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Report to Congressional Requesters

July 2007

NASA SUPPLIER BASE

Challenges Exist in Transitioning from the Space Shuttle Program to the Next Generation of Human Space Flight Systems

GAO-07-940

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Highlights

Highlights of GAO-07-940, a report to the Chairman and Ranking Member, Committee on Science and Technology, House of Representatives

Why GAO Did This Study

The Space Shuttle Program is currently supported by over 1,500 active suppliers, some of whom are the only known or certified source of a particular material, part or service. The retirement of the Shuttle and transition to planned exploration activities, as called for in the President's *Vision for Space Exploration*, creates the need for NASA to begin making decisions today about its supplier base needs for the future.

GAO was asked to (1) describe NASA's plans and processes for managing its supplier base through the Shuttle's retirement and the transition to the Constellation's exploration activities; (2) address factors that could impact the effectiveness of those plans and processes; and (3) identify any other issues that NASA will likely encounter as the agency transitions to and implements the Constellation Program.

What GAO Recommends

GAO is recommending that the NASA Administrator direct the Exploration Systems Mission and Space Operations Mission directorates to jointly develop cost estimates for transition and retirement activities beyond fiscal year 2010 so that NASA can include the funding needs for the required out-years in its fiscal year 2009 budget submission to ensure that Congress and NASA can balance investments and negotiate between competing priorities, including supplier needs. NASA concurred with this recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-07-940.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Cristina T. Chaplain at (202) 512-4841 or ChaplainC@gao.gov.

What GAO Found

NASA is developing and implementing transition plans and processes to manage its supplier base through the retirement of the Shuttle and transition to the next generation of human space flight systems. Such efforts include: various transition plans; a decision-making structure that should enable the agency to make necessary supplier decisions; and a communications strategy and metrics to gauge the progress of transition activities. In addition, NASA has identified risks associated with the shuttle's retirement and has begun identifying capabilities and suppliers needed for future exploration activities.

While NASA has developed plans and processes aimed at effectively managing the supplier base, several factors could impact their effectiveness. NASA may have to continue funding suppliers for work that would maintain the supplier's skills and capabilities, even when they are no longer working on Shuttle operations, until Constellation officials make a decision on whether or not they will be needed for future exploration activities due to a lack of detailed program requirements. In addition, relatively few supplier-related decisions have made it through the newly created decision-making process and NASA officials acknowledge the increasing number of decisions scheduled for upcoming years have the potential to overwhelm the transition decision-making process.

Other issues have been identified that NASA will have to face in order to successfully transition from the shuttle program to its next generation human space flight systems. Challenges exist in the continued use of obsolescent materials, maintaining the overall viability of the supplier base, managing the overall workforce, disposing of property and equipment, and completing environmental cleanup.

NASA has not developed cost estimates for transition and retirement activities past fiscal year 2010. Without cost estimates, NASA does not have the information needed to support the budget preparation process, assess the costs of addressing its supplier challenges, or account for how NASA will fund transition and retirement activities once the Space Shuttle Program comes to an end in 2010. Such knowledge is important because NASA and Congress will need to allocate funds among many competing priorities. In addition, it will be important for NASA to adjust its cost estimates every year as NASA gains more knowledge about its transition costs.

Contents

Abbreviations

CLV	Crew Launch Vehicle
ESMD	Exploration Systems Mission Directorate
NASA	National Aeronautics and Space Administration
SMRT	Space Shuttle Management Resource Transition
SOMD	Space Operations Mission Directorate
SRB	Solid Rocket Booster
SSME	Space Shuttle Main Engine

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

July 25, 2007

The Honorable Bart Gordon
Chairman
The Honorable Ralph M. Hall
Ranking Member
Committee on Science and Technology
House of Representatives

The National Aeronautics and Space Administration (NASA) is in the midst of phasing out the Space Shuttle Program and beginning another major undertaking, the Constellation Program, which will create the next generation of spacecraft for human spaceflight. This is NASA's biggest transition effort since landing humans on the moon more than 3 decades ago and then initiating the Space Shuttle Program a few years later. Numerous people, hardware, and infrastructures will be impacted by coming changes. Indeed, the supplier base that has been supporting the Space Shuttle since its infancy is already in flux as NASA seeks to determine which suppliers will no longer be needed after the last Shuttle mission is flown, which will transfer to the Constellation Program, and what will happen to mission-critical suppliers who have to wait years for new exploration activities to begin. Over 230 of the Space Shuttle Program's 1,500 or so active suppliers are considered critical single source suppliers, that is, suppliers for items (parts/materials) or providers of services for which there is no direct or immediate replacement available. Due to the recent budget reductions, NASA officials acknowledge that the agency will not be able to launch its new exploration vehicles until 2015, later than the scheduled first launch date in 2014. This results in a prolonged gap of over 4 years between the end of the Shuttle Program and when the Constellation's Orion and the Ares 1 vehicles come online.

