

May 2005

NASA

More Knowledge  
Needed to Determine  
Best Alternatives to  
Provide Space Station  
Logistics Support



Highlights of [GAO-05-488](#), a report to congressional requesters

**Why GAO Did This Study**

The National Aeronautics and Space Administration’s (NASA) space shuttle fleet has been key to International Space Station operations. Since the grounding of the fleet in February 2003, Russia has provided logistics support. However, due to the limited payload capacity of the Russian space vehicles, on-orbit assembly of the space station stopped.

In May 2004 and in February 2005, NASA testified before the Congress that it had assessed using alternative launch vehicles to the space shuttle for space station operations. NASA concluded that using alternatives would be challenging and result in long program delays and would ultimately cost more than returning the space shuttle safely to flight. Yet uncertainties remain about when the space shuttle will return to flight, and questions have been raised about NASA’s assessment of alternatives. GAO was asked to determine whether NASA’s assessment was sufficient to conclude that the space shuttle is the best option for assembling and providing logistics support to the space station.

**What GAO Recommends**

GAO is recommending that NASA take action to ensure that its current assessments of alternatives for providing logistics support are comprehensive and fully documented and that the assessments are completed before investments are made in commercial space transportation.

[www.gao.gov/cgi-bin/getrpt?GAO-05-488](http://www.gao.gov/cgi-bin/getrpt?GAO-05-488).

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

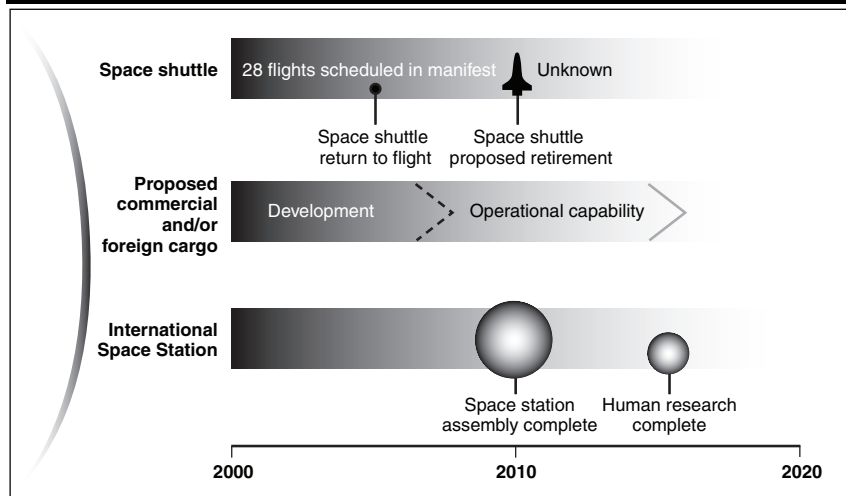
**NASA**

**More Knowledge Needed to Determine Best Alternatives to Provide Space Station Logistics Support**

**What GAO Found**

NASA’s 2004 assessment identified significant challenges associated with using alternative launch vehicles for space station assembly and operation. According to previous studies and our discussions with industry representatives, these challenges would likely preclude using alternative vehicles for assembly missions. However, NASA’s assessment was insufficient to conclude that the shuttle was the best option for logistics support missions prior to the proposed retirement of the space shuttle in 2010. NASA relied primarily on headquarters expertise to conduct the informal assessment, and while we recognize that the extensive experience of its senior managers is an important element in evaluating alternatives, NASA officials did not document the proceedings and decisions reached in its assessment. As a result, the existence of this assessment of alternatives cannot be verified, nor can the conclusions be validated.

NASA is currently evaluating responses from a September 2004 request for information from various commercial space transportation industries that could provide launch services to support space station operations, following retirement of the shuttle in 2010, until the station’s planned retirement in 2016. NASA officials indicated that a commercial launch capability to support space station operations is possible prior to the proposed shuttle retirement in 2010, but stated that this capability would not eliminate any of the scheduled space shuttle flights. NASA is also re-examining its requirements for the type of scientific research to be conducted on the space station as well as the manifest requirements of the space shuttle. Combining the information gathered from commercial industry and a better definition of space station and shuttle requirements, NASA officials agree there is an opportunity to perform a more comprehensive assessment of alternatives, especially for logistics missions late this decade.



Source: NASA; GAO (presentation).

