IG-01-027

AUDIT REPORT

ACQUISITION OF THE SPACE STATION PROPULSION MODULE

May 21, 2001

National Aeronautics and
Space Administration

OFFICE OF INSPECTOR GENERAL

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Acronyms

ATV	Autonomous Transfer Vehicle
FAR	Federal Acquisition Regulation
FGB	Functional Energy Block
GAO	General Accounting Office
ICM	Interim Control Module
ISS	International Space Station
NPD	NASA Policy Directive
NPG	NASA Procedures and Guidelines
OIG	Office of Inspector General
OMB	Office of Management and Budget
OPTS	Orbiter Propellant Transfer System
SRR	Systems Requirements Review
USPM	United States Propulsion Module
USPS	United States Propulsion System

W May 21, 2001

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: INFORMATION: Audit of Acquisition of the Space Station Propulsion Module
Report Number IG-01-027

The NASA Office of Inspector General (OIG) has completed an Audit of Acquisition of the Space Station Propulsion Module. We found that, with a life-cycle cost of $1,558 million and a diminished need for long-term U.S. propulsion capability, the Propulsion Module was not cost-effective. In March 2001, NASA cancelled the Project after recognizing that the estimated $675 million cost to complete the Project was not affordable. NASA implemented the United States Propulsion Module (USPM) design before properly accomplishing acquisition planning and preparing project documentation. For example, NASA did not validate requirements from the system requirements review[1] (SRR) before beginning a preliminary design review of the USPM. As a result, the Agency spent $97 million[2] and 19 months of effort before it determined that the design was unacceptable. For the follow-on design, the United States Propulsion System (USPS), NASA appropriately analyzed alternatives, developed an acquisition strategy, and defined requirements. However, the Agency pursued implementation of the USPS without an approved project plan or risk management plan. Also, NASA selected The Boeing Company (Boeing) as the sole-source contractor without properly documenting the justification for the noncompetitive selection. As a result, NASA had not shown that the selection was in the best interest of the Government.

Background

The purpose of the Propulsion Module Project was to provide a U.S. capability for long-term propulsion on the International Space Station (ISS). In October 1998, the Agency began the Project with the USPM design, which included a requirement for on-orbit refueling of the Propulsion Module by the Space Shuttle. The propellant transfer requirement involved another element of the USPM, called the Orbiter Propellant Transfer System (OPTS). The USPM encompassed two major programs at the Lyndon B. Johnson Space Center (Johnson), the

[1] A systems requirements review is the process to define and baseline a complete set of requirements for a project.
[2] NASA estimated expenditures of $125 million for the USPM, of which $28 million can be used on the International Space Station.

ISS Program and the Space Shuttle Program; and at the George C. Marshall Space Flight Center (Marshall), the Propulsion Module Project Office. In May 2000, the Agency cancelled the OPTS because of unacceptable risks. In July 2000, NASA suspended development of the Propulsion Module.

In September 2000, after extensive analysis of propulsion alternatives, NASA selected the USPS design.[3] The USPS consisted of a redesigned Propulsion Module that would attach to a node to be added to the forward end of the ISS. Boeing had already built the node as the Node 1 Structural Test Article and planned to modify it to provide an attachment point for the Propulsion Module and a docking port for the Space Shuttle. The USPS would not have been refueled on-orbit but would have returned to earth for maintenance and refueling.

Recommendations

Because NASA took action to cancel the Project, we are not making recommendations on the Project. However, we recommended that for future ISS projects, NASA establish an approved project plan, acquisition plan, and risk management plan; resolve all discrepancies from an SRR before beginning a preliminary design review; and establish synchronized milestones for all related program and project elements. These actions would provide a more stable baseline for project implementation, help ensure that risks are identified early, and help facilitate better coordination between project elements. We also recommended that NASA obtain an approved justification, as prescribed by the Federal Acquisition Regulation (FAR), before initiating future sole-source procurements on the ISS contract. This action would help ensure that NASA considers competitive procurement for new work and properly documents justification for exceptions to show that its decisions are in the best interest of the Government.

Management Response and OIG Evaluation

NASA concurred with the recommendation to establish an approved project plan, acquisition plan, and risk management plan. Management stated that it would manage all ISS Projects consistent with NASA policy. The Agency also provided general comments in which it disagreed with our finding that the USPM design was selected without fully considering alternatives and without developing an adequate acquisition strategy. The complete text of management's response is in Appendix E.

NASA's comments are responsive to the recommendation. Management's commitment to manage all ISS Projects consistent with NASA policy is sufficient to close the recommendation for reporting purposes. Our additional comments on management's response are in Appendix F.

NASA partially concurred with the recommendation to resolve all SRR discrepancies prior to beginning a preliminary design review. Management stated that resolving all SRR discrepancies

[3] Compared to the USPM, the USPS was designed to use a safer fuel (a monopropellant), did not require a complex and heavy system of lines and valves for transferring the more volatile bipropellant fuel, and did not involve the safety risks of transferring fuel in orbit.

prior to a preliminary design review is the goal for all projects and that processes are in place that fully support NASA guidance. However, management disagreed that it should have closed all discrepancies from the SRR before beginning a preliminary design review for the USPM (see Appendix E).

Management's comments are generally responsive to the recommendation. Although we maintain that NASA should have closed all discrepancies from the SRR before beginning a preliminary design review for the USPM, we acknowledge that the Project Office and the ISS Program Office appropriately defined requirements for the USPS (see Appendix F). Therefore, we consider management's action taken on the USPS and comments regarding future projects, in particular, the goal of resolving SRR discrepancies prior to preliminary design review, sufficient to close the recommendation for reporting purposes.

NASA concurred with the intent of the recommendation on sole-source procurements, recognizing that all procurements must follow the appropriate regulations. However, the Agency maintained that the Propulsion Module Project was within the scope of the contract and, therefore, was not subject to requirements for competitive procurements (see Appendix E).

We maintain that the Project constituted new work that required properly documented justification for the noncompetitive selection of Boeing. In fact, the Associate Administrator for Space Flight acknowledged that the obligation for a Propulsion Module was not included in the ISS contract. Further, it is in NASA's best interest to promote competition to the extent practical rather than pursue regulatory exceptions that permit noncompetitive awards (see Appendix F). Nevertheless, we consider management's statements regarding future projects sufficient to close the recommendation for reporting purposes and will continue to monitor NASA's noncompetitive awards as part of other reviews.

Details on the status of the recommendations are in the recommendations section of the report.

[original signed by]
Roberta L. Gross

Enclosure
Final Report on Acquisition of the Space Station Propulsion Module

FINAL REPORT ON
ACQUISITION OF THE SPACE STATION PROPULSION MODULE

W May 21, 2001

TO: AA/Acting Director, Lyndon B. Johnson Space Center

FROM: W/Assistant Inspector General for Auditing

SUBJECT: Final Report on Audit of Acquisition of the Space Station Propulsion Module
Assignment Number A0004300
Report Number IG-01-027

The subject final report is provided for your information and use. Please refer to the Executive Summary for the overall audit results. Our evaluation of your response is incorporated into the body of the report. Management's comments were generally responsive to the recommendations and are sufficient to close the recommendations for reporting purposes.

If you have questions concerning the report, please contact Mr. Dennis Coldren, Program Director, Space Flight Audits, at (281) 483-4773, or Mr. Jimmie Griggs, Auditor-in-Charge, at (281) 483-9965. We appreciate the courtesies extended to the audit staff. The final report distribution is in Appendix G.

[original signed by]
Russell A. Rau

Enclosure

cc:
B/Acting Chief Financial Officer
B/Comptroller
BF/Director, Financial Management Division
G/General Counsel
JM/Director, Management Assessment Division
M/Associate Administrator for Space Flight
DA01/Director, George C. Marshall Space Flight Center

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NASA Office of Inspector General

IG-01-027 **May 21, 2001**
A0004300

Audit of Acquisition of the Space Station Propulsion Module

Executive Summary

Background. The Propulsion Module Project was part of the ISS Program, for which Boeing is the prime contractor. The purpose of the Project was to develop a U.S. propulsion capability to mitigate the risk of a Russian failure to deliver critical elements or provide support to the ISS. NASA began the Project in October 1998 and selected a design called the USPM in February 1999. The USPM consisted of two elements, the Propulsion Module and the OPTS. The Project Office managed the Propulsion Module, the Space Shuttle Program Office managed the OPTS and its integration with the ISS,[4] and the ISS Program Office managed the integration of the Propulsion Module with the ISS. In May 2000, NASA cancelled the OPTS because of unacceptable safety, technical, and cost risks.[5] In July 2000, the Agency suspended development of the Propulsion Module. In September 2000, NASA selected a new design called the USPS, which also consisted of two elements, the Propulsion Module and Node 4,[6] and did not involve orbital transfer of propellant. NASA's estimate at completion for the Project was $724 million. In March 2001, NASA cancelled the USPS because of budget concerns. Appendix B contains a chronology of events for the USPM and USPS.

Objectives. Our overall audit objective was to determine whether NASA developed a cost-effective acquisition strategy for a long-term propulsion capability for the ISS. Specifically, we determined whether NASA identified and adopted the most feasible means of providing a long-term propulsion capability and developed an acquisition strategy to limit the cost of the Propulsion Module. Appendix A contains further details on our objectives, scope, and methodology.

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[4] The OPTS required major modifications to the Space Shuttle Orbiters to allow the transfer of propellant.
[5] The unacceptable risks related to the use of a volatile bipropellant fuel, a complex system of lines, valves, and tanks for transferring the fuel, a permanent weight increase of about 1,500 pounds to the Orbiters, and cost growth from $479 million to $744 million.
[6] Node 4 was the Node 1 Structural Test Article, which Boeing had already built but which needed to be modified to provide an attachment point for the Propulsion Module and a docking port for the Space Shuttle. Also, NASA redesigned the Propulsion Module for the USPS.

Results of Audit. The USPS represented a simpler and safer design than the USPM. However, at a life-cycle cost of $1,558 million, the USPS was not a cost-effective strategy because Russia's delivery and refueling of the Service Module[7] eliminated a major risk and diminished the need for long-term U.S. propulsion capability (Finding A).

The Agency attempted to implement the USPM before completing acquisition planning and project documentation and spent $97 million and 19 months in project development before determining that the design was unacceptable. For example, weaknesses in the requirement review process contributed to a failed preliminary design review. Also, although the Agency analyzed alternatives and developed an acquisition strategy for the USPS, NASA pursued implementation of the USPS (like the USPM) without an approved project plan or risk management plan and could have experienced similar negative cost and schedule impacts had the Project not been cancelled (Finding B).

