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Report to the Chairman, Committee on
Commerce, Science, and
Transportation, U.S. Senate

September 2003

SPACE STATION

Impact of the Grounding of the Shuttle Fleet





Highlights of [GAO-03-1107](#) a report to Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate

Why GAO Did This Study

In 1998, the National Aeronautics and Space Administration (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 scientific research under nearly weightless conditions. Since its inception, the program has experienced numerous problems, resulting in significant cost growth and assembly schedule slippages.

Following the loss of Columbia in February 2003, NASA grounded the U.S. shuttle fleet, putting the immediate future of the space station in doubt, as the fleet, with its payload capacity, has been key to the station's development. If recent discoveries about the cause of the Columbia's disintegration require that the remaining shuttles be redesigned or modified, delays in the fleet's return to flight could be lengthy. In light of these uncertainties, concerns about the space station's cost and progress have grown.

This report highlights the current status of the program in terms of on-orbit assembly and research; the cost implications for the program with the grounding of the shuttle fleet; and identifying significant program management challenges, especially as they relate to reaching agreements with the international partners.

www.gao.gov/cgi-bin/getrpt?GAO-03-1107.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Allen Li (202) 512-4841 or LiA@gao.gov.

SPACE STATION

Impact of the Grounding of the Shuttle Fleet

What GAO Found

Although the effects of the Columbia accident on the space station are still being explored, it is clear that the station will cost more, take longer to complete, and have further delay in the achievement of key research objectives. Due to the limited payload capacity of Russia's Soyuz and Progress vehicles—which the program must now rely on to rotate crew and provide logistics support—the station is currently in a survival mode. On-orbit assembly is at a standstill, and the on-board crew has been reduced from three to two members. NASA officials maintain that delays in on-orbit assembly will be at least a “month for month” slip from the previous schedule. However, these delays have presented a number of operational challenges. For example, several key components that were ready for launch when the Columbia accident occurred have been idle at Kennedy Space Center and now require additional maintenance or recertification before they can be launched. Moreover, certain safety concerns on-board the station cannot be addressed until the shuttle fleet's return to flight. The grounding of the shuttle fleet has also further impeded the advancement of the program's science investigations. Specifically, the limited availability of research facilities and new science materials has constrained on-board research.

NASA has yet to estimate the potential costs and future budget impacts that will result from the grounding of the shuttle fleet. Throughout the life of the program, however, maintaining goals and objectives for the space station has been a challenge for NASA. NASA has analyzed anticipated costs that the program will incur to keep a limited crew on board the station until the U.S. shuttles resume flight, and officials have stated that there would not be significant changes to the execution of the current budget and that the fiscal year 2004 budget request would remain at current levels. NASA plans to continue to develop hardware and deliver station elements to Kennedy Space Center to be prepared for launch as previously scheduled. However, a number of factors will likely result in increased costs, including costs to maintain and store station components and costs for extending contracts.

Important decisions regarding funding and partner agreements still need to be made. For example, agreements that cover the partners' responsibility for shared common operations costs may need to be adjusted, an adjustment that could result in NASA's paying a larger share of these costs. In addition, logistics flights using Russian vehicles may need to be accelerated to ensure continued operations on-board the station. Russia has stated that additional flights are possible, but it could need additional funding from the other partners. However, the United States may be prohibited from providing certain payments due to a statutory restriction. NASA and its partners must also develop a plan for assembling the partners' modules and reaching agreement on the final station configuration. The partners were on a path to agree on final configuration by December 2003, but this process has been delayed by the Columbia accident.

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G A O

Accountability * Integrity * Reliability

United States General Accounting Office
Washington, DC 20548

September 12, 2003

The Honorable John McCain
Chairman, Committee on Commerce, Science,
and Transportation
United States Senate

Dear Mr. Chairman:

In 1998, the National Aeronautics and Space Administration (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 as well as earth observations under nearly weightless conditions. Since its inception, the space station program has experienced numerous problems that have resulted in significant cost growth and assembly schedule slippages. In February 2003, the immediate future of the space station was placed in doubt when NASA grounded the shuttle fleet following the loss of the shuttle Columbia. The U.S. shuttle fleet had been key to the station's development because of its greater payload capacity for transporting essential hardware.

Delays in the fleet's return to flight could be lengthy if recent discoveries about the cause of the Columbia accident require substantial redesign or modifications to the remaining shuttles or if organizational changes are recommended by the Columbia Accident Investigation Board.¹ With the grounding of the U.S. shuttle fleet and the uncertainty about its return to flight, concerns about the space station's cost and progress have grown. In view of these concerns, you asked that we (1) describe the current status of the program in terms of on-orbit assembly and research; (2) determine the cost implications for the program with the grounding of the shuttle fleet; and (3) identify significant program management challenges, especially as they relate to reaching agreements with the international partners.