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# Contents

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<b>Letter</b>		<b>1</b>
	Results in Brief	2
	Background	3
	NASA's 2004 Assessment Was Based on Insufficient Knowledge for Concluding Space Shuttle Was Best Launch Option, but Opportunities Now Exist for More Detailed Study	7
	Conclusions	10
	Recommendation for Executive Action	10
	Agency Comments and Our Evaluation	11
<b>Appendix I</b>	<b>Scope and Methodology</b>	<b>13</b>
<b>Appendix II</b>	<b>Comments from the National Aeronautics and Space Administration</b>	<b>15</b>
<b>Appendix III</b>	<b>Challenges of Using Alternative Vehicles</b>	<b>17</b>
<b>Appendix IV</b>	<b>GAO Contact and Staff Acknowledgments</b>	<b>18</b>
<b>Figures</b>		
	Figure 1: Space Shuttle Endeavour Docked to the International Space Station	4
	Figure 2: International Space Station Operations Support until 2016	6

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## **Abbreviations**

AAS	Alternate Access to Station
ATV	Automated Transfer Vehicle
HTV	H-II Transfer Vehicle
NASA	National Aeronautics and Space Administration

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United States Government Accountability Office  
Washington, DC 20548

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May 18, 2005

The Honorable Ken Calvert  
Chairman  
Subcommittee on Space and Aeronautics,  
Committee on Science  
House of Representatives

The Honorable Sam Brownback  
United States Senate

The Honorable Dana Rohrabacher  
House of Representatives

The National Aeronautics and Space Administration's (NASA) space shuttle has been the primary vehicle for delivering components for assembly and providing logistics support to the International Space Station. NASA grounded the space shuttle fleet following the Space Shuttle Columbia accident in February 2003, leaving the space station dependent on Russia to provide crew rotation, crew rescue, and logistics support. However, due to the limited payload capacity of Russian space vehicles, on-orbit assembly of the space station has halted. NASA plans to return the space shuttle to flight by mid 2005 and resume space station assembly and logistics missions.

In May 2004 and again in February 2005, NASA testified before the Congress that it had assessed using alternative launch vehicles for completing space station assembly and providing logistics support. According to NASA officials, their assessment showed that using alternative launch vehicles would introduce unacceptable operational risks, technical challenges, long program delays, and would ultimately cost more than returning the space shuttle to flight. Therefore, NASA concluded that the space shuttle's unique capabilities provided the best available option for these missions. Despite these testimonies, concerns have been raised about NASA's conclusions, both within Congress and the industry. Due to the uncertainty regarding when the space shuttle would return to safe flight and concerns that additional flights would be needed to support assembly and logistics operations, you asked us to determine whether NASA's assessment of alternatives was sufficient to conclude that the space shuttle is the best option for completing assembly and providing logistics support to the space station.

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To conduct our work, we obtained and analyzed agency documentation and interviewed NASA officials responsible for managing the launch services, space shuttle, and space station programs within NASA headquarters as well as program managers at NASA centers involved in space shuttle and space station operations. We also interviewed commercial space transportation contractors and reviewed pertinent documentation related to expendable launch vehicles. In addition, we reviewed NASA's request for information for commercial space transportation services, which it issued in September 2004, and its plans for assessing the responses to this request and follow-on activities. We conducted our work from August 2004 through April 2005 in accordance with generally accepted government auditing standards. For a complete description of our scope and methodology, see appendix I.

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## Results in Brief

In early 2004, NASA performed an informal assessment of alternative launch vehicles that was incomplete and did not provide a clearly documented rationale to conclude that the space shuttle was the best option to support space station operations. NASA identified significant challenges associated with using an alternative to the space shuttle for space station assembly, which could preclude these missions from consideration. However, the assessment conducted by NASA did not include an analysis of the schedule impacts or costs associated with using alternative launch vehicles for logistics missions later this decade. While we recognize that the extensive experience of its senior managers is an important element in evaluating alternatives, NASA relied primarily on headquarters expertise to conduct the informal assessment. NASA officials did not document the proceedings and decisions reached in its assessment. As a result, the existence of this assessment of alternatives cannot be verified, nor can the conclusions be validated.

NASA is currently evaluating responses from commercial industry on capabilities of alternate launch services for providing cargo launch services to and the ability to return items from the space station. Additionally, NASA is re-examining its requirements for the space station and space shuttle. With this information from commercial industry and more definitive space station requirements, NASA officials agreed that there is an opportunity to perform a detailed analysis of alternatives to determine if any planned space shuttle missions to perform logistics, prior to the shuttle's retirement, could instead make use of commercial launch services.

