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United States General Accounting Office
Washington, DC 20548

National Security and
International Affairs Division

B-284687

April 28, 2000

The Honorable F. James Sensenbrenner, Jr.
Chairman
Committee on Science
House of Representatives

Subject: Space Station: Russian-Built Zarya and Service Module Compliance With Safety Requirements

Dear Mr. Chairman:

NASA invited Russia to participate in the International Space Station program in 1993 with the expectation that Russian involvement would reduce the cost, speed up the schedule, and increase the usefulness of the space station.[1] The Russian-built Zarya and Service Module are critical to the early stages of the space station's assembly. The Zarya module, launched by Russia in November 1998, provides the initial propulsion and guidance functions for the space station. Zarya was funded by NASA and is therefore considered a U.S. element of the space station. Zarya was built for NASA by a Russian company under a subcontract to NASA's space station prime contractor. The Service Module, whose launch has been delayed until at least July 2000, will provide living quarters, life support systems, and guidance functions after docking with Zarya. Russia is funding, building, and launching the Service Module as part of its contribution to the space station. Russia also plans to contribute Progress resupply vehicles, Soyuz crew transfer and emergency return vehicles, a power platform, docking and stowage modules, and research modules. (See encl. I.)

Working with the Russian space agency and other international partners, NASA is responsible for establishing overall space station safety requirements. NASA is also responsible for certifying that all elements and payloads, and the space station as a whole, are safe. NASA has established a formal review process for certifying the safety of space station elements and approving waivers of safety requirements. Russia has agreed that its elements will meet or exceed the overall safety requirements established by NASA. Russia has also agreed to provide NASA with data to support safety reviews and certifications. NASA must approve all waivers of safety requirements before it can approve launches of U.S. and partner elements. (See encl. II.)

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

You previously expressed concerns about cost increases and schedule delays because of Russian involvement in the space station program. As requested, we are providing information on Russian compliance with space station safety requirements. Specifically, we reviewed whether (1) Zarya and the Service Module comply with safety requirements, (2) NASA has approved any waivers of safety requirements, and (3) NASA was due any compensation from the Zarya contractor for items that did not meet safety requirements or had performance problems. We provided the preliminary results of our review at a hearing in March before the House Subcommittee on Space and Aeronautics.[2]

RESULTS IN BRIEF

Although Russian elements comply with the majority of space station safety requirements, Zarya and the Service Module still do not meet some important requirements. According to NASA safety officials, significant areas of noncompliance include (1) inadequate shielding from orbital debris on the Service Module, (2) inability of Zarya and the Service Module to operate if they lose cabin pressure, and (3) excessive noise levels in Zarya and the Service Module. In addition, NASA still needs to complete its review of the Service Module windows to determine whether the design complies with safety requirements. NASA officials said that shortfalls in Russian funding, designs based on existing Russian hardware, and technical disagreements with Russian engineers are the main reasons these modules do not comply with safety requirements. (See encl. III.)

NASA approved waivers of safety requirements for the Zarya module after NASA determined that the risks were acceptable, allowing Zarya to be launched, but it has not yet approved all waivers needed to launch the Service Module. In addition, NASA must complete its review of the design of the Service Module's windows before the module can be launched. Table 1 summarizes the status of compliance and waivers for each major safety issue involving Zarya and the Service Module. (See encl. IV.)

Table 1: Status of Zarya and Service Module Compliance

Safety Requirement	Zarya	Service Module
Protection from orbital debris	Complies	Waiver approved
Operate after loss of pressure	Waiver approved	Waiver needs approval
Noise levels	Waiver approved	Waiver needs approval
Window design and life	No windows	Compliance being reviewed

[2] Space Station: Russian Compliance With Safety Requirements (GAO/T-NSIAD-00-128, Mar. 16, 2000).

Part of NASA's rationale for approving the launch of elements that do not fully comply with safety requirements is that it expects deficiencies to be corrected after the modules are in orbit and exposure to increased risk to last only a limited time. However, correcting deficiencies after modules are launched can take longer than planned, can be more difficult than on the ground, and can affect other activities such as research. (See encl. IV.)