NASA selected Boeing as the sole-source contractor for the Project without determining whether a sole-source procurement was appropriate and without properly documenting its justification for the noncompetitive selection. As a result, NASA had not shown that the sole-source procurement was in the best interest of the Government (Finding C).

Recommendations. Because NASA took action to cancel the USPS, we are not making recommendations on the Project. However, for future projects, we recommend that NASA complete acquisition planning and documentation, validate requirements, synchronize milestones, and obtain an approved justification for sole-source selections.

Management Response. NASA either concurred or partially concurred with all the recommendations. NASA also agreed that by canceling the Project, it could put $675 million to better use.

Management stated that all of NASA's programs and projects would be planned and documented consistent with NASA policy. In addition, resolving all requirement review discrepancies is the goal for all projects. Program and project management will assure risks of proceeding to the next milestone are identified and controlled including resolving requirement review issues. The Agency established formal controls for defining, approving, and controlling the interfaces between elements.

NASA also stated that all of its procurements follow the appropriate sole-source selection regulations. However, NASA disagreed that the Propulsion Module Project was required to follow the Federal Acquisition Regulation and Agency regulations on source selection because NASA considered the Project to be a simple change that was within the general scope of the contract.

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[7] The Service Module, which Russia successfully delivered to the ISS in July 2000, provides attitude and reboost control, communications, electrical power generation, life support, supplies and storage, crew systems, and mechanism control. The Service Module is refueled through the Functional Energy Block (see footnote 8).

The complete text of the response is in Appendix E. Management also provided general comments on our findings (see Appendix F).

Evaluation of Management's Response. We consider management's comments generally responsive to the recommendations. However, we maintain that the Propulsion Module Project was outside the scope of the ISS contract and was subject to Federal Acquisition Regulation requirements for sole-source selection. Our response to management's general comments is in Appendix F.

Introduction

The ISS is a cooperative international program. Russia's contribution to the ISS includes propulsion services, which Russia has provided through the Functional Energy Block (FGB),[8] the Service Module, and a series of unpiloted *Progress* vehicles.[9]

The Propulsion Module is part of the ISS Contingency Plan,[10] which calls for near-term reliance on Russian contributions while accelerating U.S. capabilities for long-term self-reliance. The Project is required for the potential loss of Russian participation and is designed to provide altitude reboost, debris avoidance maneuvers, and attitude control to augment Russian propulsion capability for the life of the ISS.

In May 2000, the ISS Program tasked a special team, called the Alternative Propulsion Module Assessment Team, to conduct a trade study to evaluate options and recommend a design for the Project. Based on the team's study and a September 2000 ISS Program Integration Study,[11] the ISS Program Manager directed the Project Office to implement the USPS design.[12]

In November 2000, Marshall's Procurement Office issued a modification to the ISS contract that authorized Boeing to support the USPS Project with a limited statement of work. As part of the limited statement of work, Boeing gave NASA a preliminary make-or-buy decision briefing[13] in December 2000 that recommended Boeing make Node 4 and buy (subcontract) the Propulsion Module through competitive procurement actions. NASA planned to evaluate and approve Boeing's final make-or-buy decision before awarding the contract. In January 2001, the Project Office requested that Boeing submit a firm proposal on its make-or-buy decision by April 30, 2001.

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[8] The Functional Energy Block is a self-sufficient orbital transfer vehicle that contains propulsion, guidance, navigation and control, communications, electrical power, thermal control systems, and stowage capacity. The FGB also serves as the primary fuel tank for the Service Module. Russia delivered the vehicle in November 1998 as the first element of the ISS. The Functional Energy Block is also called the Functional Control Block, the Control Module, the FGB, and *Zarya* (Sunrise).

[9] *Progress* vehicles supply dry cargo and propellant. After the vehicles deliver propellant and cargo to the ISS, they are undocked and de-orbited; they then burn up in the Earth's atmosphere.

[10] NASA now calls this plan the ISS Off-Nominal Situation Plan.

[11] Boeing performed the ISS Program Integration Study and coordinated it with the ISS Program Office, Johnson Space Center, and the Propulsion Module Project Office.

[12] The direction to implement the design did not constitute authority to contract for the acquisition of the USPS.

[13] The preliminary make-or-buy decision briefing gave NASA advance notice of Boeing's plans regarding the contractor's recommended procurement approach for the USPS.

Findings and Recommendations

Finding A. Cost-Effectiveness of the Propulsion Module

NASA did not have a cost-effective strategy for a long-term propulsion capability. Before NASA cancelled the Project, the Project Office's estimate at completion was $724 million, an increase of $182 million (34 percent) over the Agency's budget of $542 million. While acquisition costs had more than doubled, life-cycle costs also rose almost 50 percent. Other key factors in assessing the cost-effectiveness of the Propulsion Module are its decreased capability (from the USPM to the USPS), the reduction of major risks through the successful integration of the Service Module into the ISS, the demonstrated refueling of the Service Module by a *Progress* vehicle, and the de-orbiting of the *Mir*.[14] The major remaining risk is the potential shortage of *Progress* vehicles to refuel the Service Module, for which a long-term U.S. propulsion capability is not needed. If the Project had continued, NASA could have paid as much as $1,558 million to mitigate a risk that may never materialize and that could be covered at a lower cost.

Increased Cost of the Propulsion Module

In October 1998, Boeing proposed a not-to-exceed amount for the Propulsion Module of $331 million. In February 1999, Boeing increased its estimate by $148 million (45 percent) to $479 million. The $148 million increase resulted from additional work including developing the OPTS. Boeing maintained the $479 million cost until April 2000, when it again increased its estimate by $265 million to $744 million, an increase of 125 percent in 18 months. The $265 million increase was caused by additional requirements[15] and schedule slips.

In September 2000, the Project Office estimated that the cost to complete the USPS would be $675 million, including $63 million for a Space Shuttle flight to deliver the Propulsion Module to the ISS. Including expenditures on the USPM Project, NASA's estimate for the entire Propulsion Module Project was $724 million.

Life-cycle costs had also risen $511 million (49 percent) from $1,047 million for the USPM to $1,558 million for the USPS, largely because of the expected need to refurbish the Propulsion Module on the ground and transport it to and from the ISS about once a year with a Space Shuttle Orbiter. The total life-cycle costs for the USPS included $660 million for initial operational capability and $898 million for seven round-trip Space Shuttle flights[16] and ground servicing. The total life-cycle costs of $1,047 million for the USPM included $835 million for initial operational capability and $212 million for operations costs for 12 years.

Although the costs increased, the budget stayed the same. As of February 2001, NASA's budget of $542 million had not changed since the Project began with the USPM. The Agency

[14] *Mir* was the space station that Russia launched in February 1986.
[15] The additional requirements were for thermal, acoustic, and reboost tests; tunnel size increase; and helium resupply.
[16] The seven flights were based on an initial delivery flight and annual replenishment flights for 6 years.

planned to increase the budget after reviewing the Boeing proposal that was due in April 2000. However, a blueprint of the President's budget for fiscal year 2002 indicates that funding will be redirected from high-risk elements like the Propulsion Module to help offset ISS cost growth.

Decreased Capability of the Propulsion Module

Although the life-cycle cost of the USPS would have been significantly more than for the USPM, the capability of the USPS would have been less in the following ways:

- The requirement for the USPS was 6 years on-orbit compared to 12 years for the USPM.
- The monopropellant fuel that was to be used by the USPS, although safer, is about 33-percent less efficient than the bipropellant fuel designed for the USPM.
- A 6-month gap in coverage to the ISS would have existed each time the Propulsion Module was refurbished, compared to full-time coverage with the USPM because it would not have needed refurbishing.

Reduction of Risks

When the Project began, the ISS Contingency Plan included several high-risk Russian scenarios, especially the risks that the Service Module would not be delivered (or not function) and Russia would not provide the *Progress* vehicles transporting the fuel and supplies needed for the Service Module. The successful integration of the Service Module in July 2000 and its refueling by a *Progress* vehicle 2 weeks later greatly reduced those risks. The major remaining risk to the ISS is the shortage of *Progress* vehicles. The most likely cause of such a shortage would be insufficient funding by the Russian government.[17]

Potential Alternatives for Risk Mitigation

The Propulsion Module would not have sustained the ISS against a complete loss of Service Module functionality because of its limited capabilities (discussed above) and because NASA did not design the ISS for full redundancy of the Service Module. For example, the planned location of the Propulsion Module, the front of the ISS, was not ideal for reboost because the Service Module, located at the back of the ISS, occupies the best site for that purpose. Consequently, the ISS would have to be rotated 180 degrees before the Propulsion Module could be used effectively. Executing this maneuver would have required more time and fuel (about 10 percent more fuel).

The Propulsion Module was designed to supplement rather than replace the propulsion provided by the Service Module in the event of propellant shortages caused by an interruption in the flow of *Progress* vehicles. Over its operational life, the ISS will need an average of 7

[17] An additional risk regarding *Progress* vehicles was that Russia would divert the vehicles to maintain the *Mir* instead of the ISS. However, Russia de-orbited *Mir* in March 2001, thus eliminating that risk.

metric tons[18] of propellant per year, with a range of 1 to 12 metric tons needed per year, the equivalent of one to six *Progress* vehicles.[19] The Service Module currently has a 1-year supply of propellant.[20] A combination of shorter-term alternatives, as described below, can provide a more cost-effective solution to fill potential gaps in Russian resupply of propellant by *Progress* vehicles.

Interim Control Module. The Interim Control Module (ICM)[21] offers a low-cost and low-risk concept that uses off-the-shelf hardware components and would ensure ISS guidance and navigation control, attitude control, and reboost for at least a year. The ICM holds about 5 metric tons of propellant, the equivalent capacity of two and one-half *Progress* vehicles. A Space Shuttle Orbiter could deliver the ICM to the ISS.

NASA originally planned to use the ICM to bridge a potential gap between the FGB and Service Module if the Service Module was delivered late.[22] After the Service Module became operational, NASA viewed the ICM as a short-term solution to a delay or shortage of *Progress* vehicles. Therefore, the Agency directed the Naval Research Laboratory to proceed with modifications that would make the ICM better suited to help maintain ISS altitude without a steady supply of *Progress* vehicles.