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This report makes recommendations aimed at better positioning the agency to determine the best available options for providing logistics support to the space station and ensuring that NASA's current analyses of alternative launch vehicles are comprehensive and fully documented. In written comments on a draft of this report, NASA concurred with our recommendations.

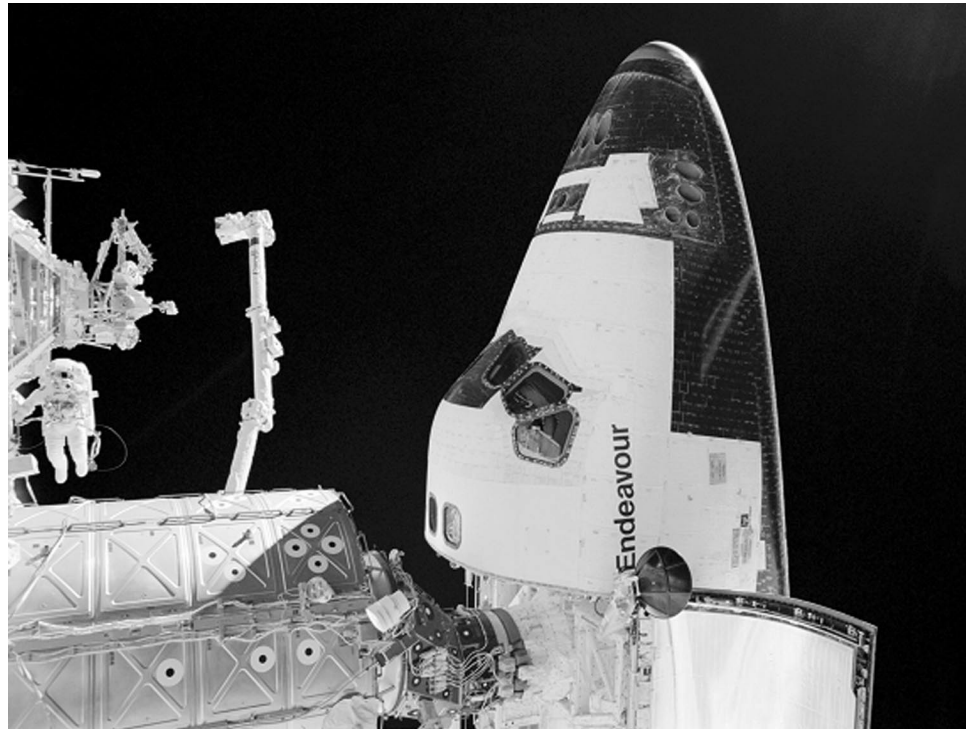
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## Background

NASA and its international partners—Canada, Europe, Japan, and Russia—are building the space station to serve as an orbiting research facility. The space shuttle is the primary vehicle supporting the assembly and resupply of the station. Figure 1 shows the Space Shuttle Endeavour docked to the International Space Station. Following the Columbia accident in February 2003, the NASA Administrator grounded the space shuttle fleet pending an investigation into the cause of the accident. The administrator appointed the Columbia Accident Investigation Board to determine the cause of the accident and to make recommendations for improving the safety of the space shuttle before it could return to flight. The board issued its report in August 2003 with 29 recommendations for improvement—15 of which must be implemented before the space shuttle can return to flight. NASA plans to return the shuttle to flight in July 2005.

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**Figure 1: Space Shuttle Endeavour Docked to the International Space Station**



Source: NASA.

While the shuttle has been grounded, space station crew transfers and logistics resupply have depended on Russian Soyuz and Progress vehicles.<sup>1</sup> Europe and Japan are also developing logistics cargo vehicles to support space station operations later this decade. These Russian, European, and Japanese vehicles are launched on expendable rockets. The European Automated Transfer Vehicle (ATV), scheduled to be available for missions to the space station in 2006, is being designed to rendezvous and dock with the space station's Russian Service Module. The Japanese H-II Transfer Vehicle (HTV) is scheduled to be available in 2008 and will fly within the proximity of the space station to be caught by the station's robotic arm before being berthed to the space station. The ATV and HTV also carry less cargo than the shuttle.

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<sup>1</sup> Soyuz vehicles are used primarily to ferry crew to and from the station. Progress vehicles are used to resupply and reboost the station.