The four most significant cases in which Zarya did not meet safety requirements or had performance problems did not warrant compensation from the contractor. Two cases—inability to operate in the event of loss of pressure and excessive noise—involved waivers of safety requirements. The other two cases—defective batteries and crew health problems initially attributed to poor air quality—involved performance problems in orbit. The contractor agreed to reduce noise levels and replace the batteries at no charge to NASA. The two other problems did not result from failure to meet contractual requirements: the specifications for Zarya exempted the module from fully meeting space station requirements to operate after loss of pressure, and NASA determined that air quality inside Zarya was not the cause of health symptoms reported by the crew. (See encl. V.)

SCOPE AND METHODOLOGY

To assess compliance of Russian-built elements with International Space Station safety requirements, we analyzed NASA's safety review policies and procedures, specifications for Russian elements, agreements between NASA and the Russian Aviation and Space Agency, and hazard and noncompliance reports for Zarya and the Service Module. We also attended meetings of the space station's Safety Review Panel and met with panel members. We interviewed NASA officials in the International Space Station Program Office responsible for safety and mission assurance, management of Russian elements, and space station structures and mechanisms. We also interviewed NASA officials responsible for crew health and training at the Johnson Space Center, Houston, Texas. To evaluate NASA's decisions concerning compensation for Zarya items with problems, we interviewed and obtained contract data from officials at NASA's Johnson Space Center and Boeing's Contracts and Pricing Department, Houston, Texas. On the basis of our review of contract and program documents and discussions with NASA officials, we selected four cases representing the most significant areas where problems occurred with compliance or performance.

We performed our work at the Johnson Space Center in Houston, Texas, from August 1999 through March 2000 in accordance with generally accepted government auditing standards.

AGENCY COMMENTS

In written comments on a draft of this report, NASA concurred that we had identified the most significant safety issues affecting early space station modules. NASA also emphasized that flight safety is the agency's number one goal and that space station modules will only fly if they are judged to have an acceptable level of risk. NASA had two concerns with the draft report, namely that (1) it focused on a small number of

instances of noncompliance by Russian hardware and (2) it did not adequately characterize the rigor of the safety review process and it lacked sufficient detail for the reader to appreciate all the factors that influence decisions to grant safety waivers. NASA's comments are reprinted in enclosure VI.

Regarding NASA's first point, we agree that the report focuses on a small number of instances of noncompliance. We reported on four safety issues with Russian-built modules because NASA officials in the safety review process identified these issues as their most significant safety concerns with early space station elements. As to NASA's second point, we agree that NASA has established a rigorous safety review process for space station elements. Our report provides a summary of the safety review process and was not intended to be a detailed description of all the steps taken and information considered in approving waivers.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 14 days from its issue date. At that time, we will send copies to the Honorable Daniel S. Goldin, Administrator, NASA, and the Honorable Jacob J. Lew, Director, Office of Management and Budget. We will also make copies available to others upon request.

If you have any questions about this report, please contact me at (202) 512-4841 or Mr. Jerry Herley, Assistant Director, at (202) 512-7609. Key contributors to this assignment were Vijay Barnabas, Richard Eiserman, and Gregory Harmon.