¹ The Columbia Accident Investigation Board's report was not issued at the time our work was completed.

Results in Brief

Although the effects of the Columbia accident on the space station are still being explored, it is clear that the station will cost more, take longer to complete, and further delay the accomplishment of key research objectives. Until the shuttle fleet is cleared to fly again, the space station is basically in a survival mode. Owing to the limited payload capacity of the Russian launch vehicles—which the program must now rely on to rotate crew and provide logistics support—on-orbit assembly is at a standstill, and the on-board crew has been reduced from three to two members. Delays in on-orbit assembly have also presented a number of operational challenges. For example, several key components that were ready for on-orbit assembly when the Columbia accident occurred have been idle at Kennedy Space Center and now require additional maintenance or recertification before they can be launched. Moreover, certain safety concerns on-board the station cannot be addressed until the shuttle fleet returns to flight. The grounding of the shuttle fleet has also further impeded the advancement of the program's science investigations. Specifically, the research being conducted on the station has been constrained by the limited availability of research facilities and new science materials.

NASA has yet to estimate the potential costs and future budget impacts incurred because of the grounding of the space shuttle fleet. Yet throughout the life of the program, NASA has been challenged to maintain goals and objectives for the space station. NASA has conducted an analysis to anticipate costs the program will incur to keep a limited crew on-board the station until the shuttle resumes flight. Officials have stated that there would not be significant changes to the execution of the current budget and that the fiscal year 2004 budget request would remain at current levels. However, a number of factors will likely result in increased costs, including costs for unplanned maintenance and storage of station components at Kennedy Space Center that were ready for launch; test and recertification of some components; and costs for extending contracts for the retention of critical skills longer than planned to complete development and assembly of the station.

The Columbia accident has delayed important decisions affecting international partner funding and agreements. Agreements that cover the partners' responsibility for shared common operations costs may have to be adjusted, and could result in NASA's assuming a larger share of these costs. In addition, alternative funding may be needed to sustain the station. To ensure operations continue on-board the station, flights using the Russian Progress logistics vehicle will need to be accelerated and additional flights may be required. Depending on the duration of the

shuttle fleet's grounding, Russia has stated it can provide additional Progress flights, if necessary, and the Russian Aviation and Space Agency is negotiating with its government in an attempt to secure the necessary funding to build those vehicles. If the Russian government does not fund the needed vehicles, other international partners may have to fund them. However, current law may prohibit the United States from providing certain payments due to a statutory restriction. NASA and its partners must also develop a plan for assembling the partners' modules and reaching agreement on the final station configuration. The partners were on a path to agree on a final on-orbit configuration of the station by December 2003, but this process has been delayed by the Columbia accident.

NASA commented on a draft of this report and agrees with its content and conclusions. NASA's response is included as appendix I.

Background

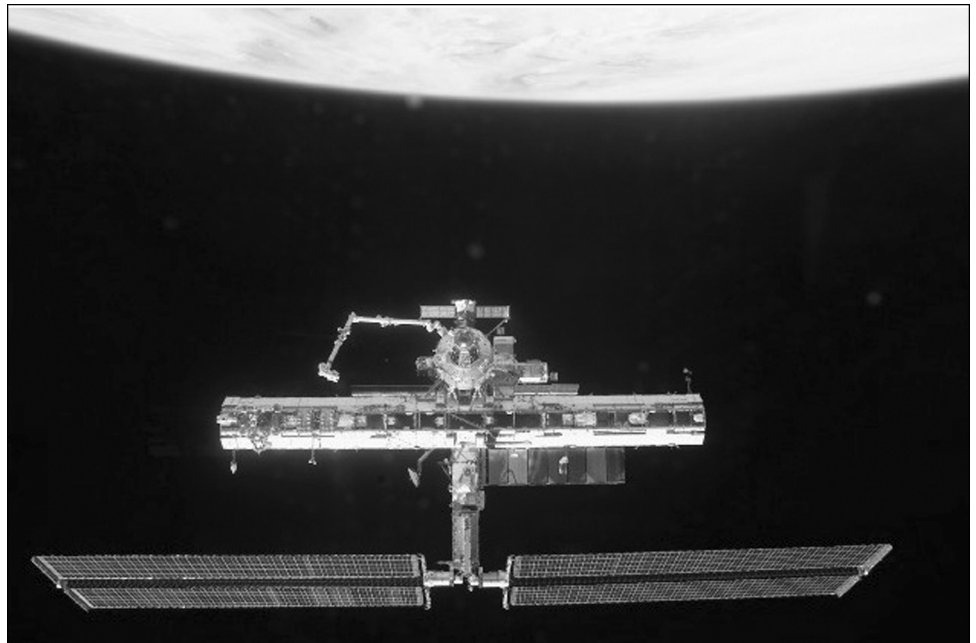
The International Space Station program has three key goals: (1) maintain a permanent human presence in space, (2) conduct world-class research in space, and (3) enhance international cooperation and U.S. leadership through international development and operations of the space station. Each of the partners is to provide hardware and crew, and each is expected to share operating costs and use of the station.²