In October 2000, NASA cancelled further ICM development because of the decreased risk of loss of Russian propulsion capability to the ISS and because $100 million could be saved by storing it before completion. NASA placed the partially completed ICM in storage and stated that it could be completed and readied for launch in about 24 months, if it is needed.[23]

***Progress* Vehicles.** NASA can purchase *Progress* vehicles from Russia to mitigate the risk of insufficient Russian funding.[24] A *Progress* can deliver 2 metric tons of propellant to the Service Module. The ISS Program Manager estimated that it costs the Russians less than $10 million to build a *Progress* and that the cost, including launch, might be $20 to $30 million. While potentially the most cost-effective alternative, this option is dependent on Russia's ability and willingness to provide the vehicles and on approval by the Congress.

FGB-2. In July 2000, Boeing and Khrunichev[25] partnered to launch and operate a second FGB (called the FGB-2), which Khrunichev built as a backup to the FGB that was delivered to the ISS in November 1998. The FGB-2 holds 4 metric tons of propellant, the equivalent of

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[18] A metric ton is 1,000 kilograms (or 2,200 pounds).
[19] The wide range of needed propellant is caused by changes in solar activity, termed the solar cycle.
[20] The 1-year supply of propellant is stored in the Service Module, FGB, and *Progress* vehicle.
[21] The Naval Research Laboratory built the ICM for another agency and was modifying it for ISS. Rockwell Aerospace presented the ICM concept to NASA in March 1996.
[22] The FGB had a design life of 16-1/2 months as an independent spacecraft but had been functioning (see footnote 7) for 20 months before the Service Module was delivered.
[23] The Naval Research Laboratory disagrees that the ICM could be completed in 24 months because laboratory representatives believe it would take longer to reassemble the team needed to finish the ICM.
[24] In October 1998, NASA modified the ISS contract to pay the Russian Space Agency $60 million to fund continued work on the Service Module. As consideration, NASA received 4,000 hours in future crew time and 2 cubic meters of stowage space originally allocated to Russia.
[25] Khrunichev is the Russian aerospace firm that built the FGB and the Service Module.

two *Progress* vehicles, and could be used to refuel the Service Module and provide additional storage space for the ISS. The ISS Program Manager estimated that it would cost $200 million to launch the FGB-2 but stated that it would not be a good business arrangement because it would be costly and could be used only once. Nevertheless, the FGB-2 is an option.

Space Shuttle Orbiters. As part of each Space Shuttle mission to the ISS, an Orbiter reboosts the ISS to a higher orbit. However, the effectiveness of this measure diminishes as ISS assembly continues and its mass grows. On a recent mission (5A), an Orbiter reboosted the ISS 14 miles. However, when ISS assembly is complete, an Orbiter will be able to reboost the ISS only 2 miles. NASA can improve this reboost capability by modifying its Orbiter fleet to allow aft fuel tanks to be used in addition to forward tanks. We reported earlier that the cost of the modification was $90 million (see Appendix A).[26]

Autonomous Transfer Vehicles. NASA can arrange with the European Space Agency to use Autonomous Transfer Vehicles (ATV's) to refuel the Service Module. An ATV can carry 5 metric tons of propellant, more than twice the amount of a *Progress*, and would be launched aboard an *Ariane* rocket. The European Space Agency is procuring nine *Ariane* rockets and ATV's and would obtain the propellant for the ATV's from Energia, a major Russian aerospace firm. The nine ATV's are part of the current ISS assembly and operations baseline; therefore, NASA would need to procure additional ATV's to replace *Progress* vehicles. The ISS Program Office provided us a rough cost estimate of $50 to $60 million for an ATV and $110 million for an *Ariane* rocket.[27]

Cancellation of the USPS

As a result of our audit findings, we would have recommended canceling the USPS. On February 12, 2001, we discussed this potential recommendation with the ISS Program Manager. The ISS Program Manager was receptive to the recommendation and responded that the ISS Program Office had begun reconsidering more cost-effective alternatives, such as the ATV. Because the ISS Program Manager subsequently took action to cancel the USPS, we are not making a related recommendation. Canceling the USPS allows NASA to put $675 million to better use, which represents the cost to complete the USPS including $63 million for Space Shuttle launch support. These savings do not include reductions in operations costs.

[26] We reported on the modification in report number IG-99-009, "Space Station Contingency Planning for International Partners," March 9, 1999.

[27] The rough cost estimate applies to the European Space Agency. The cost to NASA is currently unknown.

Finding B. Acquisition Planning and Implementation

NASA attempted to implement the USPM before completing required acquisition planning and project documentation. Specifically, NASA selected the USPM design without analyzing alternatives and did not establish a project plan, develop an adequate acquisition strategy, or prepare a risk management plan. Further, NASA did not validate requirements before beginning a preliminary design review of the USPM and did not synchronize the milestones for the two elements of the USPM. For the USPS, NASA had analyzed alternatives (see Appendix C), developed an acquisition strategy, and defined requirements but, similar to its approach for the USPM, the Agency did not have an approved project plan or risk management plan. Implementation was premature because the Agency attempted to meet an ambitious schedule for delivering a Propulsion Module to the ISS by fiscal year 2002. As a result, the Propulsion Module failed its preliminary design review, NASA spent $97 million and 19 months developing the USPM before realizing that the OPTS design was unacceptable, and the schedule to deliver a Propulsion Module to the ISS slipped by 3 years to fiscal year 2005. Similar results could have occurred with the USPS if the Project had not been cancelled.

Acquisition Guidance

NASA Procedures and Guidelines (NPG) 7120.5A, "NASA Program and Project Management Processes and Requirements," April 3, 1998, requires that all NASA projects establish a plan to provide assurance that a project is ready to proceed with the implementation phase. NPG 7120.5A also requires a risk management plan. Risk management begins with an initial risk identification and development of a risk management plan and continues throughout the project. NPG 7120.5A further requires that risk management planning be included in the project plan. In addition, the NPG requires that project implementation be executed in accordance with the controlling documents (in particular, the project plan and the risk management plan) developed during the formulation and approval phase.

NASA FAR Supplement 1807.1, "Acquisition Plans," requires that acquisition plans be approved before soliciting proposals. The NASA FAR Supplement also requires that the written acquisition plan address each topic listed in FAR 7.105. Some examples of those topics are provided below:

FAR 7.105, "Contents of Written Acquisition Plans," requires the plan to identify those milestones at which decisions should be made. The plan should address all the technical, business management, and other significant considerations that will control the acquisition. The plan should also include a summary of the technical and contractual history of the acquisition, feasible acquisition alternatives, effect of prior acquisitions on those alternatives, and any related in-house effort.

Acquisition Planning

The ISS Program Office and the Propulsion Module Project Office were aware that the Project was being implemented prematurely. However, the importance that NASA placed on an

accelerated schedule precluded appropriate project formulation and planning before project implementation.

The ISS Program Office started implementation of the USPM before establishing a Project Office and assigning a Project Manager. Boeing submitted a proposal in August 1998. In October 1998, the ISS Program Office manifested the Propulsion Module as Mission 10A.1. Also in October, Boeing proposed an updated not-to-exceed cost estimate. Later that month, the ISS Program Office assigned a Project Manager.

In December 1999, the ISS Program Office, Space Shuttle Program Office, and the Project Office signed an "Agreement and Direction for Propulsion Module Roles and Responsibilities," which identified the responsibilities of each office. NASA had conducted a separate systems requirements review (SRR) for the Propulsion Module and the OPTS and was beginning a preliminary design review on the Propulsion Module before the Agency established roles and responsibilities for the program offices and the Project Office.

Project Plan. The Project Office had not prepared a project plan prior to proceeding with implementation of the USPM. NPG 7120.5A requires a documented project plan to provide assurance that a project is ready to begin implementation of approved project requirements and plans. The Project Office had a draft project plan. However, the Marshall Center Director, ISS Program Manager, Space Shuttle Program Manager, and the Project Manager had not approved or implemented the plan.

The Project Office was developing a project plan for the USPS. However, the plan was still in draft form and had not been approved or implemented by the appropriate managers. The project plan should discuss and document all elements required by NPG 7120.5A. Specifically, the plan should include:

- A comprehensive definition of the project concept.
- Agreements, approaches, and plans for meeting the technical, budget, schedule, risk management, commercialization, acquisition, and related project requirements and performance objectives.
- Concepts, mission development strategies, acquisition strategies, implementation plans, launch service agreements, and management plans.

Acquisition Strategy. NASA did not develop an adequate acquisition strategy or acquisition plan prior to proceeding with the USPM Project. NPG 7120.5A requires that an acquisition strategy be developed and managed for executing the project plan. The Project Office did not have an approved project plan documenting the acquisition strategy or a documented acquisition plan. NASA FAR Supplement 1807 requires the Agency to approve acquisition plans prior to solicitations and to address each topic listed in FAR 7.105. To meet acquisition objectives, FAR 7.105 requires that the plan identify those milestones at which decisions should be made, address all significant considerations that will control the acquisition, and discuss feasible acquisition alternatives and any other related in-house effort. Also, the acquisition plan

should discuss the impact of prior acquisitions on alternatives and indicate prospective sources of supplies or services that can meet the need.

NASA did have better planning for the USPS. The Project Office gave a presentation to the ISS Program on a procurement approach for the USPS. The approach was to issue a limited statement of work to Boeing for engineering activities associated with a requirements review, to identify new long-lead items,[28] prepare a make-or-buy plan,[29] and prepare a proposal for the USPS. The Project Office planned to review Boeing's make-or-buy plan for adequacy and approve the plan prior to contract award. Also, the Project Office would have determined the acceptability of Boeing's selection of subcontractors and the process for key subsystems. The ISS Program Manager approved the procurement approach in September 2000. Although the Agency showed improvements in the procurement approach and planned activities, it should have had an approved acquisition plan that documented the strategy and that was incorporated into the project plan.

Risk Management Plan. NASA did not have an approved risk management plan prior to initiating the USPM Project. The risk management plan was approved in April 2000, long after the Project had been initiated. The risk management plan identified all required elements, but it did not describe the Project methodology the Agency would use to determine when the Project would no longer be viable.

NPG 7120.5A requires that the risk management plan be developed during project formulation and be included in the project plan. The Deputy Project Manager stated that the plan was in process and should be completed before the USPS was fully implemented and a contract awarded. However, the plan should be approved and implemented before NASA gives authority to proceed and before it awards a contract to assure that risks are managed and controlled by both the Agency and the contractor.

A NASA Independent Assessment Team also identified some of the same conditions regarding acquisition planning for the USPM. The team found that critical project management processes were not in place. Specifically, the assessment noted that the project plan was still a draft and that the risk management process was not well

developed. The report recommended that NASA delay the delta preliminary design review until the design was ready and the Agency had a signed project plan and mature risk management process in place.[30]

[28] Long-lead items are materials that will need to be ordered promptly in order to stay on schedule.
[29] A make-or-buy plan supports the determination on whether an item will be made in-house or purchased from another source.
[30] The Independent Assessment team presented its results to the Office of Space Flight on March 13, 2000. The Office decided not to request approval from the Program Management Council to implement the Project until the major problems were solved. Consequently, the Independent Assessment team did not present the report to the Council. Therefore, NASA considered the results preliminary.