Given the magnitude of the overall transition effort, you requested that we (1) describe NASA's plans and processes for managing its supplier base through the Shuttle's retirement and the transition to the Constellation's exploration activities; (2) address factors that could impact the effectiveness of those plans and processes; and (3) identify any other issues that NASA will likely encounter as the agency transitions to and implements the Constellation Program.

To conduct our work, we reviewed NASA plans and processes related to transition and retirement. We reviewed project-specific documentation

related to transition and retirement within NASA as well as various NASA reports and studies on similar efforts elsewhere in the federal government. We reviewed budgetary information and guidance related to transition and retirement costs. We conducted interviews with NASA officials in the Space Operations Mission Directorate (SOMD) and the Exploration Systems Mission Directorate (ESMD) who are responsible for transition and retirement efforts, including the transition managers. In addition, we interviewed NASA and prime contractor officials within the Space Shuttle and Constellation Program and project offices about the transition and retirement effort and met with NASA officials from the International Space Station Program. More details about our scope and methodology are in appendix I.

Results in Brief

NASA has taken steps in laying a foundation to transition from Shuttle retirement through the Constellation Program's return to spaceflight. NASA has laid out an overarching strategy for transition and retirement, developed a plan to integrate acquisitions between the two programs, and released a management plan that is specific to the final years of the Shuttle Program. Taken together, these plans demonstrate consideration of the challenges ahead. Outlined in these plans are methods for communicating change to the Shuttle workforce and metrics intended to help NASA management measure accomplishments and gauge cost, schedule, and performance risk. NASA has established a new organizational hierarchy and processes through which numerous decisions about suppliers will be funneled. For example, NASA has developed a Strategic Capabilities Assessment database that tracks Shuttle capabilities and the property, personnel, suppliers, and contracts related to each capability. The agency also uses a Critical Single Source Supplier List to help Shuttle program managers track suppliers, keep an eye on potential loss of capability, and assess the impact of potential losses on the ability to meet launch schedule.

The effectiveness of NASA's transition plans and decision-making processes is not yet known because few key decisions have formally been considered to date. Uncertainties about the Constellation Program's supplier base needs leave NASA's new plans and processes relatively untested. NASA officials have made preliminary decisions about suppliers that no longer will be needed after the Shuttle's retirement, but agency officials are not ready to decide whether these suppliers' capabilities will definitely be needed for the Constellation Program, which is still in the early design phase. This decision-making gap means that NASA may need to continue funding suppliers, even when they are no longer working on

Shuttle operations, until Constellation officials make a decision. To ensure that critical single source suppliers—such as the ones who produce actuators, nozzles, and heat exchange coils for the Shuttle orbiter and solid rocket booster—do not go out of business during this gap, NASA may provide gap funding until agency officials have a clear idea of Constellation's requirements. Another factor that will impact the effectiveness of NASA's new decision-making processes is the sheer volume of decisions that working groups and control boards must consider that involve each capability, corresponding supplier, real property, personnel, and contracts. Just this year, NASA has had to reschedule a number of key decision dates to later years because the original schedule was deemed overly optimistic.

NASA will likely encounter a number of other issues as the agency transitions to and implements the Constellation Program, including continued use of obsolescent materials; supplier viability; potential loss of needed science and engineering expertise; safe disposal of Shuttle facilities; and the challenge of producing estimates of transition costs. To save money, NASA plans to use certain proven Shuttle technologies in the Constellation Program. However, in doing so, the Constellation Program stands to inherit problems that the Shuttle Program was unable to resolve during its lifespan. For example, the Shuttle Program still uses chrysotile fiber (asbestos), a known carcinogen, and methyl chloroform, an ozone-depleting substance, and has not found any acceptable replacements for those two materials. In addition, maintaining a viable supplier base was a challenge for the Shuttle Program, which has, over the years, experienced many instances of suppliers dropping off unpredictably. The Constellation Program could face similar challenges as it will be using many of the same suppliers for new exploration activities. And within NASA itself, realigning employee resources and planning for a smaller workforce poses a challenge. Another challenge is how to dispose of the facilities that no longer are needed after the Shuttle's retirement while complying with federal, state, and local environmental laws and regulations. Last but not least, developing cost estimates for these and many other funding needs is a challenge. The Shuttle Program is scheduled to end in 2010, but many activities related to closeout will continue past that date, perhaps through 2020. Although NASA has identified its funding needs through fiscal year 2010 for transition activities, the total cost of retiring the Shuttle and transitioning to new exploration activities is still being developed. Without cost estimates, NASA does not have the information needed to support the budget preparation process or assess the costs of addressing its supplier challenges; for example, in its fiscal year 2008 budget submission to Congress identifying funding needs for fiscal years 2008 through 2012,