Sincerely yours,

Allen Li
Associate Director
Defense Acquisitions Issues

Enclosures-6

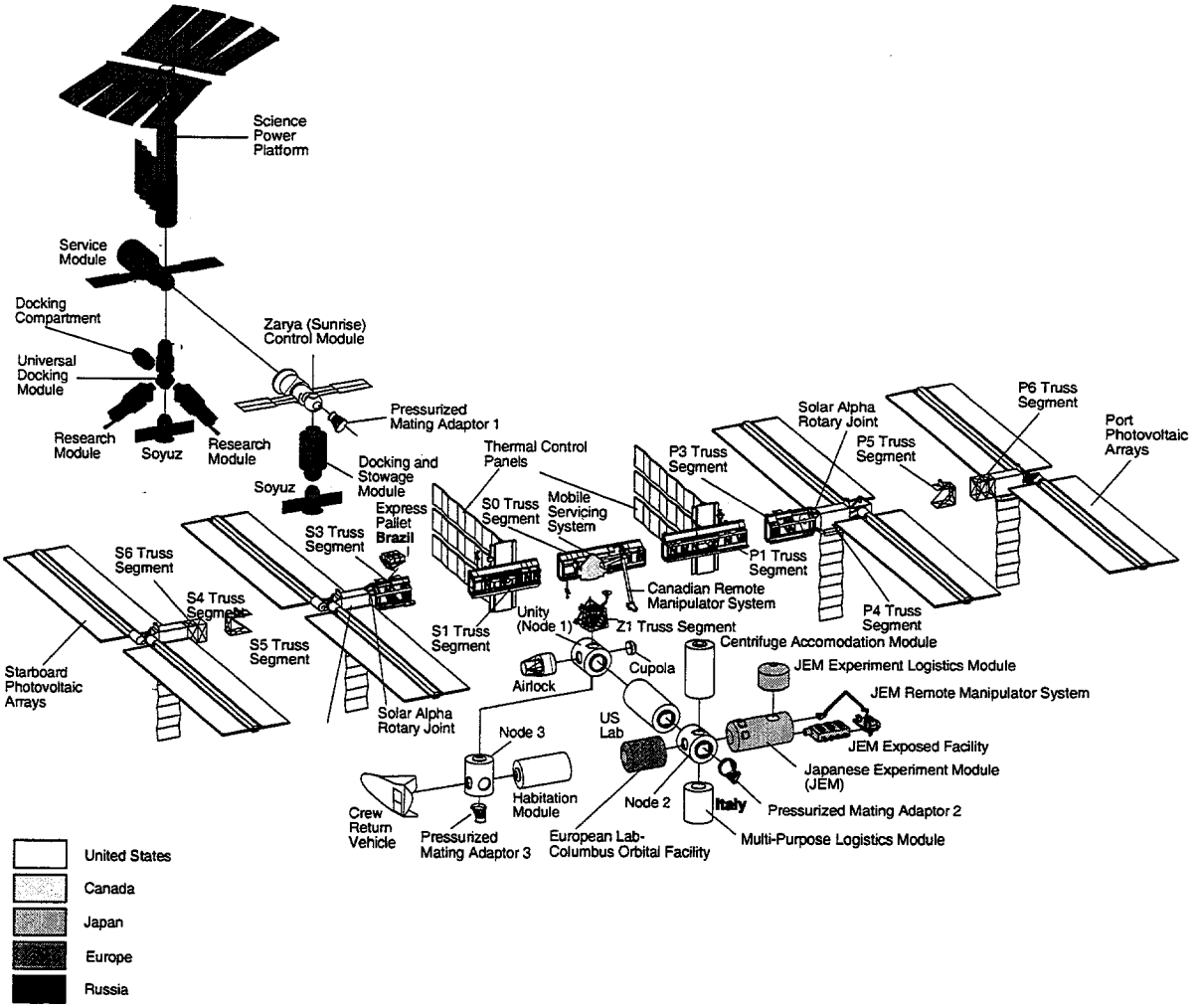
SPACE STATION BACKGROUND

The United States, Russia, Canada, Europe,[3] Japan, and Brazil are building the International Space Station to provide an Earth orbiting facility that supports human habitation and scientific research. Figure 1 shows the elements contributed by each partner. The first two space station elements—the Russian-built Zarya module and NASA's Unity node, were launched in November and December 1998. The third element, the Russian Service Module, is scheduled for launch in July 2000. Assembly of the space station is scheduled for completion in September 2005. After assembly is complete, NASA and its partners expect to operate the space station for at least 10 years.[4] In 1998, we estimated the U.S. cost to develop, assemble, and operate the space station would total $96 billion.[5]

Although built by a Russian company, Zarya is considered a U.S. element. NASA funded the development of the Zarya module through the Boeing Company, the space station's prime contractor. Boeing subcontracted with a Russian firm to build and launch Zarya. Russia is providing the Service Module as its primary contribution to the space station. Russia also plans to contribute Progress resupply vehicles, Soyuz crew transfer and emergency return vehicles, a power platform, docking and stowage modules, and research modules. Russia is responsible for funding the development and launch of its contributions.

[3] European Space Agency members participating in the space station program include Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.
[4] Space Station: Cost to Operate After Assembly Is Uncertain (GAO/NSIAD-99-177, Aug. 6, 1999).
[5] International Space Station: U.S. Life-Cycle Funding Requirements (GAO/NSIAD-98-147, May 22, 1998).