Requirements Validation

The Project Office's "United States Propulsion Module Systems Requirements Review Plan," March 3, 1999, requires that NASA resolve discrepancies (known as review item discrepancies) found during the SRR before conducting a preliminary design review. The purpose of the SRR was to establish that the Propulsion Module development, test, and integration processes and documentation were consistent with and responsive to requirements of the ISS Program and the Space Shuttle Program. Also, the SRR's objective was to baseline a complete set of requirements for the Project as a prerequisite for a preliminary design review.

The purpose of the preliminary design review was to confirm that the initial design satisfied the baseline requirements of the Propulsion Module. In December 1999, NASA began the preliminary design review for the Propulsion Module of the USPM although there were 26 open discrepancies from the SRR, which had been held in March and April 1999. To resolve the open discrepancies, the preliminary design review plan stated that all open SRR discrepancies would be converted to preliminary design review discrepancies. By converting the discrepancies, the Project Office bypassed a major control -- the requirement in the SRR plan to resolve discrepancies and validate requirements before starting the preliminary design review. Also, because the SRR discrepancies were not resolved, the baseline requirements were not fully known. As a result, the unresolved discrepancies contributed to the failed preliminary design review for the Propulsion Module in December 1999.

The Project Office and the ISS Program Office had defined requirements for the USPS. As part of the limited statement of work, Boeing and the Project Office defined requirements in order to include them as part of the request for proposal. Although the Project Office had not prepared the SRR plan for the USPS, the plan should have contained the same objectives and requirements as for the USPM. Also, the Project Office should have ensured that all SRR required elements were completed and approved before starting a preliminary design review.

The Independent Assessment Report also found that the USPM was not ready for a preliminary design review because firm requirements were not in place. The team recommended that NASA delay the delta preliminary design review until all requirement issues were resolved and a stable baseline could be developed.

The Space Shuttle Program Office prepared a "lessons learned" report on the cancellation of the OPTS. The report states that NASA allowed Boeing to baseline a cost and design solution before NASA defined requirements and developed a conceptual design based on requirements.

Milestone Synchronization

The ISS Program Office did not synchronize the SRR and preliminary design review milestones for the Propulsion Module and the OPTS. The Project Office held an SRR during March and April 1999 for the Propulsion Module. The Space Shuttle Program Office held an SRR for the OPTS in June 1999. The Propulsion Module preliminary design review failed in

December 1999, and a delta preliminary design review was held in April 2000. There was no preliminary design review for the OPTS because the ISS Program Manger cancelled the OPTS before it was ready for a preliminary design review.

The Project Office attempted to conduct the preliminary design review and then the delta preliminary design review for the Propulsion Module before the OPTS was ready for its preliminary design review. One of the main reasons the Propulsion Module could not resolve the discrepancies identified in the SRR was because the requirements definition and validation for the OPTS lagged behind the Propulsion Module. Specifically, the Space Shuttle Program Office held the SRR for the OPTS 3 months after the Propulsion Module SRR, and the OPTS never did catch up.

NASA did not know that the need for safer and more robust lines and valves for the OPTS modifications in the Orbiters would add unacceptable weight to each Orbiter until after the preliminary design review for the Propulsion Module. In effect, the modifications caused the cost of the Propulsion Module to increase significantly and the weight of the Orbiter to increase beyond the ISS Program's acceptable limit. The Project Office and Space Shuttle Program Office should have waited and had only one SRR and one preliminary design review for both elements together.

The Independent Assessment Report stated that, since the preliminary design review for the OPTS was scheduled after the Propulsion Module delta preliminary design review, late OPTS development could have affected the Project's ability to meet Propulsion Module requirements. The report recommended that NASA perform an integrated preliminary design review of the Propulsion Module and OPTS after requirements and the preliminary design were finalized. The Agency never acted on the recommendation because 2 months later, it cancelled the OPTS.

The "lessons learned" report by the Space Shuttle Program Office also noted that milestones for the OPTS and Propulsion Module were not synchronized. The report states that the Boeing Propulsion Module team was more focused on developing the Propulsion Module rather than integrating it with the OPTS. The report characterized the team as having "a compartmentalized perspective" and "resistance to developing an integrated verification/validation plan."

Although the USPS did not involve a major program other than the ISS Program, integration and software for the USPS were under the ISS Program, while the development of the Node 4 and the Propulsion Module was under the Project Office. Therefore, the milestones should have been integrated and synchronized to assure that the all efforts were well coordinated.

Recommendations, Management's Response, and Evaluation of Response

The Acting Director, Johnson Space Center, should, for future ISS projects:

1. **Establish an approved project plan, acquisition plan, and risk management plan, as required by NPG 7120.5A and NASA FAR Supplement 1807.**

Management's Response. Concur. Management stated that it would manage all ISS Projects consistent with NPG 7120.5A. Management also provided general comments in which it disagreed with our finding that the USPM design was selected without fully considering alternatives and without developing an adequate acquisition strategy. The complete text of management's response is in Appendix E.

Evaluation of Response. Management's comments are responsive to the recommendation. With regard to management's disagreement with the finding, in our opinion, there is a clear relationship between deficiencies in project planning and the ultimate cancellation of the USPM. The Agency's commitment to manage all ISS Projects consistent with NPG 7120.5A is sufficient to close the recommendation for reporting purposes. Our additional comments in response to management's position on the finding are in Appendix F.

2. **Resolve all discrepancies from a systems requirements review before beginning a preliminary design review.**

Management's Response. Partially concur. Resolving all SRR discrepancies prior to the preliminary design review is the Agency's goal for all projects. Processes are in place that fully support the guidance in NPG 7120.5A, and project management reviews the process to balance cost and schedule commitments against technical demands. In general comments on the report, NASA disagreed that it should have closed all discrepancies from the SRR before beginning a preliminary design review for the Propulsion Module Project (see Appendix E).

Evaluation of Response. Management's comments are generally responsive to the recommendation. Although we maintain that NASA should have closed all discrepancies from the SRR before beginning a preliminary design review for the USPM, we acknowledge that the Project Office and the ISS Program Office ultimately defined requirements for the USPS before the Project was cancelled (see Appendix F). Therefore, we consider management's action taken on the USPS and comments regarding future projects sufficient to close the recommendation for reporting purposes.

3. **Establish synchronized milestones for all related program and project elements.**

Management's Response. Partially concur. The ISS Program has formal controls for defining, approving, and controlling the interfaces between elements of a project. Any joint development, integration, or test activities that need to be performed for major milestone reviews will be identified and included in the integrated project schedules. However, because the recommendation provides the lowest risk posture for a project, the ISS Program would be unexecutable with a strict application of the recommendation (see Appendix E).

Evaluation of Response. NASA's comments are generally responsive to the recommendation. Although we maintain that synchronized milestones would have benefited the Propulsion Module Project, we recognize that sometimes more risk must be assumed to achieve program results when needed. We consider management's comments regarding future projects sufficient to close the recommendation for reporting purposes.

Finding C. Contractor Selection and Justification

NASA did not determine whether a sole-source procurement selection was the appropriate approach for the acquisition of a propulsion capability for the ISS. Further, the Agency did not properly document its justification for the sole-source selection of Boeing as the contractor for the Propulsion Module Project. These conditions occurred because NASA considered the propulsion capability to be within the general scope of the ISS prime contract and, therefore, not subject to requirements in the FAR for competitive procurements. However, the propulsion capability represented new work (that is, work that was not within the scope of the contract) for which NASA agreed to pay Boeing additional fee. Consequently, NASA cannot assure the Congress or the public that the sole-source contract was in the best interest of the Government.

FAR Criteria for Competition

FAR 6.101(b), "Full and Open Competition," requires that contracting officers provide for full and open competition through use of competitive procedures that are best suited to the circumstances of the contract action and consistent with the need to fulfill the Government's requirements efficiently.

FAR 6.302-7, "Public Interest," states that full and open competition need not be provided for when the agency head determines that it is not in the public interest in the particular acquisition concerned. This authority may be used only when none of the other authorities for an award without full and open competition apply.

FAR 6.303, "Justification," states that in awarding a sole-source contract, the contracting officer must prepare a written justification and have the justification approved by an agency official designated by the statute. FAR 6.303-2 sets forth the content that each justification must include (see Appendix D).

Doctrine of "Cardinal Change"

The Federal Court of Claims has enunciated a doctrine known as the "cardinal change" rule in which a change in work beyond the contemplation of the parties at the time the contract was negotiated constitutes a change in scope.[31] Further, a material increase in the amount or character of work requirements redefines the scope of the original contract so that the additional work is outside the scope of the contract. Such material alteration to a contractual understanding is a cardinal change and, when such a change occurs, rigid provisions of a contract are waived to allow recovery of additional costs and fee. Although an increase in work may result in a material change to a contract, the work may be considered within the scope of the original contract if the changes do not result in increased costs and concomitant increased fee to the contractor.

Scope of the ISS Prime Contract

[31] For a discussion of the evolution of the cardinal change doctrine, see Public Contract Law Journal Volume 24, Number 3, Spring 1995, page 77, "The Cardinal Change Doctrine and its Application to Government Construction Contracts," George E. Powell, Jr.

In August 1993, following Presidential and congressional directives to redesign the ISS, NASA determined that it was in the public interest to use other than full and open competition to make Boeing the single prime contractor for the ISS. NASA assigned Boeing the responsibility to manage and integrate all aspects of the Program. NASA also granted Boeing the authority to novate[32] existing prime contracts as subcontracts.

The broad scope of work in the ISS contract included the design, development, and construction of a Propulsion Module, but the prime contract awarded to Boeing did not include work on the Propulsion Module and, in fact, such work was tasked to Russia. Therefore, NASA's subsequent decision to develop a Propulsion Module constituted new work.

ISS Program officials explained that because the propulsion capability is an inherent part of the ISS vehicle and Boeing is the single ISS prime contractor for the U.S. portion of the vehicle, the addition of a U.S. propulsion module was within the general scope of the contract awarded to Boeing. When Boeing submitted a proposal to integrate the Propulsion Module into the ISS, NASA accepted the proposal without pursuing a full and open competitive award and modified Boeing's original contract through change orders on a "not-to-exceed" cost basis that included fee.