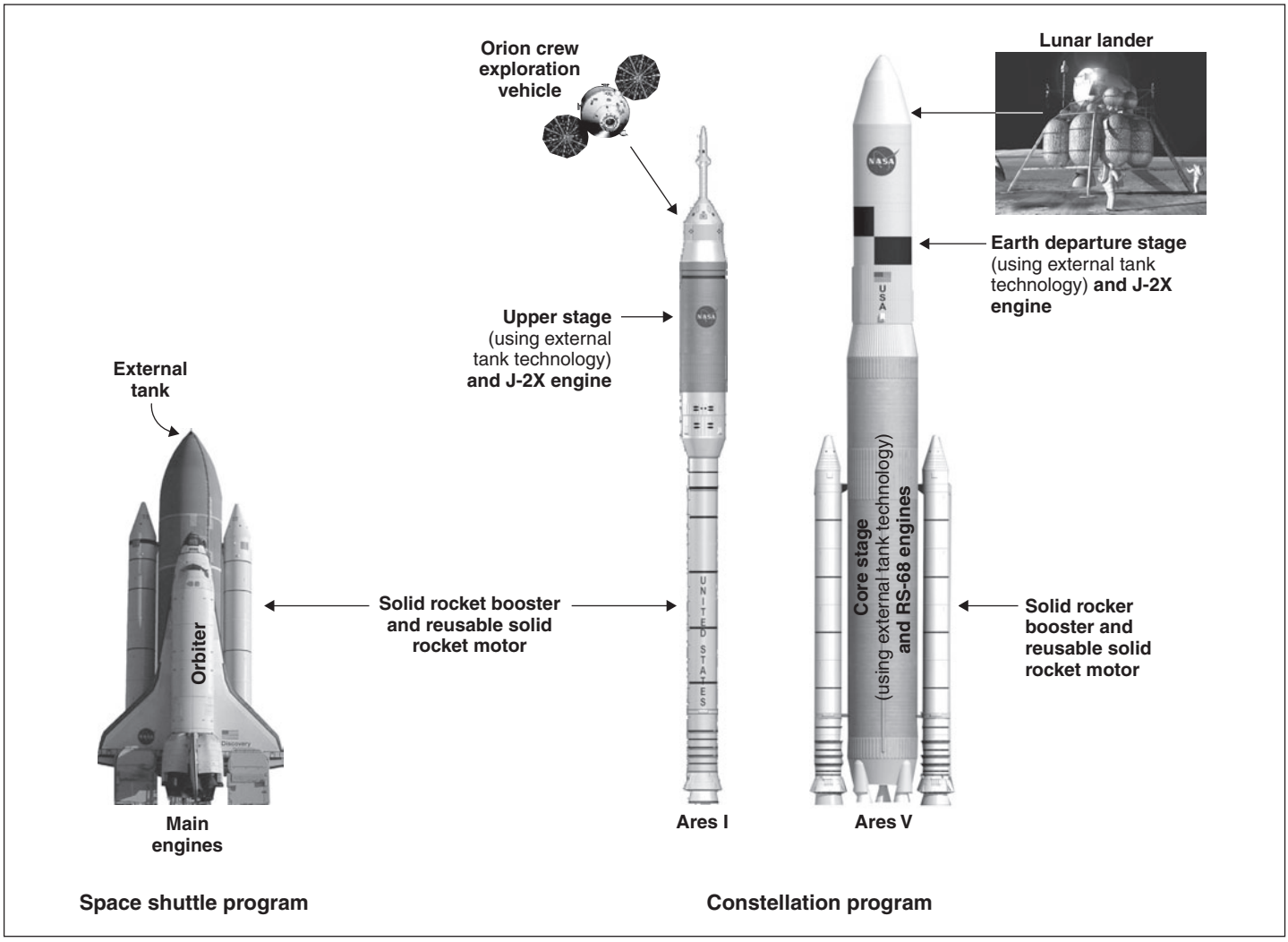
NASA elected not to include funds for transition and retirement activities beyond fiscal year 2010.

In order that NASA will be able to formulate its budget for transition and retirement activities for the years beyond 2010, we are recommending that the NASA Administrator direct the Exploration Systems Mission Directorate and Space Operations Mission Directorate to jointly develop cost estimates for transition and retirement activities beyond 2010, so that, in NASA's fiscal year 2009 budget submission, NASA can include transition and retirement funding needs for the required out-years through fiscal year 2013. We would expect the cost estimates to be adjusted every year and have more fidelity as NASA gains more knowledge about its transition costs, Constellation Program requirements and supplier needs. NASA concurred with our recommendation, but stated that NASA management will work with the Office of Management and Budget to determine the appropriate timing for including transition and retirement costs in the President's Budget Proposal.

Background

In January 2004, following the Space Shuttle Columbia disaster in 2003, the President announced a new exploration policy entitled A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration. The President's vision calls for retiring the Space Shuttle upon completion of the International Space Station in 2010 and creating a new family of exploratory vehicles for human spaceflight that will allow a return to the moon and voyages to Mars and points beyond. To implement the President's vision, NASA embarked on a major study and made recommendations for technologies and potential approaches for vehicle design. NASA incorporated these recommendations into the Constellation Program along with exploration activities called for in the President's vision. NASA's newly created Exploration Systems Mission Directorate manages the Constellation program, which will oversee three major projects—Orion Crew Exploration Vehicle, the Ares I Crew Launch Vehicle, and the Ares V Cargo Launch Vehicle. Figure 1 shows the general design of the Constellation vehicles and how they differ from the Shuttle.