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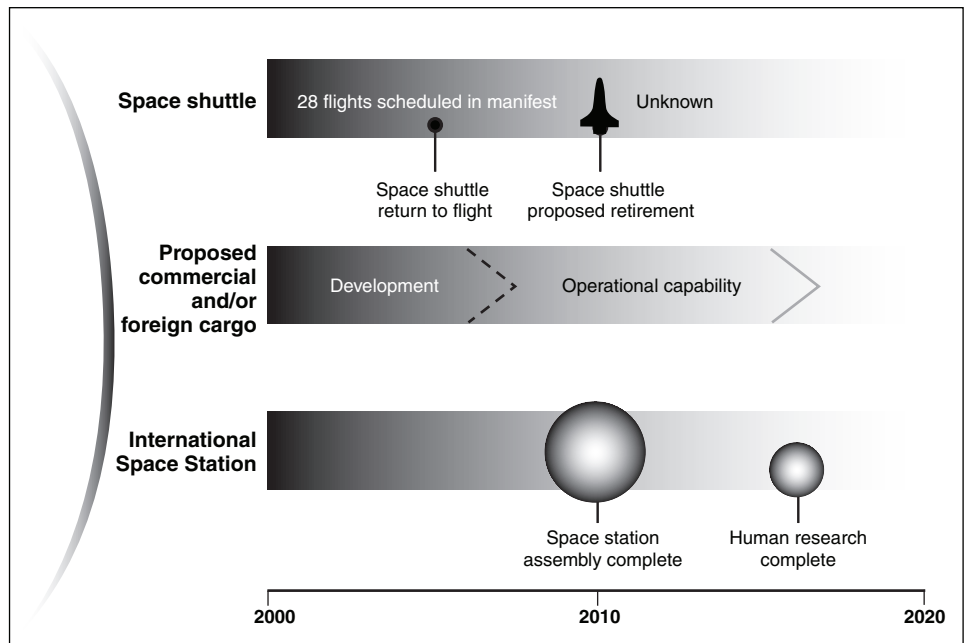
Because the Russian Soyuz and Progress are the only vehicles currently available and carry significantly less payload than the space shuttle, operations are generally limited to transporting crew, food, potable water, as well as propellant resupply for reboosting the space station to higher orbits. Launches of space station assembly elements and large orbital replacement items for maintenance have effectively ceased.

From 2000 to early 2004, NASA performed two studies that focused on the potential use of commercial launch vehicles to provide logistics services to the space station. In a 90-day study conducted in 2000, NASA determined that no commercial logistics service for the space station was possible at that time, as no launch vehicles possessed the critical capabilities necessary to provide logistics services, including automated rendezvous capabilities. As a result of this study, NASA decided to solicit and fund a more detailed review of concepts designed to provide logistics services to the space station. The Alternate Access to Station (AAS) study contracts were awarded in July 2002, with 1-year contracts given to four contractors. In summer 2003, these contractors presented architectures that relied on existing domestic or international expendable launch vehicles. In the fall of 2003, the contracts were extended, and the contractors were asked to address larger cargo delivery capabilities and “downmass” (e.g. returning research materials to earth) requirements were added for the return of cargo. This study ended in January 2004 with the contractors briefing on their study results, at which time NASA concluded that developing a domestic capability to meet most of the space station cargo service needs was possible within 3 to 5 years.

In January 2004, the President announced a new Vision for Exploration that called for retiring the shuttle in 2010, requiring NASA to find an alternative to support space station operations through 2016 by the end of the decade. The President called for a shift in NASA’s long-term focus, envisioning that NASA will retire the space shuttle after nearly 30 years of service as soon as assembly of the International Space Station is completed, planned for the end of the decade, and will develop a new crew exploration vehicle as well as launch human missions to the moon between 2015 and 2020. In essence, NASA’s implementation plan holds aeronautics, science, and other activities at near constant levels and transitions funding currently dedicated to the space station and space shuttle programs to the new exploration strategy as the space station and space shuttle programs phase out. The vision also changed the space station’s on-board research focus. Originally, the space station was to be used for conducting experiments in near-zero gravity to include life sciences research on how humans adapt to long durations in space,

biomedical research, and materials-processing research. Under the new vision, the research will be focused on determining the effects of long duration space travel on humans and developing countermeasures for those effects, with the goal that the space station research necessary to support human explorers on other worlds would be complete by 2016. Figure 2 shows NASA's proposed plan for operational support of the space station until 2016.

**Figure 2: International Space Station Operations Support until 2016**



Source: NASA; GAO (presentation).