However, the inherent part of the ISS vehicle did not include two propulsion capabilities. The one propulsion capability included in the ISS vehicle was assigned to Russia and was not included in the Boeing prime contract. Therefore, the change to add a second propulsion capability was, in fact, a cardinal change and should have been considered a new procurement that should have been competed or justified for sole-source contracting in accordance with the requirements of the FAR.

Explanation by Office of Space Flight

In November 2000, the General Accounting Office (GAO) asked NASA to explain why it decided to procure the Propulsion Module under the existing prime contract.[33] In response, the Associate Administrator for Space Flight explained that contract modifications are within the scope and under the terms of the Boeing contract and are allowable according to the FAR. Specifically, Clause I.12, of the ISS Prime Contract, "Changes-Cost Reimbursement," allows the ISS Contracting Officer to make changes within the general scope of the contract in any drawings, designs, or specifications. The Associate Administrator added that Boeing is responsible for:

- managing and integrating the ISS, in addition to coordinating the design and development of all necessary hardware;

[32] A contract is novated by an agreement in which the transferor guarantees performance of the contract, the transferee assumes all obligations under the contract, and the Government recognized the transfer of the contract and related assets.

[33] In June 2000, the Congress tasked the GAO to review the Propulsion Module Project.

- designing, developing, manufacturing, integrating, testing, verifying, and delivering the on-orbit segment of the ISS to provide support for orbital operations; and

- ensuring total ISS system performance.

However, the Associate Administrator also acknowledged that because the Russian contribution to the ISS included the Service Module, the obligation for a propulsion module was not included in the ISS contract.

Proper Justification Was Needed

As discussed earlier, the ISS vehicle did not include two propulsion capabilities, and the ISS prime contract did not include a Propulsion Module. The Propulsion Module modification materially alters the express terms of the original contract between NASA and Boeing and represents a requirement that is outside the scope of the original contractual agreement of the parties. Therefore, NASA should have considered full and open competition for the acquisition. The broad exemption in the public interest for the original award of the contract to Boeing does not extend to work that was not originally part of the contract. Accordingly, a sole-source procedure would have been appropriate only upon obtaining written justification and approval, as required by the FAR.

Although we disagree that the Agency's 1993 determination allowed for less than full and open competition to procure the Propulsion Module, we acknowledge that NASA has the authority to justify the noncompetitive selection of Boeing. However, NASA should have justified the selection in the manner prescribed in the FAR, which requires that the justification meet the criteria for a sole-source contract and be written and approved.

Recommendation, Management's Response, and Evaluation of Response

4. **The Acting Director, Johnson Space Center, should, before initiating future sole-source procurements for the ISS contract, obtain an approved justification as prescribed in the FAR.**

Management's Response. Concur with the intent of the recommendation. NASA stated that it follows the FAR and NASA FAR Supplement for all new procurements. However, NASA did not need to justify the sole-source procurement of the Propulsion Module because it was within the general scope of the ISS Contract (see Appendix E).

Evaluation of Response. NASA's comments are responsive to the recommendation to the extent that the Agency indicated an intent to follow FAR and Agency guidance on all procurements. However, we maintain that the procurement was not within the general scope of the contract (see Appendix F).

Although NASA contends that the Propulsion Module was not outside the scope of work, NASA recognizes that all procurements must follow the appropriate FAR and Agency regulations. We, therefore, consider management's response sufficient to close the recommendation for reporting purposes. However, we will continue to monitor noncompetitive procurements on the ISS contract and the related issue on scope of work.

Appendix A. Objectives, Scope, and Methodology

Objectives

The overall objective of the audit was to determine whether NASA developed a cost-effective acquisition strategy for long-term propulsion capability for the International Space Station (ISS). Specifically, we determined whether NASA:

- identified and adopted the most feasible means for providing long-term propulsion capability for the ISS, and
- developed an acquisition strategy to limit the cost of the propulsion modules.

Scope and Methodology

To accomplish our objectives, we obtained an overall understanding of the Propulsion Module Project. We also reviewed and analyzed the Propulsion Module draft project plan, risk management plan, system requirements review plan, independent cost estimates, Independent Assessment Team briefing, budget submissions for Program Operating Plan 1999 and 2000, trade study briefing, Alternative Propulsion Module Assessment Team (APMAT) Report, and the International Space Station Schedule II.

Our audit included three visits to Marshall Space Flight Center. In addition, we interviewed personnel at Lyndon B. Johnson Space Center (the ISS Program Office and the Space Shuttle Program Office). We also interviewed personnel at Boeing, International Space Station in Houston, Texas, and at Boeing, Reusable Space Systems, Huntington Beach, California.

We identified and reviewed the following relevant Federal and NASA regulations on program management and procurement execution:

- NASA Policy Directive (NPD) 7120.4B, "Program and Project Management," December 1999
- NPG 7120.5A, "NASA Program and Project Management Processes and Requirements," April 1998
- NASA FAR Supplement 1807.1, "Acquisition Plans," August 1997
- Office of Management and Budget (OMB) Circular A-109, "Major System Acquisitions," April 1976
- FAR, Parts 6 and 7 (see Appendix D for complete listing)

Management Controls Reviewed

For this report, we reviewed the following management controls relative to NASA oversight of the project management process function:

- NPD 7120.4B, "Program and Project Management," December 1999
- NPG 7120.5A, "NASA Program and Project Management Processes and Requirements," April 1998
- NASA FAR Supplement 1807.1, "Acquisition Plans," August 1997
- OMB Circular A-109, "Major System Acquisitions," April 1976

We determined that implementation of management controls for acquisition planning (Finding B) and noncompetitive procurements (Finding C) need to be strengthened.

Audit Field Work

We performed the audit field work from May 2000 through February 2001 at Johnson and Marshall. We performed the audit in accordance with generally accepted government auditing standards.

Prior Audit Coverage

GAO recently issued an audit report on the procurement process for the Propulsion module. Also, the NASA Office of Inspector General and the GAO has each issued an audit report that discusses ISS propulsion capability and contingency planning.

IG-99-009, "Space Station Contingency Planning for International Partners," March 9, 1999. The report states that NASA had not developed an integrated and comprehensive plan to address risks to the assembly of the ISS caused by the possible delay or default by international partners. The report also states that it would cost about $90 million to modify all four Space Shuttle Orbiters to support ISS reboost missions if there were temporary shortfalls in *Progress* vehicles. Without the modification, the reboost capability would be useful only through flight 12A when the weight of the ISS would become too heavy. See www.hq.nasa.gov/office/oig/hq/issueaudits.html for a copy of the report.

GAO-01-576R, "International Space Station Propulsion Module Procurement Process," April 26, 2001. The report states that the original 1984 U.S. design for a space station included a propulsion module. In 1993, Russia joined the newly created ISS Program and agreed to provide the propulsion capability. Because of concerns about Russian delays, NASA later initiated a U.S.-funded propulsion module effort in December 1998. NASA did not consider a competitive procurement for the Propulsion Module. Instead, the Agency modified the existing ISS contract with Boeing. GAO concluded that the modification of Boeing's contract was appropriate because the changes clause of the contract allowed NASA to modify the contract provided the change was within the scope of the contract. Additionally, the report states that NASA reasonably concluded that the Propulsion Module was within the scope of Boeing's contract.

GAO/NSIAD-99-175, "Space Station: Russian Commitment and Cost Control Problems," August 17, 1999. The report states that the United States was capable of providing permanent reboost to the ISS. The estimated cost would be $730 million, with the Propulsion Module being the most expensive item. The report also states that NASA did not develop cost estimates. NASA initially relied on a contractor quote to estimate the cost but subsequently refined its requirement for a Propulsion Module, resulting in a much higher cost estimate. The report notes that NASA had raised questions about Russia's ability to support the ISS during and after assembly. NASA prepared a contingency plan in case the Service Module experienced further delays and the Russians do not provide *Progress* vehicles for reboosting the ISS.

Appendix B. Chronology of Events for the Propulsion Module

Date	Event
Summer 1998	NASA undertakes initial efforts in the ISS Contingency Plan to provide for a U.S. capability to mitigate the impact of further Russian delays caused by the uncertain fiscal situation of the Russian government.
8/28/98	At NASA's request, Boeing submits a technical proposal (which does not include a cost estimate) to build two Propulsion Modules.
10/6/98	Boeing submits an updated proposal to build one Propulsion Module for $331 million.
10/14/98	ISS Program Office selects a Project Manager at Marshall Space Flight Center.
11/20/98	Russia launches the Functional Energy Block (FGB) as the first element of the ISS.
12/23/98	Johnson Procurement Office issues a Long-Lead Hardware and System Definition Change Request to the Boeing Contract. The rough cost of this change is $9.1 million.
1/29/99	NASA begins a review of Propulsion Module requirements. The Technical Coordination Meeting includes the ISS Program Office, Propulsion Module Project Office, and Boeing.
2/17/99	Associate Administrator for Space Flight orally approves funding of $479 million for the Propulsion Module Project through preliminary design review.
3/99	Project Office develops a parametric cost estimate of $343 million for the United States Propulsion Module (USPM).
3/99-4/99	Project Office conducts a systems requirements review (SRR) for the Propulsion Module element of the USPM.
5/99	Project Office develops a parametric cost estimate of $362 million for the USPM.
6/99	Space Shuttle Program Office conducts an SRR for the Obiter Propellant Transfer System (OPTS).

Date	Event
10/18/99	ISS Program Operating Plan includes $479 million for a Propulsion Module.
11/5/99	Associate Administrator for Space Flight issues a Project formulation letter.
12/9/99	Propulsion Module (USPM) fails its preliminary design review.
3/20/00	ISS Program Office transfers the Design, Development, Test and Evaluation (Schedule II of ISS Prime Contract) to the Project Office. Also, the ISS Program Office issues a contract modification to establish Schedule II.
4/24/00	Budget Review Teams from the Project Office and the Johnson ISS Program Office perform a review of Boeing's cost growth of $479 million to $744 million for the USPM.
5/9/00	Project Office begins the delta preliminary design review for the Propulsion Module element of the USPM.
5/22/00	ISS Program Manager cancels the OPTS because of cost and weight growth and safety concerns.
5/30/00	Project Office initiates a review of alternatives (called "trade studies") for the Propulsion Module.
6/15/00	Project Office issues a request for information worldwide for an opportunity to build a Propulsion Module for the ISS.
7/7/00	Alternative Propulsion Module Assessment Team briefs its results and recommendations to the ISS Program Office.
7/14/00	Project Office asks Boeing to reassess and recommend solutions for identified risks.
7/25/00	Service Module ("*Zvezda*") successfully docks with the ISS.
7/27/00	Contracting Officer at Marshall issues a redirection of effort letter to Boeing that all design, development, test and evaluation effort, exclusive of long-lead procurement activities, contract closeout, and settlement activities are not authorized after July 31, 2000.