Figure 1: Overview of Space Shuttle and Constellation Programs



Source: NASA.

The Space Operations Mission Directorate manages the Space Shuttle Program. In order to support the 5 major projects—orbiter, Space Shuttle main engine, solid rocket booster, reusable solid rocket motor, and external tank—that comprise the Space Shuttle Program, NASA has 654 facilities that utilize more than 980,000 line items of equipment and employs over 2,000 civil service and more than 15,000 contractor personnel. NASA has several space centers, but the three that hold the majority of this workforce are Johnson Space Center in Houston; Kennedy Space Center, in Cape Canaveral, Fla.; and Marshall Space Flight Center in

Huntsville, Ala. The Space Operations Mission Directorate also manages the International Space Station.

NASA's New Plans and Processes Establish a Foundation for Managing Transition, Retirement, and the Supplier Base

NASA has developed plans intended to help the agency sort through a myriad of decisions relating to transition and retirement, with some aspects focused on NASA's transition management structure and others specifically addressing the supplier base. NASA has an overarching agency-level transition plan, a joint acquisition plan, and a Space Shuttle Program Transition Management Plan, which demonstrate an initial effort to establish a strategy for managing change. Monitoring risk at different levels of the agency is one of the issues addressed in the plans. Also addressed, in general, is the decision-making process related to transitioning the supplier based from the Space Shuttle Program to the Constellation Program.

New Plans Reflect NASA's Overall Strategy to Manage Transition and Retirement

In response to a legislative mandate,[1] NASA developed the Human Space Flight Transition Plan. This agencywide plan describes the overarching strategy for transition from the Shuttle to the Constellation Program's new exploration activities and discusses desired outcomes, processes, roles, responsibilities, and certain program-level requirements. The plan also includes a range of issues that NASA will need to address to achieve a successful transition—budget, acquisition, human capital, and property and environmental management. NASA expects the Human Space Flight Transition Plan to serve as initial, top-level strategic guidance and a governance framework for the development of lower-level directorate, program, and project transition planning guidance documents. NASA officials say they are revising the plan to incorporate guidelines that the inspector general recommended with respect to program and project management.[2]

The Space Operations and Exploration Systems Mission Directorates are developing a joint acquisition road map to avoid substantial duplication of acquisition costs. For example, the Constellation Program has begun work under a current NASA follow-on contract for Shuttle-related support to the

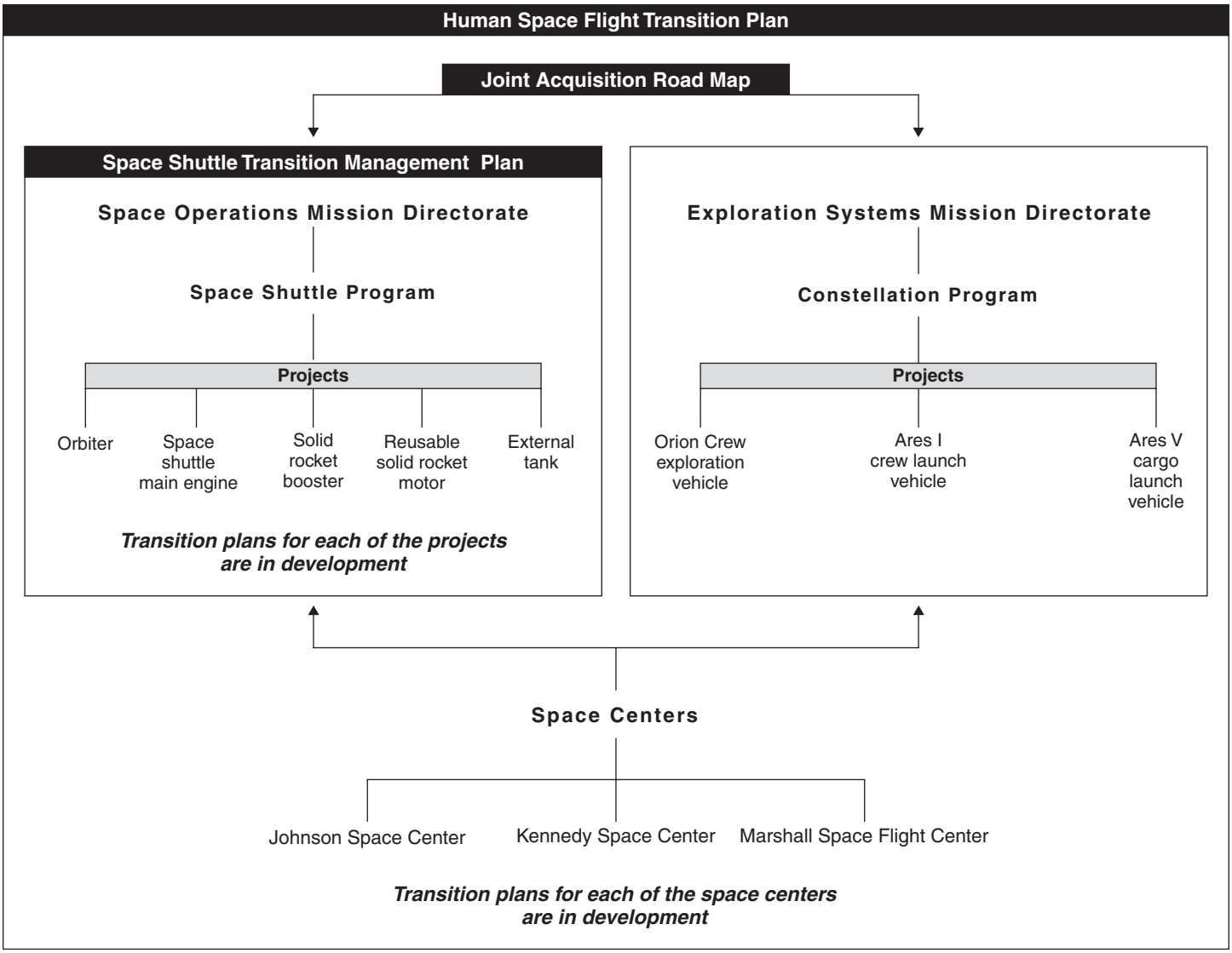
[1]NASA Authorization Act of 2005, Pub. L. No. 109-155, § 502 (b) (2005).