Figure 1: International Space Station Elements



Source: NASA

Zarya and the Service Module are critical to the early stages of the space station's assembly. Zarya was the first element in the assembly sequence and provides the early propulsion, guidance, navigation, and control functions. Zarya had to be in orbit before any of NASA's other elements could be launched. The Service Module is also essential early in the space station assembly sequence to provide living quarters and life support functions. After docking to Zarya, the Service Module will assume the guidance, navigation, and control functions from Zarya, which will then be used primarily for fuel storage. Zarya and the Service Module are derived from existing Russian hardware. The Zarya module is based on the Salyut Functional Cargo Block, which has extensive flight history in the Russian space program. The Service Module is largely derived from the core module of Russia's existing Mir space station, launched in 1986.

In 1995, NASA officials became increasingly concerned about Russia's ability to fund its space station commitments.[6] Funding shortages became so acute that in 1998 NASA transferred $60 million to the Russian space agency to help it complete the Service Module. In exchange for the $60 million, the Russian space agency agreed to provide 4,000 hours of Russian crew time for NASA research and stowage space aboard Russian elements. NASA officials are considering transferring another $35 million to the Russian space agency to purchase additional goods and services.

The launch of the Service Module has been delayed several times due to Russian funding shortages and problems with the Russian rocket that will be used to carry the module into orbit. When Russia joined the space station program in 1993, the Service Module was scheduled for launch in July 1997. When the first space station element was launched in November 1998, the Service Module launch had slipped to July 1999. The Service Module is now planned to be launched in July 2000.

[6] Space Station: Russian Commitment and Cost Control Problems (GAO/NSIAD-99-175, Aug. 17, 1999).

PROCESS FOR REVIEWING SAFETY HAZARDS AND APPROVING WAIVERS

NASA has established a formal process for reviewing and approving the safety of space station elements. Each partner is responsible for analyzing its own hardware and software for potential hazards. NASA space station personnel, working with other partners, can also identify safety hazards. When a potential safety hazard is identified, the element provider prepares a hazard report. The report describes the severity of the potential hazard and the likelihood of the hazard actually occurring. It also includes a description of the potential causes of the hazard and the controls necessary to mitigate or eliminate it. The hazard report must also identify the method for verifying that the controls will mitigate the hazard.

All hazard reports must be reviewed and approved by NASA's Safety Review Panel, which is composed of senior NASA officials from both within and outside the space station program and includes representatives from NASA's international partners. The panel can also identify hazards and request hazard reports from element providers. When the panel is satisfied that a potential hazard is understood, that effective controls are in place to mitigate it, and that the controls can be verified, the panel chairman signs the hazard report, thus indicating that safety requirements have been met.

When a potential hazard cannot be eliminated or controlled enough to meet safety requirements, NASA can prepare a noncompliance report to document the rationale for accepting the risk of waiving the requirements. NASA's Safety Review Panel approves such waivers only after thoroughly reviewing the issue and determining that the risks are acceptable. Depending on the problem, a waiver can be finalized by the panel, or it can receive higher levels of review and approval. For example, if the edges of a piece of hardware are too sharp to comply with safety requirements, NASA engineers will test the edges to ensure that they will not harm crewmembers or spacesuits. In many cases, these types of noncompliance are eventually considered acceptable and do not require a waiver to be approved beyond the safety panel. When the issue is considered more serious, such as inadequate protection against orbital debris,[7] the waiver is forwarded to the space station program manager for review and approval. Waivers for any requirement must also be approved by a series of management boards established to review changes to the space station program. All relevant hazard reports must be signed ("closed") and all waivers approved by NASA before launch of a space station element is approved.

[7] In this report, we use orbital debris as a general term referring to both naturally occurring micrometeoroids and other materials in orbit such as spent rocket stages and satellite fragments.

RUSSIAN ELEMENTS DO NOT COMPLY WITH SOME KEY SAFETY REQUIREMENTS

Although Russian elements comply with the majority of space station safety requirements, Zarya and the Service Module still do not meet some important requirements. According to NASA safety officials, significant areas of noncompliance include (1) inadequate shielding from orbital debris on the Service Module, (2) inability of Zarya and the Service Module to operate if they lose cabin pressure, and (3) excessive noise levels in Zarya and the Service Module. In addition, NASA still needs to validate the design and service life of the Service Module windows. These shortcomings increase the risk of health hazards and of what NASA terms "catastrophic" failure[8] of the modules. NASA officials said that shortfalls in Russian funding, designs based on existing Russian hardware, and technical disagreements with Russian engineers are the main reasons these modules do not comply with safety requirements.