Date	Event
7/31/00	NASA directs Boeing to stop work on the USPM.
8/4/00	Space Shuttle Program Office issues "lessons learned" report on OPTS.
8/8/00	*Progress* vehicle successfully refuels Service Module for the first time.
9/00	Project Office develops a parametric cost estimate of $675 million for the USPS.
9/7/00	ISS Program Office briefs its options assessment to the Office of Space Flight.
9/27/00	NASA selects the Node X design for the USPS.
10/9/00	Project Office issues to Boeing a request for a not-to-exceed proposal with a limited statement of work.
10/31/00	Boeing submits a proposal for the limited statement of work.
10/31/00	ISS Program Manager decides to store the Interim Control Module because of decreased risk of loss of Russian propulsion capability.
11/18/00	*Progress* vehicle delivers supplies and spare parts to ISS.
1/10/01	Project Office issues a request for proposal to Boeing, based on Boeing's decision to make Node 4 and buy the Propulsion Module for the USPS. Boeing's proposal is due on April 30, 2001.
2/10/01	Orbiter *Atlantis* delivers U.S. Laboratory ("*Destiny*") to the ISS. *Destiny* will serve as the center for U.S. scientific experiments and will assume command and control of the ISS from the Russians.
2/28/01	A blueprint of the President's Budget for fiscal year 2002 indicates that funding will be redirected from high-risk elements like the Propulsion Module to help offset ISS cost growth.
3/2/01	ISS Program Manager cancels the USPS because of budget concerns.

Appendix C. Analysis of Alternatives for the Propulsion Module

NASA performed an analysis of alternatives for the USPS before selecting that design. However, NASA did not evaluate alternatives for its selection of the USPM because it viewed the concept of using existing Space Shuttle hardware and unused reserve fuel from Orbiters as the best solution.

Guidance on Alternative Evaluations

NPG 7120.5A, "NASA Program and Project Management Processes and Requirements," April 3, 1998, requires that systems analysis be accomplished by performing trade studies (a review of alternatives) among candidate project concepts that consider affordability, technology, content, risk, and potential acquisition strategies.

OMB Circular No. A-109, "Major System Acquisitions," April 5, 1976, was designed to assure the effectiveness and efficiency of acquiring major systems. The Circular requires Federal agencies to place emphasis on the initial activities of the system acquisition process to allow competitive exploration of alternative system design concepts in response to mission needs. One objective of the Circular is that each agency should depend on, whenever economically beneficial, competition between similar or different system design concepts throughout the entire acquisition process.

USPM Concept and Selection

Boeing presented the USPM concept to NASA in March 1997, stating that the USPM could make use of existing hardware and technology and off-the-shelf engines and be refueled using excess fuel carried by the Orbiters. The design concept was based on the premise that it was a cost-effective solution for the Propulsion Module with proven components and operations. Boeing identified existing Space Shuttle hardware, such as certified components available at the White Sands Test Facility, that was a Space Shuttle test article. Also, Boeing planned to use existing logistics spares and off-the-shelf engines. Another concept was that the Orbiter carries extra fuel on each flight for contingency purposes and could transfer the extra fuel during each mission to the ISS. Boeing's package also indicated that an Orbiter could return the Propulsion Module if it needed repair or maintenance. In response to Boeing's presentation package, in February 1999, the Associate Administrator for Space Flight authorized the Director, Johnson Space Center, to proceed with the formulation and limited implementation of the USPM.[34]

USPM Alternatives

Since 1996, the Agency considered various other alternatives for propulsion capabilities but usually in the form of a presentation by a contractor and usually without a documented analysis or decision. The only documented analysis was the Mission Integration Office's May 1999 comparison between the Functional Energy Block-2 (FGB-2) and the USPM. The alternatives

[34] The Associate Administrator for Space Flight documented the direction in a November 1999 memorandum.

may not have provided a long-term propulsion capability (see Finding A). Some alternatives that contractors briefed to NASA officials included the following:

> **FGB-2.** Russia built the FGB-2 as a backup to the FGB that was delivered in November 1998 as the first element of the ISS.[35] Both vehicles are self-sufficient orbital transfer vehicles that contain propulsion; guidance, navigation, and control; communications; electrical power; thermal control systems; and stowage capacity. NASA performed an assessment of modifying the FGB-2 and using it instead of a U.S.-built Propulsion Module. NASA also evaluated options to add an Orbiter-refueling capability. In May 1999, the Mission Integration Office provided the assessment and estimated the FGB-2 could be ready to launch in about 12 to 18 months. The USPM was selected over the FGB-2 because the latter design required full Russian participation and did not remove the ISS from critical long-term dependency on Russia. In summer 2000, Boeing purchased the FGB-2 to serve as a commercial space station in partnership with Khrunichev.
>
> **Space Shuttle Options for Service Module Delay.** A NASA team performed a study to determine a way to utilize the Orbiter to provide Service Module functions for up to 1 year. The Agency included the results in a Special Team Report dated September 13, 1996. The report recommended that NASA seek alternative sources.

USPS Selection and Alternative Evaluations

After the cancellation of the USPM, NASA performed extensive alternative evaluations before selecting the USPS. The objective of the Alternative Propulsion Module Assessment Team (APMAT) was to assess the Propulsion Module design concepts and the potential capability to meet the ISS Program's requirements. The APMAT evaluated five options for a new propulsion system using weighted assessments of 33 criteria within 3 categories. The categories were programmatic; design, development, test, and evaluation; and integration. The team provided its results to the ISS Program Office in July 2000.

Based on the results, the ISS Program Office tasked Boeing to perform an additional detailed integration assessment on the two top-rated options. Boeing established an Integration Evaluation Team for the assessment with close coordination from the ISS Program Office, Johnson Space Center Directorates, and the Propulsion Module Project Office.

[35] Although Russia built the FGB, the United States funded it through the ISS prime contract. Boeing subcontracted the work to the Russian firm Khrunichev.

The integration assessment evaluated integration risks and uncertainties behind the APMAT recommendation. After the assessment results, the Project Office reassessed the options using the APMAT criteria and evaluation methodology. The five evaluated options were the following monopropellant concepts:

Node X Option. NASA selected this option and later renamed it the USPS. The design concept uses the Node 4 installed on the forward end of the ISS. Node 4 would include a radial (side) port to install the Propulsion Module and an Orbiter docking port.

Z-1 Truss Option. The Propulsion Module would have attached to a platform mounted behind the Z-1 segment of the ISS.[36] This option was APMAT's top-rated choice. However, after the detailed integration assessment performed by the Integrated Evaluation Team and reassessment based on the APMAT criteria and evaluation method, NASA chose the Node X option.

Split Element Option. This option was similar to the Node X option in that both options contained two elements, one of which was the same Propulsion Module. However, the split element option did not use the Node 4 but instead required the construction of a separate element with a tunnel for access to and from the ISS. Also, using this option, the module would have been docked with a forward docking port.

Modified Baseline Option 2. This option included the Propulsion Module from the USPM but excluded the OPTS. The baseline option would have been modified to use monopropellant and have one set of fuel tanks. The OPTS was a bi-propellant system.

Modified Baseline Option 2A. This option is the same as the Modified Baseline Option 2 except that it has a removable modular unit and an additional set of permanent tanks.

[36] The Z-1 Truss is an early exterior framework that allows first U.S. solar arrays to be temporarily installed on U.S. Node 1 (*"Unity"*) for early power.

Appendix D. Criteria for Project Management and Sole-Source Procurement

OMB Circular A-109, "Major System Acquisitions," April 5, 1976, sets forth policies that apply to the acquisition of major systems by an agency of the Federal Government. The Circular applies to management of the acquisition of major systems including engineering, development, and testing and evaluation to achieve program objectives. The Circular directs agencies to determine mission needs through an analysis of mission requirements and a comparison of alternative system design concepts. Additionally, each agency should depend on, whenever economically beneficial, competition between similar or differing system design concepts throughout the entire acquisition process.

NPG 7120.5A, "NASA Program and Project Management Processes and Requirements," April 3, 1998, requires a documented project plan that includes a comprehensive definition of the project concept and agreements, approaches, and plans for meeting the technical, budget, schedule, risk management, commercialization, acquisition, and related project requirements and performance objectives. All NASA projects shall implement the formulation process to provide assurance that the project is ready to proceed into implementation. Project implementation initiates the approved project requirements and plans. The requirements and plans include risk management. Risk management begins with an initial risk identification and development of a risk management plan and continues throughout the project. Risk management planning shall be developed and included in the project plan. Project implementation shall be executed in accordance with the controlling documents developed during the formulation and approval subprocesses.

FAR 6.303, "Justification," requires a contracting officer to provide written justification for the award and certification of a sole-source contract and to secure approval for it before (1) commencing negotiations for a sole-source contract, (2) commencing negotiations for a contract resulting from an unsolicited proposal, or (3) awarding any other contract without providing for full and open competition. FAR 6.303-2 sets forth the content that each justification must include:

- A document that identifies the agency and contracting activity and identifies itself as a "Justification for other than full and open competition."
- Nature and description of the action being approved.
- Description of the services or supplies.
- An identification of the statutory authority permitting other than full and open competition.
- A demonstration that the proposed contractor's unique qualifications or the nature of the acquisition requires the authorization.

- A description of efforts made to ensure that offers are solicited from potential sources as is practicable.
- A determination that the anticipated cost to the Government will be fair and reasonable.
- A description of the market research and result or a statement of the reason such research was not conducted.
- Any other facts supporting the use of other than full and open competition.
- A list of sources that expressed an interest in the acquisition.
- A statement of the actions the agency may take to overcome barriers to competition.
- Contracting officer certification that the justification is accurate and complete.

FAR 7.105, "Contents of Written Acquisition Plans," requires the acquisition plan to identify those milestones at which decisions should be made. The plan shall address all the technical, business management, and other significant considerations that will control the acquisition. Included in the plan will be a summarization of the technical and contractual history of the acquisition, feasible acquisition alternatives, impact of prior acquisitions on those alternatives, and any related in-house effort. The plan will discuss technical, cost, and schedule risks and describe the efforts planned or under way to reduce risk and the consequences of failure to achieve goals. If concurrency of development and production is planned, the plan will discuss its effects on cost and schedule risks.