On-orbit assembly of the space station began in November 1998 and, since October 2000, two to three crew members, who maintain and operate the station and conduct hands-on scientific research, have permanently occupied the space station. 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

² 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. Protocol Including Terms, Conditions, and Assumptions, Summary Balance of Contributions and Obligations to International Space Station and Resulting Rights of NASA and Russian Aviation and Space Agency to International Space Station Utilization Accommodations and Resources, and Flight Opportunities (June 11, 1996).

used for various earth observation activities. Figure 1 shows the International Space Station on-orbit.

Figure 1: International Space Station On-Orbit



Source: NASA.

Since its inception, the station program has been plagued with cost and schedule overruns. When the space station's current design was approved in 1993, NASA estimated that its cost would be \$17.4 billion.³ 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. Since fiscal year 1985, the Congress has appropriated about \$32 billion for the program. 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." The administration said that enhancements to the station might be possible if NASA demonstrates improved cost-estimating and program management, but the

³ All amounts are stated in current-year dollars.

administration is only committed to the completion of the core complete configuration.

In July 2001, the NASA Administrator appointed an independent International Space Station Management and Cost Evaluation Task Force to assess the financial management of the station program and make recommendations to get costs under control. The task force published its report in November 2001 and recommended that the program (1) extend crew rotations from 4 to 6 months and reduce the number of shuttle flights to 4 per year; (2) consolidate the number of contracts and reduce government staff in station operations and sustaining engineering; (3) establish an Associate Administrator for space station at NASA Headquarters, with total responsibility for engineering and research; and (4) prioritize research to maximize limited resources.⁴ NASA implemented most of the recommendations, and the task force reported in December 2002 that significant progress had been made in nearly all 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.

In response to the task force's recommendations, the Office of Management and Budget (OMB) imposed a 2-year "probation" period on NASA to provide time to reestablish the space station program's credibility. Activities that are to take place during this period include establishing a technical baseline and a life-cycle cost estimate for the remainder of the program, prioritizing the core complete science program, and reaching agreement with the international partners on the station's final configuration and capabilities. OMB, with input from NASA, is developing criteria that are to be used for measuring progress toward achieving a credible program. NASA provided its input to OMB in June 2003, but as of August 2003, OMB and NASA had not reached agreement on the success criteria.

⁴ National Aeronautics and Space Administration, *Report by the International Space Station Management and Cost Evaluation Task Force to the NASA Advisory Council* (Nov. 1, 2001).

Grounding of Shuttle Fleet Has Further Delayed On-Orbit Assembly of Space Station and Research

The grounding of the U.S. shuttle fleet has presented a number of operational challenges for the space station program. With the 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 to maintenance and safety, but these areas have also presented significant challenges and could further delay assembly of the core complete configuration. While some on-board research is planned, it will be curtailed by the limited payload capacity of the Russian vehicles.

Current On-Orbit Assembly, Maintenance Operations, and Safety Challenges

The space shuttle fleet has been the primary means to launch key hardware to the station because of the shuttle’s greater payload capacity. 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. With the shuttle fleet grounded, current space station operations are solely dependent on the Soyuz and Progress vehicles.⁵ Because the Soyuz and Progress vehicles’ payloads are significantly less than that of the U.S. shuttle fleet, operations are generally limited to transporting crew, food, potable water,⁶ and other items, as well as providing propellant resupply and reboosting the station to higher orbits. On-orbit assembly of the station has effectively ceased.

Maintaining the readiness of ready-to-launch space station components has also presented a number of operational challenges, as in the following examples:

