifications, effective program performance also measures results achieved, oversight of contractors, infrastructure maintenance, and sound financial management to provide decision makers with accurate information with which to make resource tradeoffs and long-term investments. The program performance anchor helps address the question "How do we translate what we do into processes and procedures—that is, how do we operationalize our work?"
- **Monitoring and Review:** The oversight and enforcement of safety is a shared responsibility between program officials, Associate Administrators, the NASA Administrator, and independent groups such as non-advocate reviews and the Aerospace Safety Advisory Panel. The monitoring and review anchor helps address the question "How is this reinforced?"

We believe this framework can serve to identify the priorities agency leadership must communicate, the human capital activities needed to ensure that expected employee performance is achieved, the safety processes and procedures that need to be operationalized as part of program performance, and the scope of enforcement responsibilities. As such, use of this framework can help the Congress monitor the corrective actions NASA will undertake to strengthen the agency's culture.

Mr. Chairman, this concludes my prepared statement. I will be happy to answer any questions you or other members of the subcommittee may have.

Contact and Acknowledgments

For future information, please contact Allen Li at (202) 512-4841 or lia@gao.gov. Individuals making key contributions to this testimony include Jerry Herley, James Beard, Rick Cederholm, and Karen Sloan.

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