Appendix E. Management's Response

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696

Reply to Attn of: BD5

APR 26 2001

TO: NASA Headquarters
Attn: W/Assistant Inspector General for Auditing

FROM: AA/Acting Director

SUBJECT: Management's Response to OIG's Draft Report on Acquisition of Space Station Propulsion Module, A0004300

We have reviewed the draft report, and thank you for the opportunity to provide comments. This response has been coordinated with the Office of Space Flight. We do not agree with the audit findings regarding our acquisition methodology nor all the actions depicted which led to the cancellation of the U.S. Propulsion System (USPS). However, as part of a bottoms-up review of the components of the International Space Station (ISS) Program, the ISS Program Manager did cancel this project in March 2001. Your report stated that cancellation of the USPS allowed NASA to put an estimated $675 million to better use. We generally agree with this finding, but emphasize that the Program is making many decisions to rebalance our overall program risk posture to address the budget shortfalls from within the Human Space Flight budget. In this view, the overriding consideration of the ISS Program in canceling USPS is to meet Program mission objectives by leveraging the reduced risks throughout the international partnership while also reducing ISS Program costs.

We do concur with the audit recommendations which reiterate requirements of Agency and Federal guidelines for any program or project acquisition. The International Space Station is a vital Program that is under great scrutiny by both internal and external reviewers, thus each and every project and major acquisition receives numerous reviews from all levels of management. Because of the generic wording of the recommendations, the continuing reviews of the ISS Program, and our management controls in place, we asked that the recommendations be closed on issuance of the report. If you have any questions regarding this response, please contact Ms. Pat Ritterhouse, JSC Audit Liaison Representative, at 281-483-4220.

Roy S. Estess

Enclosure

cc:
OA/T. Holloway
OA/P. Marshall
HQ/JM/J. Werner
HQ/M/J. Rothenberg
HQ/M/M. Hawes
HQ/MX/G. Gabourel
MSFC/DA01/A. Stephenson
MSFC/RS40/D. Walker

Management's Response to OIG's Draft Report on Acquisition of Space Station Propulsion Module, A0004300

Auditor's Finding A

" NASA did not have a cost-effective strategy for a long-term propulsion capability. Before NASA cancelled the Project, the Project Office's estimate at completion was $724 million, an increase of $182 million (34 percent) over the Agency's budget of $542 million. While acquisition costs had more than doubled, life-cycle costs also rose almost 50 percent. Other key factors in assessing the cost-effectiveness of the Propulsion Module are its decreased capability (from the USPM to the USPS), the reduction of major risks through the successful integration of the Service Module into the ISS, the demonstrated refueling of the Service Module by a *Progress* vehicle, and the de-orbiting of *Mir*."

JSC Comments

The long-term strategy for ISS propulsion capability has always been centered on services provided by the Russian Segment as a primary contribution of the Russian Government to the ISS. The ISS Program committed to the development of US propulsion capabilities at a time when the ability of the Russians to maintain their commitments for these critical capabilities was in question. These capabilities were always augmentations to the Russian services. With the successful demonstration of Russian propulsion functions on the ISS, the Program has determined that major system augmentations are no longer necessary. The ISS Program Manager, as part of a comprehensive content reduction process, has canceled the USPS. While projected costs were increasing as reflected in the Propulsion Module historical record, they did not double as stated in this report. The NASA original budget commitment for USPM development was $542 million as stated. This budget included all of Boeing's estimates for the Propulsion Module, for the Orbiter prop transfer modifications, and for other anticipated integration costs. The Program also had significant NASA costs in the original budget for hardware, unique testing support and other special skills that were required. At the time of suspension of USPM development, the NASA projection of total propulsion module acquisition costs were over $800 million. At the time USPS was suspended, the NASA projection of total program cost was estimated roughly at $700 to $740 million including the expenditures on the USPM. The ISS Program recognized these cost projections were unacceptable and took action to assure the overall success of the program without incurring these large additional budget demands on the program.

See Appendix F, OIG Comment 1

The report is correct in highlighting the large increase in life cycle costs as the propulsion module project matured. The difference reflects the significant increase of USPS operations costs for routine ground servicing compared to the USPM being refueled on-orbit by the Orbiter. However, Orbiter modifications for on-orbit transfer were canceled due to the growing weight penalties, cost, and other safety and performance concerns. This action caused the operations costs for USPM to rise to the levels similar to the later USPS design due the necessary ground servicing of the system. The avoidance of operations cost impacts for ground servicing were the efficiencies the Program was attempting to achieve with the original USPM design concept. A higher operating cost

Enclosure

was the trade that we explicitly accepted to adopt an overall much lower risk design approach.

By suspending development of the propulsion module, the ISS Program is adopting certain elements of the risk mitigation strategy described in the report. With any prolonged shortfall or curtailment of Russian propellant delivery services, the ISS Program has three remaining sources of propulsion capability to carry into sustained operations. First, even if Russian propellant delivery is interrupted, the Russian Segment still maintains propellant reserves to provide at least one year of propulsion service. Second, with over two years of ISS operations we now know the total system effectiveness of Shuttle reboost to be larger than prior conservative estimates. These capabilities, at present performance levels, are sufficient to support the ISS until activating the European Automated Transfer Vehicle (ATV) in late '04 or early '05. The ATV will give the program a robust propellant delivery and operating platform to augment Progress capabilities if needed in sustained operations.

The report describes other alternatives that are neither cost-effective nor credible options for mitigating propulsion capability shortfall. The Interim Control Module was originally developed to perform temporary ISS propulsion functions had the Russian Service Module not been successfully deployed on the ISS. With the propulsion functions now in place on the ISS, the ICM has served its purpose and does not appreciably add to current capabilities. At over $100 million to integrate into ISS for this purpose, it is not seen as a cost effective alternative for ISS contingency planning. The FGB-2 (at $200 million) similarly is not a cost-effective element of a long-term solution. Progress vehicles still must refuel the FGB-2 so by itself, it is only a temporary solution. Finally, NASA is not free to purchase Progress vehicles as stated in the report. The Iran Nonproliferation Act of 2000 (INA) (P.L. 106-178) prohibits NASA from purchasing all but those goods and services that are consistent with the "Crew Safety" exception of the law. Progress vehicles currently do not fall under the exception provisions.

See Appendix F, OIG Comment 2

Auditor's Finding B

"NASA attempted to implement the USPM before completing required acquisition planning and Project documentation. Specifically, NASA selected the USPM design without analyzing alternatives and did not establish a project plan, develop an adequate acquisition strategy, or prepare a risk management plan."

Recommendations For Corrective Action

"The Acting Director, Johnson Space Center, should for future ISS projects:

1. Establish an approved project plan, acquisition plan, and risk management plan, as required by NPG 7120.5A and NASA FAR Supplement 1807.

2. Resolve all discrepancies from a systems requirements review before beginning a preliminary design review.

3. Establish synchronized milestones for all related program and project elements.

JSC Comments

Recommendation 1. We concur with the need to adhere to all Agency policy regarding execution of any of our Programs and Projects. The execution of all ISS Projects will continue to be managed through established program processes, at all levels, consistent with NPG 7120.5A. In addition, there is extensive oversight by internal and external committees such as the Aerospace Safety Advisory Panel, the Program Management Council, the annual Program Operating Plan (POP) and Congressional oversight of any monies expended. Our actions are sufficient to address this recommendation, and we ask that it be closed for reporting purposes.

See Appendix F, OIG Comment 3

We disagree with the findings that NASA selected the USPM design without fully considering alternatives or developing an adequate acquisition strategy. The plan to add the USPM to the Prime contract by change order (see finding C below) in an incremental fashion was presented by the Project Manager to the ISS Program Manager, the JSC Center Director and the Associate Administrator, Office of Space Flight in a briefing on February 17, 1999. NASA's consideration of alternatives was a comprehensive, multi-year assessment that involved the propulsion experts from three NASA centers and numerous industry sources. Our evaluation began during the transition from the Space Station Freedom Program to the new ISS in 1993, and continued even as the Russians were brought into the program to provide propulsion services. The U.S. initially focused on backup capabilities using existing assets in the industry (approximately 5 options considered) and found their conversion to meet ISS requirements and operating environment to be costly and require unacceptable development time. The initial USPM design evolved from the Resupply Control Module study conducted by NASA/MSFC starting in 1995 and continuing into 1997 during which time approximately 8-10 mission and design configurations were evaluated. The selected USPM design had benefited from significant study, which formed the basis for the programmatic decision to initiate development in early 1999.

Recommendation 2. Partially concur. There is no "zero risk" process for projects to follow to guarantee all project objectives are met. Project management must continually balance the costs and schedule commitments of the program against the purely technical demands of the project to resolve issues. Our processes are based upon well-established practices for developing space flight hardware and are standard procedures under the ISS program. These practices fully support the guidance included in NPG 7120.5A. Our actions in this regard are sufficient to address this recommendation, and we ask that it be closed for reporting purposes.

See Appendix F, OIG Comment 4

The recommendation as stated is the lowest risk posture to obtain prior to Preliminary Design Review (PDR), and the goal that all projects adopt in conducting a System Requirements Review (SRR). However, deferring PDRs for all ISS elements until all requirements issues were eliminated would have resulted in schedule erosion and cost growth with very little benefit to the program. Alternatively, ISS projects (including propulsion module) baseline requirements following the completion of SRR and place them under formal configuration control, well prior to the PDR. Residual requirements issues are captured by the project management, and worked to resolution at a very high level of program visibility. Management from both the Program and project thereby assures potential risks of proceeding to subsequent milestone reviews are identified and under sufficient control with appropriate project resources available to respond to potential downstream impacts. Immediately following a design review milestone, the

projects vigorously work identified issues with the appropriate program stakeholders to assess requirements impacts and identify any requirements modifications necessary as a result of the reviews. These impacts and requirements changes are elevated to the Program for formal approval and included in the official record of design review closeout.

Recommendation 3. Partially concur. The ISS Program has an established formal schedule management process (also in accordance with NPG 7120.5A) through which all ISS project entities report schedule performance, and is the means for identifying and mitigating project schedule risk. We consider our actions are sufficient to address this recommendation, and we ask that it be closed for reporting purposes.

The recommendation as stated is theoretically the lowest risk posture to obtain in executing a project. It should be noted that the ISS Program would not have been executable with the strict application of this recommendation since all interfacing ISS elements could not be developed on the same schedule, nor could all design reviews be performed simultaneously. We believe the spirit and intent of the recommendation, however, is correct. For this reason, and in accordance with NPG 7120.5A, the Program established formal controls for defining, approving, and controlling the functional and physical interfaces between elements that are central to the requirements baseline upon which requirements and design reviews are based. From the process of baselining interface definitions, the project derives an understanding of interface risks that must be properly mitigated within the plans of each interfacing element. Any joint development, integration or test activities that must be performed as a dependency for major milestone reviews is identified and included in integrated project schedules and negotiated between the elements. It is critical to the execution of any project to have an approved schedule baseline with formal controls and routine tracking as one of the principle management tools.