[2]NASA Office of Inspector General, *NASA's Plan for Space Shuttle Transition Could Be Improved by Following Project Management Guidelines*, IG-07-005 (Washington, D.C.: January 2007).

Constellation Program and intends to begin work on the engine that will be used in the Ares V Cargo Launch Vehicle through an interagency agreement with the Air Force and National Reconnaissance Office.

NASA also recently approved the Space Shuttle Program Transition Management Plan, which defines how the Space Shuttle Program should organize and manage its retirement and transition activities to support the agency-level Human Space Flight Transition Plan and overall Vision. The plan describes the organizational structure, management approach, processes, products, and tools used to manage the transition and retirement of Space Shuttle Program capabilities. The shuttle program's five project offices are developing separate transition plans, as are three of NASA's space centers. Figure 2 shows the various plans and the NASA organizations affected by the plans.

Figure 2: NASA's Plans for Transition and Retirement



Source: GAO analysis of NASA data.

Note: The Projects depicted are the ones with major supplier transitions, but the list is not inclusive of all of the Projects within the respective programs.

In addition to the plans mentioned above, NASA has developed a communications strategy to keep the Shuttle workforce informed about the activities, intentions, and goals related to retirement of the Shuttle and transition to new exploration activities. Weekly teleconferences, monthly reports, quarterly newsletters and magazines, and Transition Quarterly

Program Manager's Reviews will strive to lessen confusion and frustration in this environment of change. NASA and the prime contractors are conducting supplier visits to better inform the subcontractor workforce about transition activities and the opportunities available for future work.

To measure progress on Shuttle retirement and transition, NASA has identified a collection of metrics that can be used at an agencywide or program level to assess cost, schedule, technical, and risks. NASA officials say they intend, on a quarterly basis, to analyze progress made and to look ahead for opportunities to, for example, save money, mitigate risks, and see what decisions need to be made about which suppliers. Key metrics at the agency level include cost avoidance, schedule variances, and government personnel time charges for work on single versus multiple programs. Various tools will be used to track risks related to transition and retirement activities. Such risks include loss of critical Shuttle personnel, transfer of facilities funding from the Space Shuttle Program to the Constellation Program, and cargo transportation shortfalls for the International Space Station after 2010.

NASA Has Developed New Decision-Making Process to Manage Supplier Base

NASA has developed a new decision-making process to manage supplier decisions related to the retirement of the Shuttle and transition to the Constellation Program. The new process defines key areas of authority and responsibility and lines of reporting. Control boards, comprising representatives from the Space Shuttle, Constellation, and International Space Station programs, are expected to provide guidance and facilitate decisions on important transition issues. Transition managers have been appointed at the directorate, program, and center levels. Table 1 provides an overview of the various processes.