Service Module Is Not Adequately Protected From Orbital Debris

The Service Module does not meet space station requirements for protection against penetration from orbital debris. Depending on the location of the penetration and the size of the debris, a penetration could harm the crew and cause the loss of the space station. The Service Module was supposed to have no more than a 2.4-percent probability of a penetration over a 15-year period, but it has been assessed as having a 25-percent probability with current shielding. Debris protection for the Service Module is based on the existing Mir space station's shielding, which does not meet the International Space Station's requirements.

In 1995, NASA and the Russian space agency agreed that the Service Module's shielding would have to be improved in order to meet safety requirements and that they would add more shielding in orbit. NASA and the Russian space agency are currently planning to complete shielding upgrades in 2004, 3.7 years after the planned launch of the Service Module. The shields cannot be installed prior to launch because they would make the Service Module too heavy to lift into orbit. NASA estimated the probability of a penetration without fully upgraded shielding during the first 3.7 years to be 5 percent. The additional shields should reduce the probability of a penetration to 3.8 percent over the remaining 11.3 years of the 15-year period; this still does not meet the original target requirement.

Zarya and the Service Module Will Not Operate After Losing Cabin Pressure

The space station program requires that equipment located in pressurized modules be capable of functioning if cabin pressure is lost. Pressure loss can be caused by leaking seals or valves or by penetration by orbital debris. Russian-built modules are based on

[8] NASA defines catastrophic failure as any condition that may cause a disabling or fatal personal injury or loss of the shuttle, space station, or major ground facility.

existing designs that do not meet this space station requirement. Much of the equipment in the modules requires air for cooling and will eventually fail in a vacuum. When NASA procured Zarya "off-the-shelf," NASA specifically exempted the module from fully meeting this requirement. Consequently, loss of pressure in Zarya and failure of its guidance systems would result in the loss of the space station.

The Service Module is scheduled to dock to the space station in July 2000 and take over from Zarya critical guidance functions for maintaining the space station in orbit. But the Service Module equipment will also fail if it loses cabin pressure, and if it does, the space station will be lost. NASA plans to install global positioning system hardware and other guidance, navigation, and control equipment on its laboratory module and on a truss segment, allowing the Service Module to maintain control even if it loses pressure. This equipment is not planned for installation until the end of 2001.

Zarya and the Service Module Are Too Noisy

Noise levels in Zarya and the Service Module exceed specifications. The general space station specification set by NASA states that noise levels should not exceed an average of 55 decibels over a 24-hour period. NASA relaxed the requirement to 60 decibels for Russian-built elements because Russian space officials would not agree to meet the general specification. However, after launch in November 1998, noise levels in Zarya measured between 65 and 74 decibels. Recognizing that noise levels were too high, Boeing and its Russian subcontractor provided noise reduction devices that were installed aboard Zarya in orbit in May 1999. Noise levels subsequently dropped to an average of 62 to 64 decibels. Boeing and the subcontractor are planning additional corrective actions during a future shuttle flight to the space station.

Projections are that the Service Module will be in the 70- to 75-decibel noise range. NASA officials are particularly concerned about excessive noise levels in the Service Module because it will serve as the crew's living quarters. High noise levels could affect operations if crew members have difficulty in communicating with each other or with ground controllers. Officials are also concerned that working and sleeping in a noisy environment could increase crew fatigue. To lower the Service Module's noise levels, the Russian space agency agreed to a plan calling for hearing protection equipment, mufflers, barriers, isolators, and quieter fans. However, implementation of the plan has been slow, primarily due to lack of funding. To protect themselves until noise levels are reduced, the crew will have to wear hearing protection equipment because long-term exposure to such noise levels can cause temporary or permanent hearing damage. However, wearing hearing protection devices could affect the crew's ability to hear caution and warning signals and to communicate with each other. In addition, NASA officials are concerned that the crew will not use these devices if they are uncomfortable.