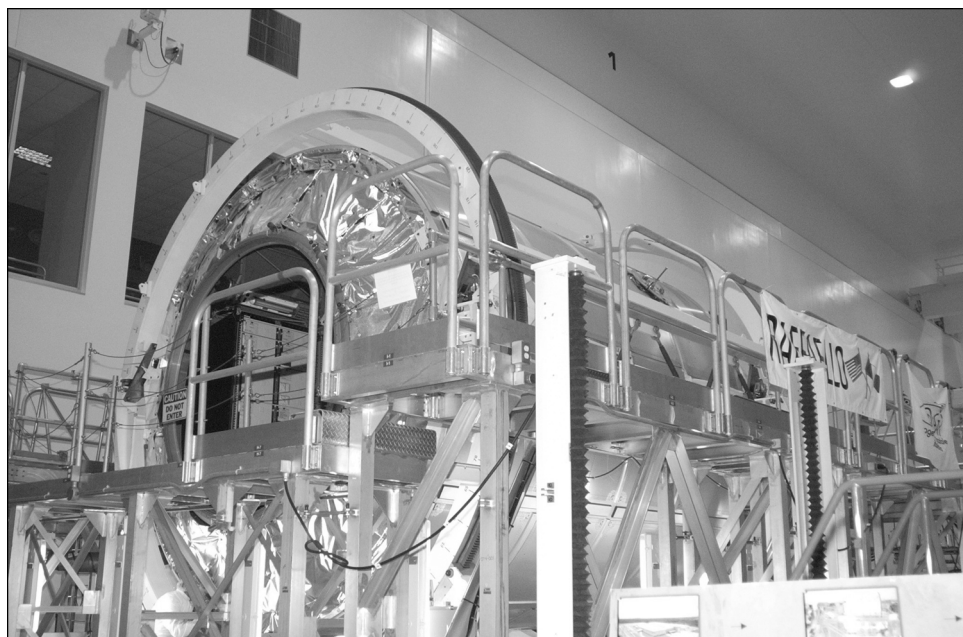
- A logistics module, which carries research facilities and life support items to the station, that was scheduled and ready for launch in March 2003 had to be opened and unpacked (see fig. 2). Several racks were removed to provide the proper preventative maintenance of the contents until they can be rescheduled on a future flight. In addition, crew-specific items had to be removed in anticipation of crew changes for the next shuttle flight.

⁵ The Progress vehicles transport materials—such as propellant, food, and water—and supplies to the space station. Once a Progress vehicle arrives and is unloaded, it is repacked with trash, undocks from the station, and burns up when it re-enters the atmosphere.

⁶ Potable water is a constraint to sustaining station operations. For example, crew members currently have a limit of two liters of water per day per crew member.

This module requires more than 2 months to be repacked and tested prior to launch.

Figure 2: The Logistics Module Scheduled for March 2003 Shuttle Launch Being Unpacked at Kennedy Space Center in Florida



Source: NASA.

- One of the solar array wings scheduled for launch in May 2003 was approaching its 45-month prelaunch storage limit. Due to the launch delay, the wing had to be removed from the truss section and replaced with a new wing (see fig. 3). The removed wing was shipped to the contractor for deployment testing, which NASA hoped would result in a lengthening of the prelaunch storage limit to at least 60 months. However, according to NASA officials, preliminary results were very positive, and the storage life certification could be extended to as much as 8 years or more.

Figure 3: Solar Array Wings



Source: NASA.

Truss section where the canister containing a solar array wing was removed to be tested (photograph on left), and the removed canister (foreground) and its replacement (background) that is being readied for assembly on the truss section (photograph on right).

- The performance of the batteries on the truss sections that were ready for launch has also raised concerns. Prolonged storage at ambient temperatures could shorten the overall life of the battery. According to NASA officials, a process has been developed to charge the batteries periodically without removing them from the trusses during storage, then to provide a charge capability on the launch pad just prior to launch. This

process, however, will require a new device to be developed and expending resources not previously planned for this function.

Station program managers are resolved to meet these challenges and have station components ready for flight when the next shuttle is ready for launch. In addition, NASA is using this longer storage time to determine the feasibility of adding new testing procedures. For example, NASA is developing tests to apply power to some elements and may also perform additional leak tests.

The grounding of the shuttle fleet has also hampered NASA's ability to correct known safety concerns on-board the station. For example, NASA has had to delay plans to fly additional shielding to the space station to adequately protect the on-orbit Russian Service Module from space debris. NASA's analysis of the problem shows the probability of orbital space debris penetrating the module increases by 1.6 percent each year the shielding is not installed. NASA accepted this risk by issuing a waiver for the noncompliance with a safety requirement, but planned to have the shielding installed within 37 months of the module's launch in July 2000. Six of the required 23 panels have been installed on the module, and NASA is negotiating with the Russian Aviation and Space Agency to manufacture the 17 remaining panels. NASA officials told us that they are studying alternatives for launching and installing the debris protection panels earlier than originally planned. In addition, there will be delays in analyzing the failure of an on-orbit gyro—one of four that maintain the station's orbital stability and control. According to NASA, a shuttle flight planned for March of this year was to carry a replacement gyro to the station and return the failed unit for detailed analysis. Because the shuttle flight was canceled, the failed unit was not returned. Consequently, NASA is unable at this time to provide a definitive analysis of the reasons for the failure of the unit or to know if the problem applies to the remaining units.