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**NASA's 2004 Assessment Was Based on Insufficient Knowledge for Concluding Space Shuttle Was Best Launch Option, but Opportunities Now Exist for More Detailed Study**

According to program officials, NASA's 2004 informal assessment concluded that alternative launch vehicles would present operational risks, technical challenges, and long program delays and would cost more than returning the space shuttle to flight, making the space shuttle the best option for both assembly and logistics missions through the end of the decade. According to previous studies and our discussions with commercial industry representatives, the time involved for developing an alternate capability would probably preclude assembly missions from consideration. However, NASA did not have sufficient knowledge to support its conclusion regarding logistic support missions. Specifically, NASA did not perform a comparative cost analysis that considered the schedule impacts or associated costs of planned space shuttle operations. Furthermore, NASA officials did not document these informal proceedings and decisions reached; therefore, the thoroughness of any assessment of alternatives cannot be verified, nor can their conclusions be validated.

NASA is currently evaluating responses from commercial industry on different ways to provide logistics services to and from the space station. NASA's re-examination of its requirements for the space station and space shuttle, coupled with the cost information of alternatives obtained from commercial industry responses, provide NASA with a basis for performing a detailed analysis of alternatives to determine if any planned space shuttle logistics missions could be performed by or complemented with commercial launch vehicles later this decade.

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**Technical Challenges Difficult to Overcome for Assembly Missions, but Cost Comparison of Later Logistics Missions Insufficient**

As a result of the informal assessment, NASA outlined a number of technical challenges to using an alternate vehicle for space station support, especially for assembly missions where the space shuttle's crew and remote manipulator arm perform key functions. Appendix III provides a discussion of these challenges. NASA officials stated they used the AAS study, which concentrated solely on logistics support missions, as the foundation for its 2004 informal assessment. In a summary of that study, NASA reported that the AAS contractors projected the cost to develop an alternate launch capability would be approximately \$1 billion, take 3 to 5 years to develop, and require \$2 to \$3 billion per year for operations. We held discussions with commercial industry representatives who concurred with this time frame to develop an alternate capability to support space station operation. Since a majority of the space station assembly missions are scheduled within the next 3 years, these types of missions could preclude the use of an alternative vehicle.

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However, NASA did not have sufficient knowledge to conclude that the shuttle was the best option for logistics missions prior to its retirement of the shuttle in 2010. NASA officials stated that the technical challenges for developing an alternative vehicle could be overcome, but probably not before the 28 missions scheduled through 2010, of which 8 are for logistics, including 5 of the last 7 missions. However, we found no evidence of analyses performed by NASA to compare the cost and schedule impact of using alternate launch systems with the scheduled space shuttle program costs, to include the cost of returning the space shuttle to flight. We recently reported that the majority of NASA's budget estimates for returning the space shuttle to flight had not been fully developed.<sup>2</sup> In fact, NASA officials stated that they did not compare estimated costs for developing alternative launch vehicles against budget estimates for the 28 space shuttle flights currently planned to support the space station, which total more than \$22 billion between fiscal year 2005 and fiscal year 2010. In addition, NASA has also requested \$1.8 billion for crew and cargo services over the same time frame to purchase commercial services using existing and emerging capabilities, both domestic and foreign. In its fiscal year 2006 budget request, NASA indicated that such commercial services are expected to be available not later than 2009 and that these services are a key element in the future of the space station program.

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## Informal Assessment Was Not Documented

In addition to lacking sufficient knowledge with regard to the use of alternatives for logistics missions, NASA did not document the proceedings and decisions reached in its 2004 assessment. Specifically, the agency did not record the processes it followed and therefore did not capture the basis of the decisions reached. When asked about the details of the assessment, NASA officials indicated that the informal assessment was based primarily on the expertise within the headquarters and they did not formally document the decision paths. While we recognize that the extensive experience of its senior managers is an important element in evaluating alternatives, the existence of any formal assessment of alternatives covering the entire range of missions for space station support cannot be verified, and the agency's position on the space shuttle being the best option cannot be validated.

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<sup>2</sup> GAO, *Space Shuttle: Cost for Hubble Servicing Mission and Implementation of Safety Recommendations Not Yet Definitive*, [GAO-05-34](#) (Washington, D.C.: Nov. 19, 2004).