Table 1: Overview of NASA's Decision-Making Process

Directorate level	
Joint Integration Control Board	Focuses on long-range strategic decisions, such as budgets, schedules, and conflicting directorate priorities; ensures successful integration of development with operations in support of exploration architecture.
Transition Control Board	Serves as short-term decision-making forum; for example, if it is unclear which program (Shuttle or Constellation) should provide funding to sustain a given supplier during the gap[a] between the Shuttle's retirement and on start of the Constellation Program, this board would make the determination.
Program level	
Joint Program Requirements Control Board	Will resolve technical or programmatic problems and approve joint program requirements and milestones; this board, which existed prior to the President's vision, was expanded to include the Constellation Program.
Transition Program Requirements Control Board	Recommends courses of action with regard to existing capabilities and associated suppliers; prime contractors for the Shuttle Program can provide input to this board; this board has its own budget to fund transition-related activities and was allocated $10 million in fiscal year 2006 and $30 million in fiscal year 2007 from the Shuttle Program's budget. Will fund shutdowns of suppliers, transitions of suppliers to Constellation Program, and gap funding. Still in development is the creation of a control board that will deal specifically with the Constellation Program's transition requirements.
Center level	
Johnson Space Center Working Group	Provide intra-center forums for exchanging information relevant to transition and elevating significant issues to senior management; center-level transition plans are still in development.
Kennedy Space Center Working Group	
Marshall Space Flight Center Working Group	
Project level	
Five Shuttle project offices (orbiter, Space Shuttle main engine, solid rocket booster, reusable solid rocket motor, external tank)	Transition managers at each of the five Shuttle project offices are responsible for planning and implementing project-specific transition plans, which are still in development; most of the coordination between the Shuttle and Constellation programs is occurring at the project level and done through informal means with participation by the Constellation Program Transition Manager.

Source: NASA (data); GAO (presentation and analysis).

[a]Gap funding can take place, according to NASA, when the Space Shuttle Program no longer needs a supplier and the Constellation Program does not have an immediate need but may have a future need for the same supplier. NASA can then choose to fund the supplier, which is typically a subcontractor to a NASA prime contractor, for work that would maintain the supplier's capability/skills during the gap.

To make better informed decisions, the boards obtain supplier assessments, known as Space Shuttle Management Resource Transition (SMRT) documents, usually completed by the project offices, which provide rationale and potential impact for recommended courses of action. Shuttle capabilities with potential use for the Constellation

Program are usually elevated to Transition Control Board for coordination and review.

NASA is using the Critical Single Source Supplier List and the new Strategic Capabilities Assessment database to manage its supplier base through the retirement of the Shuttle and transition to the Constellation Program. The Critical Single Source Supplier List existed prior to the announcement of the Shuttle's retirement and is used to monitor the unique capabilities provided by critical single source suppliers and note any supportability issues that could arise.[3] NASA considers a supplier to be a critical single source supplier if it is the only known or only certified source of particular hardware or services and has received hardware or services from them in the past 5 years or expects to do business with them again in the future. The list contains over 230 suppliers identified by each of the five major Shuttle project offices (see app. II for a list of NASA's critical single source suppliers). NASA can exercise various options to ensure that certain key capabilities and the critical suppliers associated with those capabilities are maintained until no longer needed. For example, a skills retention contract can be put in place by Shuttle program officials through the prime contractor to ensure that a subcontractor will maintain the minimum skills necessary to perform failure analysis until the end of the Shuttle Program.

The Strategic Capabilities Assessment database, created after the Shuttle's retirement was announced, provides an initial review and categorization of Shuttle's assets and is used for tracking, controlling, maintaining, and updating information associated with Shuttle capabilities. Each capability comes bundled with property, personnel, suppliers, contracts, and Shuttle last-need date, which together produce a product or service, and the database tracks risk associated with each capability. Using the information gathered in the database, NASA can generate a master schedule that provides the basis for transition plans and adds insight into the progress of transition and retirement activities. The Transition Program Requirements Control Board plans to use the master schedule to estimate how many decisions need to be made each quarter. The Shuttle Program has

[3]NASA assigns a supplier code to each critical single source supplier that defines the risk to the program including the inability to deliver hardware and the impact on meeting the launch schedule. Identification of these risks varies depending on whether alternate paths exist for obtaining the hardware, such as cannibalizing other shuttle components. NASA also identifies "generic causes" for the defined risk, including, for example, obsolescence, no longer in business, or lack of skills to perform the work.

identified most of the last-need dates and release dates for the 300 or so capabilities that are contained in the Strategic Capabilities Assessment database, according to NASA officials. Constellation Program officials have completed in the spring of 2007 a preliminary assessment of which capabilities will be needed in the future, but acknowledged that further requirements refinement and definitions are needed.

Effectiveness of NASA's Transition Plans and Processes Not Known until Constellation's Supplier Base Needs Become Clearer and More Decisions Have Been Processed

Whether NASA's transition plans and processes will be effective is unclear because NASA has not set requirements for Constellation's supplier base needs and few decisions about suppliers have worked their way through the new processes.