The Service Module is essentially the same vehicle as the core module of the Mir. The Mir's noise levels have been measured at 59 to 72 decibels. A study of 50 Mir cosmonauts showed that virtually all suffered temporary hearing damage, and some had permanent damage that disqualified them from future space flights. At least one NASA astronaut

who stayed aboard Mir for an extended time also suffered significant temporary hearing loss. The crew that suffered hearing damage did not wear hearing protection equipment because of comfort problems.

Service Module Windows Have Not Been Verified

NASA has not verified that the Service Module's windows meet space station requirements because it did not receive sufficient test data from Russian engineers until very recently. NASA officials said that they received additional data from Russian engineers during meetings that ended in Moscow on March 10, 2000, and they are currently assessing whether the data is sufficient to verify the design and service life of the windows.

Space station windows must be designed to prevent catastrophic loss if a window pane breaks. According to space station officials, if a window were to fail, it would cause rapid loss of pressure, most likely resulting in the loss of the crew and of the space station. Service Module windows have two panes. Until the March meeting, Russian engineers had not provided data to show that one window pane would withstand the sudden change in pressure if the other pane were to break—for example, after being struck by orbital debris. NASA engineers recognize that there can be legitimate disagreements on technical design issues but added that without verification data, they would not be able to determine whether the design meets safety requirements.

Space station windows must also be certified to last at least 15 years. However, the Service Module windows are based on the same design used for the existing Mir space station and are designed to last 5 years. Until recently, the Russian space agency had not provided NASA with sufficient test data to verify that the windows would last 15 years, citing instead the fact that no windows failed during the Mir's 14 years in orbit. But space station program officials have noted that the Mir's windows show evidence of damage from orbital debris. NASA is concerned that over the years, the outer pane may become damaged to the point of cracking and breaking. The Russian space agency has developed metal covers that can be installed over damaged windows.

WAIVERS OF SAFETY REQUIREMENTS MUST BE APPROVED BEFORE LAUNCH

NASA must approve any waiver of safety requirements before approving the launch of space station elements. NASA believes that the higher risks of waiving requirements are acceptable if mitigation plans are in place and if deficiencies last only a limited time. Part of the rationale for approving waivers is that NASA and the Russian space agency plan to correct safety deficiencies in orbit during future space station assembly and logistics flights. However, there could be problems in deferring corrective actions until after modules are launched.

NASA Approved Waivers for Zarya

NASA approved waivers for ability to operate in the event of loss of pressure and noise levels on Zarya prior to its launch.

- NASA approved a waiver in August 1998 for Zarya's inability to operate after losing pressure because extensive reviews determined that controls to prevent leaks from seals and valves were satisfactory and that the module is adequately protected from penetration by orbital debris. At the time, NASA also expected the Service Module to take over Zarya's critical functions relatively soon because the Service Module was scheduled to be launched in April 1999, about 5 months after Zarya. But according to the latest estimates, the Service Module will not be launched until at least July 2000, or about 20 months after Zarya.

- NASA approved a waiver in November 1998 for Zarya's noise levels because the crew could limit time in the module and exposure to the higher noise levels. Should the crew need to increase time spent in the module, they could wear hearing protection.

Waivers Must Be Approved Before Service Module Can Be Launched

NASA has approved a waiver for debris shielding on the Service Module but has not yet approved waivers for ability to operate after loss of pressure and noise levels on the Service Module and has not closed the hazard report for the Service Module's windows. The status of each waiver is as follows:

- NASA approved a waiver report in August 1999 for the Service Module's inability to meet requirements for protection against orbital debris. The space station program is willing to accept a higher risk during the 3.7 years that are scheduled to pass from when the Service Module is launched to when additional shielding is attached. In approving the waiver, NASA recognized that even after additional shielding is installed, the probability of a penetration will still be above original target requirements, but the result will be a considerable improvement over the 25-percent probability if shielding is not augmented.

- NASA is considering approving a waiver for the Service Module's inability to operate after loss of pressure because extensive reviews determined that controls to prevent leaks from seals and valves are satisfactory. In addition, the time of higher risk should be limited to the time between the launch of the Service Module and the launch of NASA's guidance equipment at the end of 2001, about 15 months. Using guidance data from NASA's equipment, the Service Module should be able to maintain control of the space station even after pressure is lost.