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## NASA's Current Request for Information from Commercial Industry and Requirements Review Presents an Opportunity to Perform a More Detailed Analysis

NASA received 26 responses from a September 2004 request for information that asked for, among other things, input from the commercial space industry regarding capabilities and market interest for missions for providing cargo launch services to, and the ability to return items from, the space station. This request for information had similar characteristics as the AAS study, which also had as its objective to explore the development of alternative cargo “upmass” and “downmass” support for the space station. The responses are being evaluated, and NASA plans to seek more detailed information from the commercial launch industry for additional study or development work in June 2005. According to NASA officials, the responses from industry with regard to space station logistics support have been very promising. The officials indicated that it might be possible to have a developed and certified capability to provide commercial cargo launch service to the space station prior to space shuttle retirement late this decade, rather than only after its retirement. However, we were told these services would not eliminate any of the scheduled space shuttle flights, but only augment the capabilities of the space shuttle.

While these responses are being evaluated and knowledge is being gathered, NASA is also reviewing the space station research requirements and re-examining the planned manifest for the 28 space shuttle flights in an attempt to better align their missions to the Vision for Space Exploration. According to NASA's fiscal year 2006 budget submission, the agency is examining configurations of the space station that meet the needs of the new vision and the international partners with as few space shuttle flights as necessary.

Combining the information gathered from commercial industry and a better definition of space station requirements, NASA officials agreed there is an opportunity to perform a more comprehensive assessment of alternatives, especially for the logistics missions late this decade. According to a recent revision of NASA's internal guidance, the most important aspect of formulating a program technical approach is conducting a thorough analysis of alternatives.<sup>3</sup> NASA guidance defines an analysis of alternatives as a formal method that compares alternatives by estimating their ability to satisfy mission requirements through an effectiveness analysis and by estimating their life cycle costs through cost

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<sup>3</sup> NPR 7120.5C: NASA Program and Project Management Processes and Requirements, March 22, 2005.

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analysis. The results of these two analysis are used together to produce a cost-effectiveness comparison that allows decision-makers to assess cost and effectiveness simultaneously. An analysis of alternatives broadly examines multiple elements of program alternatives (including technical performance, risk, life cycle cost, and programmatic aspects), and is typically an important part of the formulation studies.

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## Conclusions

NASA views a thorough analysis of alternatives as an important aspect in the formulation of a program technical approach. While we recognize that the extensive experience of its senior managers is an important element in evaluating alternatives, NASA did not have the full breadth of knowledge necessary to perform a comprehensive assessment of alternative launch vehicles to enable it to conclude the space shuttle was the best option to support space station operations. However, NASA's recent request for information from industry offers the agency an opportunity to enhance its knowledge of alternatives to the space shuttle for providing logistics support for the space station and to explore the use of alternatives to the existing space shuttle manifest currently under review. Although alternate vehicles would not be available for missions to the space station until later this decade and difficult to use for assembly missions, several of the space shuttle's final flights are planned logistics support missions that might be conducted using alternative launch vehicles. By completing a comprehensive analysis, NASA could also identify the feasibility and risks associated with an alternative means of providing logistics support to the space station in case delays occur requiring extension of the planned 2010 date. Furthermore, a comprehensive and thoroughly documented analysis of launch requirements and launch alternatives can provide NASA with comparative cost information and afford the agency the opportunity to use its resources more effectively and efficiently. This is particularly important now since the space station and space shuttle programs will be competing for limited resources.

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## Recommendation for Executive Action

To better position the agency to determine the best available option for providing logistics support to the space station, we recommend the NASA Administrator take the following three steps:

- Direct current efforts to explore other space launch options to utilize a comprehensive and fully documented assessment of alternatives that matches mission requirements, and associated manifest, with the launch vehicles expected to be available;

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- As part of this assessment, (a) determine the development and operation costs associated with these potential alternatives and (b) perform a detailed analysis of these alternatives to determine the best option for delivering the logistics cargo required for space station operations prior to and after space shuttle retirement; and
  - Ensure this assessment is completed before any NASA investments are made for commercial space transportation services to the space station.

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## Agency Comments and Our Evaluation

In written comments on a draft of this report, NASA concurred with our recommendations and stated that the agency seeks to fully explore space launch options for assuring access to the space station in conjunction with its retirement planning for the space shuttle. NASA plans to document its acquisition strategy through a NASA Headquarters Acquisition Strategy Meeting prior to release of a request for proposal for commercial space station cargo services later this summer. In addition, NASA said it will evaluate the cost and capabilities of the proposed transportation system to meet space station and agency needs, as well as the needs of its partners. NASA also said that its acquisition strategy will be consistent with space station requirements, international partner agreements, and available funding.