Constellation Lacks Detailed Supplier Base Needs Requirements

While the Shuttle is, in some cases, ready to release or transfer certain suppliers, its ability to do so has been impacted by the lack of detailed requirements from the Constellation Program. According to NASA officials, because the Constellation Program is early in its design cycle, it is not able to "pull" suppliers to Constellation as a counter to the "push" from the Shuttle Program to release or transfer suppliers. For instance, according to the Space Shuttle Main Engine (SSME) project manager, even though his office has identified, to the best of its abilities, the suppliers that could be needed for the J-2X engine (which will be used on the Crew Launch Vehicle), the Constellation Program is still working on the requirements for the J-2X and has not made any determinations about which Shuttle suppliers will be needed. The SSME project office was able to identify suppliers that could be used for new exploration activities because the same prime contractor that produces the Shuttle main engines will produce the J-2X engine. There is a risk that the SSME project will have to make decisions prior to the establishment of defined requirements at a risk of losing some key capabilities. When NASA makes decisions as whether to maintain an existing supplier that might not be needed in the future, NASA is attempting to balance the risk associated with losing that

supplier and unnecessarily spending funds that could be used for other priorities. As a result of Constellation's lack of detailed requirements, there are cases where NASA has provided funding for certain Shuttle suppliers' work through its prime contractor's subcontracts because of a possible future need for the suppliers with the Constellation Program and the need to maintain the critical skills. Following are examples of such cases.

- One subcontractor is a critical single source supplier that makes tubes for nozzles and heat exchange coils. At the time of our review, the last delivery from the subcontractor is scheduled for summer of 2007, after which the prime contractor could end its relationship with the subcontractor. However, the SSME project office will seek gap funding for work that would maintain the subcontractor's capability/skills because SSME project office officials believe that Constellation Program will likely have a future, but not an immediate need for the subcontractor's services. SSME project office officials pointed out that the subcontractor may go out of business without NASA funding.

- Another subcontractor is a critical single source supplier certified to refurbish and re-certify the post-flight Solid Rocket Booster (SRB) actuators. The SRB project currently has inventories that can support the remaining Shuttle flights plus eight spares. Therefore, the SRB project office could have informed the prime contractor that it no longer needed the subcontractor's services as of January 2007. However, because the subcontractor's refurbishment capability may be needed for the Ares 1 Crew Launch Vehicle (CLV), the SRB project office sought and obtained $1.8 million in gap funding from the Transition Program Requirements Control Board for work that would preserve the subcontractor's capability/skills for the CLV through the end of fiscal year 2007. Otherwise, according to analysis completed by NASA, if the Constellation Program needed to restart the subcontractor's refurbishment capability in the future through a new subcontract with the CLV's prime, it would cost $15 million. At the time of our review, the Space Shuttle Program Transition Manager stated that the Constellation Program should decide by summer of 2007 whether it needs the subcontractor as its supplier.

The lack of a "pull" from the Constellation Program—that would identify current Shuttle suppliers that will be used in the new exploration program—may result in additional gap funding for some critical suppliers, costly production restarts in the event that some suppliers are let go but found to be needed later, or the capability could be lost altogether.

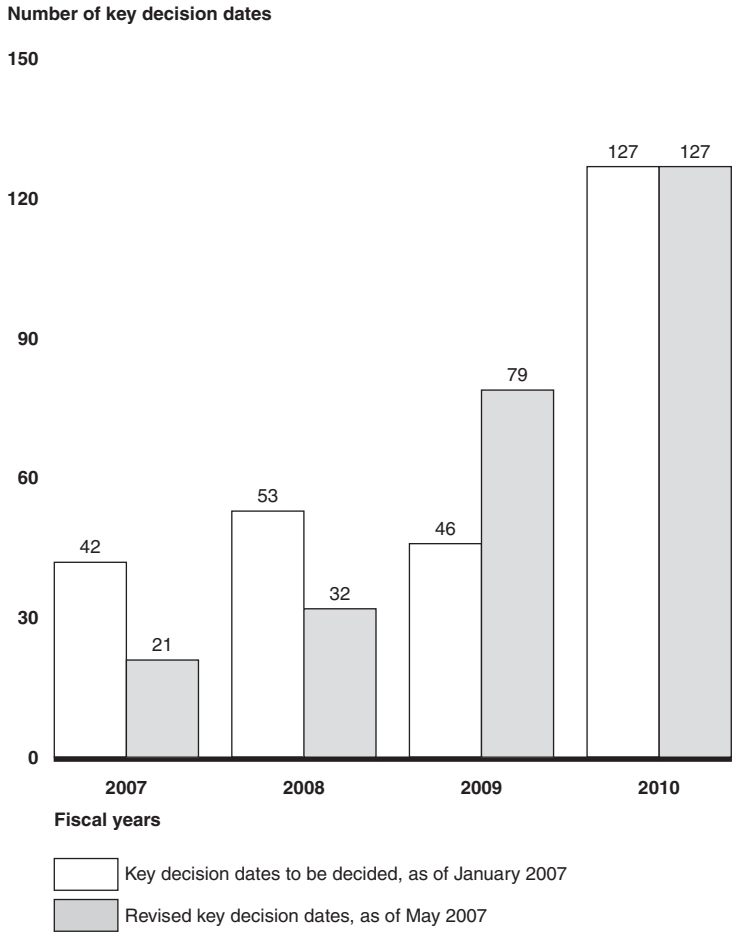
Increasing Number of Supplier and Capability Decisions to Be Made in Coming Years Could Overwhelm NASA's Processes

The lack of requirements for the Constellation Program is not the only factor impacting NASA's transition plans and decision-making processes. NASA's plans and decision-making processes are relatively untested because only a small number of supplier decisions have been vetted through the decision-making process thus far. The Strategic Capability Assessment database, as described earlier, was created to efficiently and effectively manage the transition and retirement of Shuttle capabilities. The database divides each Shuttle project element into a list of capabilities that comprise the entire project. Each capability covers property, personnel, suppliers, and contracts data. A key decision date, last-need date, and estimated release date are determined for each capability.