NASA had planned to assemble the core complete configuration of the station by February 2004. NASA officials have maintained 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. At best, then, the core complete configuration would not be assembled before sometime in fiscal year 2005.

Current Research Efforts Curtailed by Limited Payload Capability

While the space station crew's current responsibility is primarily to perform routine maintenance, the two-crew members will conduct some research on-board the station. An interim space station research plan developed by NASA details the amount and type of research that will be conducted. Further, NASA states that although the crew has been reduced from three to two members, more crew time will be available to carry out research tasks because no assembly or space walks are planned. Regardless, the limited payload capability of the Russian vehicles directly affects the extent of research that can be conducted, as illustrated in the following examples:

- *Outfitting of U.S. research facilities halted:* Lacking the shuttle fleet's greater lift capability, the amount of research hardware transported to and from the station has been significantly limited. 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.⁷ As of August 2003, 7 of the 20 planned research facilities are on orbit. NASA had planned to add 7 more facilities by January 2008. At this time, it is 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, in November 2002, the Microgravity Science Glovebox—which provides an enclosed and sealed workspace for conducting experiments—failed and did not become operational until late March 2003. NASA officials state there also have been failures of the existing refrigerator-freezers on-board the station, which serve as the main cold storage units until a larger space station cold temperature facility becomes available. The larger cold temperature facility was one of three facilities that had been planned for launch in March 2003.
- *Limited science material:* Currently, there are no allocations for science materials to be transported to or from the space station by the Russian Soyuz and Progress vehicles. Based on the payload planning for these flights, however, there will be limited opportunities to launch small research projects. NASA officials state that the next two Progress flights could carry up to 40 kilograms and 100 kilograms, respectively, based on continuous payload planning. This would be much greater than the April 2003 Soyuz flight, which was able to carry 2.5 kilograms (about

⁷ The research facilities that were packed in a logistics module awaiting launch had to be removed from the flight module and serviced.

5.5 pounds) of science material to the station for experiments in the current increment.

As a result, research experiments for the current flight increment have been reduced. Specifically, only about two-thirds of new investigations and about three-quarters of ongoing investigations from previous increments will be accomplished on the current increment. Further, returning samples from these investigations will be delayed until the U.S. shuttle fleet returns to flight because of the Soyuz's limited storage capacity. The investigations on the next increment are also in jeopardy as there is no planned up mass allocation for science material.⁸

Delays in transporting needed hardware and materials for research to the space station could be further constrained, depending on any safety modifications to the shuttle fleet based on recommendations of the Columbia Accident Investigation Board. If safety modifications to the shuttle increase the vehicle's weight, the payload carrying capability for research could be adversely affected. For example, if NASA determines that the shuttle's robotic arm is needed on future flights to address safety concerns, approximately 1,000 pounds of weight would be added, which would reduce the shuttle's payload capacity for research equipment and other hardware.

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

Since the program's inception, we have repeatedly reported on the challenges NASA has faced in maintaining goals and objectives for the space station program.⁹ And while NASA has conducted reassessments and independent reviews of the program in efforts to institute corrective actions that would ensure proper cost controls, difficulties in controlling costs have persisted. NASA budgets and funds the space station program at essentially a fixed annual average level of about \$1.7 billion a year based on full cost accounting.¹⁰ To date, NASA officials stated they have not completely estimated the potential increased costs and future budget

⁸ Currently, science material is flown to the station 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.

⁹ Appendix II lists prior GAO reports and testimonies related to the space station program.

¹⁰ Full cost accounting is an accepted accounting practice that ties all NASA costs (including government personnel costs) to major activities (programs and projects) and budgets, accounts, reports, and manage programs and projects from a full cost perspective.

impact incurred due to the grounding of the space shuttle fleet. However, they have identified a number of factors that will likely result in increased costs—including the continued maintenance and storage of ready-to-launch station components as well as the testing and recertification of some components and the need to extend contracts to complete development and assembly of the station. NASA officials told us that the agency is assessing these potential cost and schedule impacts and how to mitigate the impacts within existing resources.

In fiscal year 2003, NASA received \$1.85 billion in appropriated funds for the space station and has requested \$1.71 billion for fiscal year 2004 (see table 1). The funding reduction in fiscal year 2004 was based on near completion of the hardware development for the U.S. core configuration and the transition to on-orbit operations. NASA estimates that after the last year of development, the annual cost to operate the station will average \$1.5 billion over a 10-year useful life. This estimate does not include all funding requirements, such as costs associated with necessary upgrades to preclude on-orbit hardware obsolescence, launch costs, and other support costs that are captured in other portions of NASA’s budget.