- NASA is considering approving a waiver report for the Service Module's noise levels because a remedial action plan has been developed. But before approving the waiver, NASA officials want the Russian space agency to provide a schedule for implementing the action plan. The officials said they believe the period covered by the waiver should be limited to the first long-term crew's stay aboard the space station, scheduled to begin in October 2000. The crew is supposed to install noise reduction devices during its 3-month stay.

- NASA has not signed a hazard report for the Service Module windows. NASA engineers said that they expect to close the report after they have determined that data recently received from Russian engineers proves the window design meets safety requirements and the windows can last 15 years.

NASA must close all hazard reports and approve all waivers before it can approve the launch of the Service Module. Had the Russian space agency been prepared to launch the Service Module as scheduled in July 1999, NASA might have had to withhold launch approval because at the time, the waivers for pressure loss and noise and the hazard report for windows had not been approved. However, because completion of the Service Module was delayed beyond July 1999, NASA was not put in the position of having to withhold launch approval. Because the Service Module is critical for continuing assembly of the space station, withholding launch approval could delay the program's schedule and increase NASA's costs. Delays in critical Russian space station elements have already had a significant impact on NASA's costs. A January 1999 space station program office analysis estimated that delays in Russian elements could add $3 billion to NASA's program costs through completion of assembly.

Potential Problems With Deferring Corrections Until After Launch

Correcting safety deficiencies after modules are launched can take longer than planned, can be more difficult than on the ground, and can affect other activities such as research.

- Over the years, the space station assembly schedule has been stretched out, and the total period of higher risk of losing the space station in the event cabin pressure is lost in Russian elements has grown from 7 to 35 months. When Russia first joined the space station program in 1993, the Service Module was supposed to be launched 2 months after Zarya, and NASA's guidance equipment was to be launched 5 months after that. Now, the Service Module may be launched 20 months after Zarya, and NASA's guidance equipment 15 months after that.

- The period of higher risk could increase if development and production of the corrections are delayed. Because of funding shortages, the Russian space agency is behind schedule in developing items to address noise levels in the Service Module. NASA officials cited Russian funding problems as a major reason for delays in designing and testing the additional debris shields for the Service Module.

- The period of higher risk may be longer if corrective actions do not bring the modules in compliance with safety requirements. For example, the initial round of remedial actions implemented on Zarya did not fully correct noise problems, and the module will not comply with noise requirements until additional actions are taken. Because some noise countermeasures are still being designed for the Service Module, it is not clear how many will be in place when the first long-term crew arrives on the space station in October 2000 or how effective they will be. Although Russian space officials have committed to reducing the probability of orbital debris penetrating the Service Module, the effectiveness of the additional shields will not be known until the designs are completed and tested.

- Implementing corrections in orbit can be more difficult than on the ground. The shuttle crew on the space station in May 1999 had difficulty wrapping mufflers on Zarya's air ducts. According to NASA officials, the crew did not receive adequate training and instructions on how to install the mufflers and could not get them to fit properly. In attempting to force the mufflers around the ducts, the crew crimped the ducts. NASA officials believe that installing some noise reduction devices on the Service Module will be difficult in orbit and have suggested to their Russian counterparts that installation be done on the ground.

- Performing corrections in orbit could divert crew time from other planned tasks such as research. Crews will have to perform extensive work inside the Service Module to install mufflers, baffles, and other noise reduction materials. Crews will also have to prepare for and conduct at least four space walks to install additional debris shields on the exterior of the Service Module. It is not yet known what the safety issues may be or what corrections may have to done in orbit for the other elements (such as docking and research modules) Russia will supply later in the assembly sequence.

COMPENSATION TO NASA FOR PERFORMANCE PROBLEMS

The four cases we reviewed in which Zarya did not meet requirements or had performance problems did not warrant compensation from the contractor. These cases involved excessive noise, defective batteries, inability to operate after loss of pressure, and health symptoms experienced by the crew.

The Boeing Company, NASA's space station's prime contractor, is responsible for delivering the Zarya module to NASA. In 1995, Boeing signed a fixed-price subcontract for $190 million with Russia's Khrunichev State Research and Production Center to build and launch the Zarya module for NASA. The contract value increased to $234 million with modifications. Boeing accepted Zarya from Khrunichev when the module was launched in November 1998. NASA will accept Zarya from Boeing when the Service Module successfully docks to Zarya.