We are encouraged that NASA has taken steps to pursue a deliberate alternative cargo transportation system assessment. However, NASA should not limit documentation of this effort to the acquisition strategy meeting, but should also document the decision paths leading up to that event and throughout the evaluation of the transportation systems proposed by contractors responding to NASA's request for proposals. This approach should identify the decision makers involved and provide a fully documented rationale of the acquisition processes as NASA analyzes all alternatives to determine the best options for delivering the logistics cargo for space station operations. NASA's comments are reprinted in appendix II.

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As agreed, unless you publicly announce the contents earlier, we plan no further distribution of this report until 15 days from its issue date. At that time, we will send copies to the NASA Administrator; the Director, Office of Management and Budget; and other interested parties. We will also make copies available to others on request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

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

A handwritten signature in black ink that reads "Allen Li". The signature is written in a cursive style with a large initial 'A' and a distinct 'Li' at the end.

Allen Li  
Director  
Acquisition and Sourcing Management



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# Appendix I: Scope and Methodology

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To determine whether NASA conducted a detailed assessment of alternatives to the space shuttle for completing assembly and providing logistics support to the International Space Station, we:

- Obtained and analyzed pertinent NASA documents and briefing slides related to the International Space Station, space shuttles, and other launch alternatives, such as Expendable Launch Vehicles, including: European Space Agency Segment Specifications for the Automated Transfer Vehicle; Specification for the Japanese H-II Transfer Vehicle; International Space Station Payload Integration and Assembly Sequence specifications; Evolved Expendable Launch Vehicle configurations; space station and space shuttle status, history, and cost briefings; Return to Flight Status Briefings; and, Alternate Access to Station briefings.
- Reviewed previous GAO reports on NASA, the Space Shuttle Program, International Space Station Program, and best practices in many areas and multiple agencies. We also reviewed reports from the Congressional Budget Office, Congressional Research Service, Office of Management and Budget, and the Planetary Society, and Russian Space Program.
- Interviewed officials responsible for managing the programs within the Space Operations Mission Directorate at NASA headquarters, as well as program managers at Johnson Space Center, Texas. We also interviewed NASA officials at Kennedy Space Center, Florida, who are responsible for processing space station payloads and integrating those payloads with the launch vehicles. We interviewed contractors at Boeing Launch Services and Lockheed Martin Space Systems and reviewed pertinent documentation related to expendable launch vehicles for space station assembly and logistics support. We also reviewed NASA's request for information related to commercial industry interest in providing that capability and NASA's plans for assessing responses to the request for information and follow on activities. For this, we interviewed NASA officials within the Space Operations Mission Directorate and at Johnson Space Center, Texas. We also interviewed Air Force officials from the Evolved Expendable Launch Vehicle Program. We also received, reviewed, and analyzed follow-up written and oral comments from several individuals at these locations and NASA's Science Directorate.

To accomplish our work, we visited and interviewed officials at NASA Headquarters, Washington, D.C.; Johnson Space Center, Texas; and Kennedy Space Center, Florida. These centers were chosen because they

maintain primary responsibility for conducting space shuttle and space station operations on a day-to-day basis. The offices we met with at headquarters and each of these centers included space station program officials, space shuttle program officials, NASA Launch Services Office, the International Space Station Payload Processing Directorate at Kennedy Space Center, and Space Shuttle Program Integration Office at Kennedy Space Center. We also visited the Boeing Launch Services, Inc., in Huntington Beach, California, and Cape Canaveral Air Force Station, Florida; Boeing Commercial Space Systems in Research Park, Huntsville, Alabama; and Lockheed Martin Space Systems Company in Littleton, Colorado, and Cape Canaveral Air Force Station, Florida.

We conducted our work from August 2004 through April 2005 in accordance with generally accepted government auditing standards.

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# Appendix II: Comments from the National Aeronautics and Space Administration

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

May 9, 2005



Mr. Allen Li  
Director, Acquisition and Sourcing  
Management Team  
United States Government Accountability Office  
Washington, DC 20548

Dear Mr. Li:

Thank you for the completed comprehensive evaluation of alternatives to provide Space Station logistics support. I am pleased to express my gratitude for the professionalism your team exhibited while conducting this essential audit. NASA appreciates the opportunity to comment on the Draft Government Accountability Office (GAO) report entitled, "NASA: More Knowledge Needed to Determine Best Alternatives to Provide Space Station Logistics Support" (GAO-05-488). Below, please find our comments to the recommendations provided in your report.