Table 1: Projected Funding for the Space Station Program

Dollars in millions		
Office of Space Flight	Pres. Budget FY 2003	Pres. Budget FY 2004
Total	\$6,107	\$6,110
Space Station	1,851	1,707
Space Shuttle	3,786	3,968
Space Flight Support	471	434

Source: NASA’s fiscal year 2004 budget request.

NASA officials told us that soon after the Columbia accident, they published ground rules and assumptions that stated there would be no significant changes to the station’s budget execution and would maintain budget requests at current levels until the shuttle returns to flight. At that point, NASA program officials stated they will begin to evaluate the impact that new developments, enhancements, inventories, and staffing needed to sustain and operate the space station will have on future budget submissions, including requests for supplemental appropriations, and the execution of the station funding, including program reserves.

NASA’s strategy for the station program following the Columbia accident has been to continue developing hardware as planned, to deliver these

components to Kennedy Space Center as scheduled, and to prepare them for launch when the shuttle fleet returns to flight. Through contingency planning efforts, NASA has identified additional costs to be incurred by the space station program office as a result of these continuing developmental operations. However, these additional costs are based on an assumption that the shuttle will return to flight within 12 months of the Columbia accident, an assumption that is subject to change based on more definitive information concerning the status of the shuttle fleet's operations. NASA officials state they have not finalized plans or risk assessments for continued assembly and operation of the space station if the shuttle fleet is grounded for a longer period of time.

NASA has also implemented a management decision analysis¹¹ that anticipates additional costs to be incurred in keeping a crew on-board the station while the shuttle fleet is grounded. The analysis is based primarily on management decisions regarding crew rotation and payload issues that involve shifting cargo and the use of consumables, such as potable water. Other factors, according to NASA officials, that the station program office identified could also result in cost increases, but it has not fully quantified these costs:

- recertification of hardware;
- disassembly and reassembly of component parts;
- unpacking and repacking equipment from the logistics module that was ready for launch;
- storage of station components that are ready for launch;
- maintaining battery life;
- unfurling and testing solar array wings, which could be affected by prolonged storage;
- additional travel to Russia to facilitate discussions on Soyuz and Progress vehicles' schedules and payloads and export controls issues;
- additional resupply flights; and
- retention of some critical skills necessary to complete development and assembly of the station.

¹¹ A management decision analysis is a process for reviewing potential risks in the station program that could impact costs. The process includes reviews of outstanding safety waivers and the identification of additional required testing.

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

In addition to the operational challenges facing NASA, funding and partner agreements present significant challenges.¹² 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. 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. In addition, since the final on-orbit configuration is likely to be different from the configuration when the Intergovernmental Agreements were signed in 1998, NASA officials state the partners may have to adjust agreements that cover the partners' responsibility for shared common operations costs.

Depending on the duration of the shuttle fleet's grounding, the space station program may need to consider funding alternatives to sustain the station. International agreements governing the space station partnership specify that the United States, Canada, Europe, and Japan are responsible for funding the operations and maintenance of the elements each contributes, the research activities it 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.¹³ 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's share of common operations costs could be reduced with the other partners paying more.

Station requirements dictate that some Progress launches be accelerated and, depending on how long the shuttle fleet is grounded, could require additional flights. Russia maintains that it can provide additional launches, and the Russian Aviation and Space Agency is negotiating with its government in an effort to obtain the necessary funding. If those negotiations are unsuccessful, the other partners may have to provide the

¹² Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, Jan. 29, 1998.

¹³ The international agreements stress that the partners should seek to minimize the exchange of funds through the performance of specific space station operations activities or, if concerned partners agree, through the use of barter.

needed funding. However, the U.S. may be prohibited from making certain payments due to a statutory restriction.¹⁴ NASA is engaged in discussions with the other partners on how to sustain operations if additional flights are required.

Further, following the release of the Columbia Accident Investigation Board's report and recommendations, NASA and the partnership must agree on a final configuration of the on-orbit station that will be acceptable to all parties. 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 now expects the partners to agree on a program action plan in October 2003 that will lead to an agreement on the final on-orbit configuration.

During a July 2003 meeting, international partner space agency leaders from the U.S., Europe, Canada, Japan, and Russia expressed support of the space station program. The leaders recognized the Russian Aviation and Space Agency for its support of station operations, logistics, crew transportation, and crew rescue while the shuttle fleet is grounded. The partners also expressed their support of NASA's return to flight strategy, the resumption of station assembly, and the opportunity to enhance the use of the station for conducting world-class research.