NASA procured Zarya as an "off-the-shelf" module knowing that some of its design characteristics did not conform with all space station requirements. According to NASA contracting officials, NASA can request compensation from Boeing if NASA determines that performance of the Zarya module is degraded or if additional costs are incurred to fix a problem.

- Although noise levels in Zarya exceeded NASA's safety requirements, the agency did not ask for compensation because Boeing and its Russian subcontractor agreed to fix the problem at no charge to NASA. Khrunichev developed noise-limiting devices that were installed during a shuttle flight in May 1999 and significantly reduced noise levels. However, because noise levels still exceed safety requirements, Boeing and Khrunichev plan to provide additional devices to be installed on a shuttle flight scheduled for later in 2000.

- The Zarya module experienced battery problems four times while in orbit, but Khrunichev is fixing these problems at no charge to NASA. The module uses six batteries, but only three are needed to keep Zarya operational. In the first instance, the battery failed due to defective hardware, which Khrunichev replaced. The cause of the other battery problems is still under investigation, but NASA officials stated that Khrunichev has already agreed to provide the hardware to fix the problems.

- NASA did not seek compensation for Zarya's failure to meet the space station requirement for operation after loss of cabin pressure because NASA specifically exempted Zarya from this requirement. When NASA and Boeing procured Zarya, they knew that the module was not designed to operate after losing pressure. NASA did require the module to maintain structural integrity, audio communications, and the capability to transfer power and fuel after losing pressure, and NASA determined that the module met these limited requirements.

- During a shuttle flight in 1999, crewmembers experienced headaches, flushed faces, and nausea while working in Zarya for extended periods. The crew attributed these symptoms to poor air quality caused by inadequate ventilation and high carbon dioxide levels. After investigating the incident, NASA ruled out poor ventilation and air quality as factors in the crew's reported symptoms. NASA is still investigating the incident, but so far, it has not identified any problems with Zarya that would warrant seeking compensation from the contractor.

COMMENTS FROM THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

APR 26 2000

Mr. Allen Li
Associate Director
Defense Acquisition Issues
General Accounting Office
Washington, DC 20548

Dear Mr. Li:

Thank you for the opportunity to review and comment on the recent draft report entitled, "Russian-Built Zarya and Service Module Compliance with Safety Requirements" (GAO/NSIAD-00-96R). NASA concurs that the report captures the most significant issues still in work that affect the early ISS Modules.

The report focuses on a small number of instances of non-compliance of Russian hardware with safety requirements. In these instances, risk mitigation plans are in place to implement operational procedures and modifications to increase safety and reduce risk. The report does not capture the rigor of the safety certification process that has been developed over the thirty plus years of human space flight. In this process, NASA requires an accounting of the factors affecting any situation where requirements are not met and ensures that NASA and its partners have an understanding of the residual risk posture and mitigation plans. Russian segment specifications and safety requirements are in place and their hardware goes through the same thorough safety review process as NASA and other internationally provided hardware.

There are cases of non-compliance reports with U.S. and other International Partner hardware, which as the GAO report accurately states, "...may justify a waiver only after thorough review of the respective issue and a determination that the risk is acceptable." The report accurately defines the areas of concerted effort to understand and address compliance with requirements between the Russian Aviation and Space Agency (Rosaviakosmos) and NASA. However, the report does not adequately characterize the complete set of the information provided to the program engineers, managers, and safety personnel who evaluate the entirety of the testing, analysis, and other pertinent information to make the right decision. NASA's concern with the report is that it lacks sufficient detail for the reader to appreciate or understand all the factors that have significantly influenced decisions to grant waivers to requirements.

Safety of flight, is, and will continue to be, our number one goal. This does not change with the involvement of international partners. The process observed by the GAO reflects NASA's attention to safety. The ISS modules will only fly if, after review by NASA and our International Partners, they are judged to have an acceptable level of risk. Please contact Mr. Dan Hedin on (202) 358-1691, if further assistance is required.

Sincerely,

Daniel R. Mulville
Associate Deputy Administrator

(707442)

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