**Recommendation 1:** *"Direct current efforts to explore other space launch options to utilize a comprehensive and fully documented assessment of alternatives that matches mission requirements, and associated manifest, with the launch vehicles expected to be available;"*

**We concur with your recommendation.** NASA has pursued deliberate alternative cargo transportation system assessment activities through refinements in the International Space Station (ISS) logistical and utilization requirements, release and evaluation of responses to a Commercial Transportation Services Request for Information and an Industry Day held April 25, 2005, to further refine acquisition alternatives and ongoing discussions with international partners. NASA seeks to fully explore space launch options for assuring access to the ISS in conjunction with retirement planning for the Space Shuttle. The acquisition strategy pursued will be documented through a NASA Headquarters Acquisition Strategy Meeting (ASM) prior to release of a subsequent commercial ISS cargo transportation services Request for Proposal (RFP) expected later this summer.

**Recommendation 2:** *"As part of this assessment, (a) determine the development and operation costs associated with these potential alternatives and (b) perform a detailed analysis of these alternatives to determine the best option for delivering the logistics cargo required for space station operations prior to and after space shuttle retirement;"*

**We concur with your recommendation.** As part of the evaluation of the ISS cargo transportation system RFP later this year, NASA will evaluate the cost and capabilities of the proposed transportation system to meet ISS and Agency needs.

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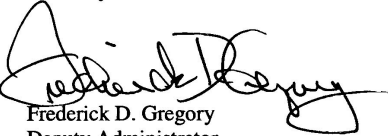
NASA expects to develop an acquisition strategy that meets our ISS Partners' commitments with necessary flexibility to accommodate changing requirements throughout the life of the ISS program.

**Recommendation 3:** *"Ensure this assessment is completed before any NASA investments are made for commercial space transportation services to the space station."*

**We concur with your recommendation.** NASA's acquisition strategy for ISS Cargo Services will follow the Agency ASM process regarding release of an RFP through contract award and will be approved by Agency management. The approach will be consistent with ISS requirements, international partnership agreements, and available funding.

Again, thank you for the critical insight the report provided. We assure you that we are well on our way toward implementing your recommendations.

Cordially,



Frederick D. Gregory  
Deputy Administrator

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# Appendix III: Challenges of Using Alternative Vehicles

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According to NASA officials involved in the 2004 assessment, accommodating a transition to other launch vehicles would create significant challenges that drive risk, schedule, and costs. NASA officials stated the space station elements were designed and built to take advantage of the more benign launch environment in the space shuttle's cargo bay, to be removed and repositioned by the space shuttle's robotic arm, and then connected together by the space shuttle crew during space walk activities. The following outlines the major challenges NASA identified:

- There would be a need to develop a new process to assemble the space station using only the space station crew and without the benefit of the space shuttle remote manipulator arm.
- Using another launch vehicle would require the redesign and retesting of space station elements already built due to the change in launch environment. NASA officials stated the space shuttle launch environment, with respect to vibration and g-force exerted on the payload, cannot be duplicated on an expendable launch vehicle.
- A new, unique transfer vehicle would need to be developed in order to rendezvous and dock assembly elements with the space station. For logistics cargo support, two transfer vehicles are currently being developed for logistics mission to support space station operations, the European Automated Transfer Vehicle (ATV) and the Japanese H-II Transfer Vehicle (HTV). These vehicles, much like the Russian Progress vehicle, have a limited cargo capability when compared to the space shuttle. The ATV, scheduled to be available for missions to the space station in 2006, is being designed to rendezvous and dock to the space station via the Russian Service Module. The HTV is scheduled to be available in 2008 and will fly within the proximity of the space station to be caught by the space station's robotic arm before being berthed to the space station.
- A carrier to go inside the new transfer vehicle to replicate the space shuttle attach points would need to be developed.
- According to these officials, in order to meet volume requirements, the payload fairings would have to be modified from the current 5-meter to a 6-meter version to accommodate the larger diameter payloads to the space station during assembly missions.

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# Appendix IV: GAO Contact and Staff Acknowledgments

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## GAO Contact

Allen Li (202) 512-4841

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## Acknowledgments

Staff making key contributions to this report were Jim Morrison, James Beard, Rick Cederholm, Karen Sloan, and T.J Thomson.

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## GAO's Mission

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