Conclusions

This is one of the most challenging periods in the history of the international space station program. NASA officials acknowledge that the loss of the space shuttle Columbia poses cost and schedule risks that have direct implications on completing the development and assembly of the station and the research that is to be conducted on-board as well as on NASA's budgets for fiscal year 2004 and beyond. However, NASA officials told us that it is too soon to determine the magnitude and costs of delayed assembly and implications of any recommendations from the Columbia Accident Investigation Board to the space station. Until the shuttle return-to-flight date is known, it is difficult to determine how and when potential cost and schedule increases will impact the station program or the agency as a whole.

¹⁴ Iran Nonproliferation Act of 2000, Pub. L. 106-178.

Agency Comments

In written comments on a draft of this report, NASA's Deputy Administrator said that the agency agrees with the content and conclusions in the report. He said that the space station program is taking the steps necessary to be ready to resume assembly immediately upon the space shuttle's return-to-flight and to eliminate or offset cost impacts. He also pointed out that the international partners continue to collaborate on how to best support near-term space station on-orbit operations until the space shuttle returns to flight. NASA offered some technical comments on the report, which have been incorporated as appropriate.

Scope and Methodology

To describe the current status of the space station program in terms of on-orbit assembly and research, we reviewed NASA's plans for completing station assembly prior to the Columbia accident and compared those plans to the agency's actions following the accident to continue on-board operations while the shuttle fleet is grounded. To assess the planned research program, we reviewed NASA's efforts to prioritize research on-board the station as well as plans to continue research while the shuttle fleet is grounded. We also interviewed NASA officials regarding the agency's efforts to maintain the station and continue research following the Columbia accident.

To determine the cost implications for the program with the grounding of the shuttle fleet, we reviewed NASA's fiscal year 2003 budget amendment and appropriations as well as the agency's fiscal year 2004 budget request. We also reviewed NASA's assessments of potential cost impacts to the program and plans for mitigating those potential impacts. In addition, we reviewed NASA's plans/interactions with its international partners to secure support for the station while the shuttle fleet is grounded and to reach agreement on a final station configuration that will be acceptable to all partners. We interviewed NASA officials with responsibility for estimating and controlling space station costs, managing space station research, and dealing with the international partners.

To identify program challenges facing the space station program, we reviewed actions being taken by NASA to ensure continued safe operations of the station, toured the Space Station Processing Facility to view flight-ready hardware in storage, and reviewed NASA's actions in response to the International Space Station Management and Cost Evaluation task force report. We interviewed space station program officials to obtain their views on the challenges facing the program.

To accomplish our work, we visited NASA headquarters, Washington, D.C.; Johnson Space Center, Texas; and Kennedy Space Center, Florida. We also attended two meetings of the NASA Advisory Council.

We conducted our work from November 2002 through August 2003 in accordance with generally accepted government standards.

Unless you publicly announce the contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will send copies to the NASA Administrator; the Director, Office of Management and Budget; and other interested parties. We will also make copies available to others on request. In addition, the report will be available on the GAO Web site at <http://www.gao.gov>.

Please contact me at (202) 512-4841 if you or your staff have any questions about this report. Major contributors to this report are listed in appendix III.

Sincerely yours,



Allen Li
Director
Acquisition and Sourcing Management

Appendix I: Comments from the National Aeronautics and Space Administration

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



September 2, 2003

Mr. Allen Li
Director
Acquisition and Sourcing Management
General Accounting Office
Washington, DC 20548

Dear Mr. Li:

NASA appreciates the opportunity to comment on the draft report, "Space Station: Impact of the Grounding of the Shuttle Fleet." Specific comments are provided in the enclosure. Overall, we agree with the content and conclusions contained in the report.

NASA and its International Partners (IP) have aggressively pursued all possible avenues to reduce the risks associated with the completion of the International Space Station's (ISS) assembly and to mitigate the impacts of the Space Shuttle standdown on ISS operations. The ISS program is taking all steps necessary to be ready to resume assembly immediately upon the Space Shuttle Return To Flight (RTF) and to eliminate or offset cost impacts. The fact that meaningful science continues onorbit, and that we can safely rotate and support the ISS crews until the Shuttle returns to flight, attests to the strength of the program's international partnership and commitment to continue onorbit research. The program has been able to take advantage of every opportunity to manifest research, supplies, and experiments on the Russian-provided Soyuz and Progress vehicles. Investigations in bioastronautics and physical sciences continue and, as logistics permit, additional studies are planned for the next expedition. NASA has engaged its IPs in collaborative efforts to share hardware in order to optimize the overall research output on the ISS.