Auditor's Finding C

"NASA did not determine whether a sole-source procurement selection was the appropriate approach for the acquisition of a propulsion capability for the ISS. Further, the Agency did not properly document its justification for the sole-source selection of Boeing as the contractor the Propulsion Module project."

Recommendation for Corrective Action

"4. The Acting Director, Johnson Space Center, should, before initiating future sole-source procurement for the ISS contract, obtain an approved justification as prescribed in the FAR."

JSC Comments

We concur with the intent of the recommendation, but maintain the integrity of all JSC procurements being done according to Federal Acquisition Regulation (FAR) and Agency guidelines.

Findings B and C reflect a fundamental disagreement between the Office of Inspector General and NASA management over the nature of the propulsion module contracting action. The propulsion module was properly added to the existing prime contract via the changes clause within the contract. Our reasons for doing so are well documented in a

See Appendix F, OIG Comment 5

letter dated December 2000 from the Associate Administrator for Space Flight to the General Accounting Office on the subject. Since providing that letter, NASA has received a draft report from the GAO stating "The modification of NASA's contract with Boeing was proper." Additionally, the GAO said "...the modification was within the scope of Boeing's prime contract since it did not materially change the nature or purpose of the contract."

The abbreviated discussion of "Cardinal Changes" on page 12 of the draft report does not adequately address some key concepts and implies that the propulsion module change orders were cardinal changes, which would constitute "new procurement" and thereby be subject to Competition in Contracting Act requirements. A complete discussion of the distinction between cardinal and ordinal changes, within the context of our ISS prime contract, would show that the propulsion module change orders were clearly within the general scope of the contract based on mainstream thinking among NASA procurement and legal personnel.

The acquisition related regulatory and procedural issues identified in several places in the draft report flow directly from this fundamental disagreement. The FAR (Part 6 and 7) and NASA FAR Supplement (Part 1807) requirements addressed in the draft audit report relate to "new procurements." Whenever we conduct "new procurement", we clearly adhere to these requirements. The regulatory guidance for contracting actions under the changes clause is covered in Part 43 of the FAR and Part 1843 of the NASA FAR Supplement. These are the procedures that were followed and appropriately documented.

We consider we met the intent of the recommendation, and ask that it be closed for reporting purposes.

Appendix F. OIG Comments on Management's Response

The Johnson Space Center (Johnson) provided the following comments in its response to our draft report. Our responses to the comments are also presented.

Management Comments. Johnson stated that the projected costs were increasing but had not doubled as stated in the report. Johnson indicated that the original budget was $542 million and at the time of suspension of the project, the estimated acquisition costs were from $700 to $740 million.

1. OIG Comments. Our report states (in Finding A) that the acquisition costs more than doubled in relation to the contractor's proposed estimate, not in relation to the budget. Boeing proposed $331 million in October 1998. In April 2000, Boeing increased its estimate to $744 million. The report also states that the increase was affected by changes in requirements and schedule delays.

Management Comments. Johnson stated that the report provided alternatives that are neither cost-effective nor credible. Also, NASA is not free to purchase *Progress* vehicles as stated because of the Iran Nonproliferation Act of 2000. The only exception to the Act is for crew safety.

2. OIG Comments. Our intent is to show some possible alternatives to the Propulsion Module. Because we realize that some alternatives may not be as cost-effective as others, we attempted to outline the pros and cons of each one without endorsing any of them. For example, the report states that the Interim Control Module could be a short-term solution for a delay or shortage of *Progress* vehicles. Additionally, we reported that the ISS Program Manager stated that the FGB-2 would not be a good deal for NASA. We also agree that the Iran Nonproliferation Act restricts NASA's purchase of *Progress* vehicles. However, there is an exception to the Act that allows NASA to make payments for the maintenance of the Service Module, which would otherwise be prohibited.[37] Therefore, a NASA purchase of *Progress* vehicles is possible.

Management Comments. Johnson disagreed that alternatives were not considered and that an adequate acquisition strategy was not developed on the USPM.

3. OIG Comments. Our report acknowledges that NASA considered alternatives for the USPM. Specifically, we state in Appendix C that the Agency considered various alternatives for propulsion capabilities. However, consideration of the alternatives was usually limited to concept briefings by contractors without formal comparison to other

[37] The Act defines maintenance as "activities, which cannot be performed by NASA, and which must be performed in order for the Service Module to provide orbital maintenance functions, which cannot be performed by an alternative means at time of payment."

alternatives and without a record of an Agency decision on the concepts. In contrast, for the USPS, NASA performed thorough comparative analyses of alternatives and made a selection based on the analyses.

We agree that NASA had an acquisition strategy but maintain that the strategy for the USPM did not comply with the Federal Acquisition Regulation (FAR) regarding justification for a noncompetitive procurement (see Finding C). However, our report acknowledges that NASA showed better planning for the USPS through its planned review of Boeing's make-or-buy plan for adequacy and approval prior to contract award. Also, the Project Office planned to determine the acceptability of Boeing's selection of subcontractors and the process for key subsystems.

Management Comments. Johnson responded that there is no process that guarantees that all project objectives will be met. Deferring the preliminary design review for the USPM until all system requirements review issues were eliminated would have caused schedule delays and cost growth. Additionally, management placed all open requirement issues under formal configuration control. Requirement issues were under sufficient control, and project personnel could respond to any impacts.

4. OIG Comments. We maintain that existing processes and controls were not effectively used on the USPM. Requirement issues were not resolved, and firm requirements were not in place prior to the preliminary design review. We also maintain that these factors contributed to the design review failing, the schedule eroding, and the cost increasing. This conclusion is consistent with those of NASA's independent assessment team.

Management Comments. Johnson stated that it did not need to justify the sole-source procurement of the Propulsion Module because propulsion capability was within the general scope of the ISS Contract. The Propulsion Module was properly added to the existing contract through the change order process, which does not require compliance with FAR Part 6 and 7. Also, the Propulsion Module should not be considered a "cardinal change" in context of the ISS prime contract. Additionally, FAR Part 1807 was not applicable for the same reasons. Because the Propulsion Module was within the general scope of the ISS Contract, the Propulsion Module was properly procured through modification to the ISS contract and was exempt from new procurement regulations. A recent GAO report supports this position (GAO-01-576R, see Prior Audit Coverage in Appendix A of this report). Further, a complete discussion between cardinal and ordinal changes would show that the Propulsion Module was within the scope of the contract.

5. OIG Comments. We maintain that the procurement was not within the general scope of the contract. The Propulsion Module was not included in the ISS contract or as hardware for the U.S. on-orbit segment. The ISS prime contract calls for the design, development, manufacture, integration, test, verification, and delivery of the U.S. on-orbit segment of the ISS. Additionally, the prime contractor is responsible for managing, integrating, and coordinating the

design and development of all hardware as well as ensuring total ISS system performance. We agree that the prime contractor's responsibility to integrate and coordinate the design and development of the Propulsion Module was within the scope of the ISS contract. However, we maintain that the actual development and manufacture of the hardware was outside the scope.

As our report states, the contract did not assign Boeing the responsibility to build every component of the ISS, and the contract did not specifically address the Propulsion Module. The ISS contract, as consolidated in 1993, did not assign Boeing the responsibility to design and build parts of the ISS that were specifically tasked to Russia. Additionally, there are parts of the ISS U.S. on-orbit segment that NASA did not specifically contract with Boeing.

NASA's statement that a complete discussion on cardinal and ordinal changes would clearly show that the Project was within the scope of the ISS Contract is not supported. Johnson's response acknowledges that a cardinal change would constitute a new procurement. As a new procurement, FAR Part 6 and Part 7 as well as NASA FAR Supplement Part 1807 would be applicable. As discussed in the report, a cardinal change constitutes a change that is of such material alteration to the contractual understanding that the new work is considered outside the scope of the contract and should be treated as a new procurement. Even though we have provided justification to support our conclusion that the Propulsion Module Project should be considered outside the scope of the contract and is, therefore, a new procurement, we can also support the conclusion that even if the Propulsion Module was considered within the contract scope, the procurement would still be a cardinal change, and the Agency would need to follow the FAR for new procurements. NASA's actions in the treatment of the Propulsion Module Project support the consideration that the change be considered a material alteration and, therefore, a cardinal change. Based on NASA's definition of a project[38] and the fact that NASA implemented the Propulsion Module as a project, NASA is supporting our position that the Propulsion Module change is indeed a material change to the original scope of work as contemplated when the ISS contract was negotiated.

As NASA indicates, GAO's recent report on the procurement process for the Propulsion Module supports the Agency's position that the Propulsion Module was within the scope of the contract. Although we disagree with that position, our report does not conclude that a sole-source procurement was inappropriate, but merely that NASA did not adequately document its reasons for that method of contracting, even though justification for sole-source procurements is required by the FAR.

As our report acknowledges, NASA has the authority to justify the noncompetitive selection of Boeing. Additionally, based on the Associate Administrator for Space Flight's explanation and NASA's response to our draft report, we believe that the Agency can sufficiently justify the sole-source selection. However, the justification needs to be

[38]NASA Policy Directive 7120.4B, "Program and Project Management," December 1999, defines a project as a significant activity within a program.

documented in the manner prescribed by the FAR. Therefore, we maintain that the Propulsion Module procurement should have complied with the FAR requirements for new work and not just for an ordinary change order.

Appendix G. Report Distribution

National Aeronautics and Space Administration (NASA) Headquarters

A/Administrator
AA/Chief of Staff
AI/Associate Deputy Administrator
B/Acting Chief Financial Officer
B/Comptroller
BF/Director, Financial Management Division
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Congressional Member

Honorable Pete Sessions, U.S. House of Representatives

NASA Assistant Inspector General for Auditing
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Report Title: Acquisition of the Space Station Propulsion Module

Report Number: _____ **Report Date:** _____

Circle the appropriate rating for the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
1. The report was clear, readable, and logically organized.	5	4	3	2	1	N/A
2. The report was concise and to the point.	5	4	3	2	1	N/A
3. We effectively communicated the audit objectives, scope, and methodology.	5	4	3	2	1	N/A
4. The report contained sufficient information to support the finding(s) in a balanced and objective manner.	5	4	3	2	1	N/A

Overall, how would you rate the report?

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