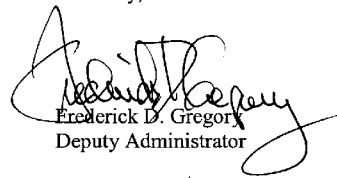
NASA and its IPs continue to build, integrate, and prepare flight hardware for launch according to the program's original schedules, and we look forward to the day when the ISS reaches its full research potential. In May 2003, NASA's European-built Node 2 arrived for processing at Kennedy Space Center (KSC) at the same time that Japan delivered its laboratory module for ground testing and launch preparation. The European Space Agency is also continuing to press ahead with its plans to provide additional resupply capability with the launch of its Automated Transfer Vehicle in late 2004, and the planned delivery of its laboratory module to KSC in mid-2004. Canada is completing work on its final robotic element, which is currently scheduled to be delivered to KSC in late 2004. All of the IPs continue to collaborate on how to best support near-term ISS onorbit operations until the Space Shuttle RTF.

**Appendix I: Comments from the National
Aeronautics and Space Administration**

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We are prepared to answer any additional questions you may have as we proceed with our RTF activities. In the event that additional information is required to support your audits, please contact Mark Uhran of the Office of Space Flight on (202) 358-2233.

Cordially,



Frederick D. Gregory
Deputy Administrator

Enclosure

Appendix II: Prior GAO Reports and Testimonies Related to the International Space Station Program

NASA: Major Management Challenges and Program Risks. [GAO-03-114](#). Washington, D.C.: January 2003.

Space Station: Actions Under Way to Manage Cost, but Significant Challenges Remain. [GAO-02-735](#). Washington, D.C.: July 17, 2002.

NASA: Compliance With Cost Limits Cannot Be Verified. [GAO-02-504R](#). Washington, D.C.: April 10, 2002.

NASA: Leadership and Systems Needed to Effect Financial Management Improvements. [GAO-02-551T](#). Washington, D.C.: March 20, 2002.

NASA: International Space Station and Shuttle Support Cost Limits. [GAO-01-100R](#). Washington, D.C.: August 31, 2001.

Space Station: Inadequate Planning and Design Led to Propulsion Module Project Failure. [GAO-01-633](#). Washington, D.C.: June 20, 2001.

Space Station: Russian-Built Zarya and Service Module Compliance With Safety Requirements. [GAO/NSIAD-00-96R](#). Washington, D.C.: April 28, 2000.

Space Station: Russian Compliance with Safety Requirements. [GAO/TNSIAD-00-128](#). Washington, D.C.: March 16, 2000.

Space Station: Russian Commitment and Cost Control Problems. [GAO/NSIAD-99-175](#). Washington, D.C.: August 17, 1999.

Space Station: Cost to Operate After Assembly Is Uncertain. [GAO/NSIAD-99-177](#). Washington, D.C.: August 6, 1999.

Space Station: Status of Russian Involvement and Cost Control Efforts. [GAO/T-NSIAD-99-117](#). Washington, D.C.: April 29, 1999.

Space Station: U.S. Life-Cycle Funding Requirements. [GAO/T-NSIAD-98-212](#). Washington, D.C.: June 24, 1998.

International Space Station: U.S. Life-Cycle Funding Requirements. [GAO/NSIAD-98-147](#). Washington, D.C.: May 22, 1998.

Space Station: Cost Control Problems. [GAO/T-NSIAD-98-54](#). Washington, D.C.: November 5, 1997.

**Appendix II: Prior GAO Reports and
Testimonies Related to the International
Space Station Program**

Space Station: Deteriorating Cost and Schedule Performance Under the Prime Contract. [GAO/T-NSIAD-97-262](#). Washington, D.C.: September 18, 1997.

Space Station: Cost Control Problems Are Worsening. [GAO/NSIAD-97-213](#). Washington, D.C.: September 16, 1997.

NASA: Major Management Challenges. [GAO/T-NSIAD-97-178](#). Washington, D.C.: July 24, 1997.

Space Station: Cost Control Problems Continue to Worsen. [GAO/T-NSIAD-97-177](#). Washington, D.C.: June 18, 1997.

Space Station: Cost Control Difficulties Continue. [GAO/T-NSIAD-96-210](#). Washington, D.C.: July 24, 1996.

Space Station: Cost Control Difficulties Continue. [GAO/NSIAD-96-135](#). Washington, D.C.: July 17, 1996.

Space Station: Estimated Total U.S. Funding Requirements. [GAO/NSIAD-95-163](#). Washington, D.C.: June 12, 1995.

Space Station: Update on the Impact of the Expanded Russian Role. [GAO/NSIAD-94-248](#). Washington, D.C.: July 29, 1994.

Space Station: Impact of the Expanded Russian Role on Funding and Research. [GAO/NSIAD-94-220](#). Washington, D.C.: June 21, 1994.

Appendix III: Staff Acknowledgments

Acknowledgments

Individuals making key contributions to this report included Jerry Herley, James Beard, Fred Felder, Lynn LaValle, Rick Cederholm, Josh Margraf, and Karen Sloan.

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