Documenting decisions is an important part of the decision-making process. Each transition-ready capability in the Strategic Capabilities Assessment database should be paired with a corresponding SMRT document that will wind its way through the decision-making process and then be approved by the program-level Transition Program Requirements Control Board and/or the Transition Control Board at the directorate level. The document provides a body of relevant information from which decisions can be rendered, communicated, documented, and tracked. This paperwork is needed for any Shuttle capability that is being partially or fully terminated before the Shuttle Program ends—including those to be transferred to the Constellation Program.

As of January 2007, Shuttle program officials predicted they would need to set 42 key decision dates for fiscal year 2007; in May 2007, after realizing that this target was too optimistic, officials reduced the number to 21 and rescheduled a number of key decision dates to later years. Future dates also were adjusted. Figure 3 shows the number of dates set in January 2007 and then revised in May 2007.

Figure 3: Revision of NASA's Anticipated Key Decision Dates for Shuttle Capabilities



Source: GAO analysis of NASA data.

As the number of key decision dates and the corresponding SMRT documents to be processed increase in the coming years, the ability of the transition process to function effectively will be tested. NASA officials acknowledge that the increasing number of SMRT documents scheduled for upcoming years has the potential to overwhelm the transition decision-making process.

Obsolescence, Workforce Issues, and Transition Cost Estimates Pose Other Challenges to NASA's Transition Efforts

NASA is likely to encounter other issues as it transitions to new exploration activities, including:

- obsolescence, particularly with regard to outdated materials for which no replacements have yet been developed;
- supplier viability;
- potential loss of NASA personnel with science and engineering expertise;
- safe disposal and cleanup of Shuttle facilities and equipment; and
- developing estimates of transition costs.

Obsolescence

To lower development costs for the Constellation Program, NASA plans to leverage some of the Space Shuttle Program's existing technologies. In doing so, the Constellation Program stands to inherit problems, such as the continued use of obsolete materials for which replacements have yet to be found. Some long-used Shuttle materials are now known to pose environmental or health hazards. Examples include chrysotile fiber (asbestos), a component in rubber insulation; hydrazine, a type of fuel; methyl chloroform, a cleaning solvent and degreaser; and HCFC-141b, a foam-blowing agent. The Environmental Protection Agency classifies asbestos as a known carcinogen and hydrazine as a probable carcinogen, while both methyl chloroform and the foam-blowing agent are classified as ozone-depleting substances. If the Constellation Program continues to use these materials, health and environmental concerns will persist and administrative and technical burdens will likely increase.

Supplier Viability

Supplier viability presents another challenge. Over the years, the Shuttle Program has experienced many instances of suppliers dropping off unpredictably, making supply chain management more difficult and costly. The Integrated Space Operations Summit, attended by representatives from NASA, industry, and academia, issued a report in April of 2005 that stated the following: "the average mitigation cost from a loss of supplier, based on over 100 industry case studies, is between $200,000 and $700,000. Inventory, tooling, design, freight, people time, rush premiums, and extraordinary costs add to this figure."[4] NASA created the Critical Single Source Supplier List as a way to monitor critical suppliers that were

[4]NASA Integrated Space Operations Summit, *Space Shuttle Program Transition Panel Final Report* (April 2005).

the only known source or only certified source of a certain component or material. In addition, the statement of work in Shuttle's Space Program Operations contract specifies that the prime contractors need to identify and resolve issues pertaining to loss of repair capabilities, failure analysis, or production capabilities. This information allows Space Shuttle Program officials to proactively monitor the supplier base and formulate appropriate risk mitigation plans, if needed. Given that the Constellation Program is the Shuttle's replacement and will likely span decades, supplier viability issues could arise as they did during the Shuttle Program. Appropriately monitoring the supplier base early on, especially during the production and sustainment phases of the Constellation Program, could help to mitigate potential supplier viability issues.

Potential Loss of NASA Expertise

NASA acknowledges that it must realign employee resources and plan for a smaller workforce. NASA projects fewer resources will be required for operating and sustaining hardware, especially during vehicle processing and launch operations. By fiscal year 2012, the total number of personnel needed to meet NASA's strategic goals is likely to drop from 18,100 to 17,000. As new space systems are designed, emphasis will shift to personnel with skills in systems development and engineering, program management, and systems integration. NASA made the decision to maintain program management and systems engineering competencies within the civil service workforce to ensure that it has the capabilities it needs to develop programs and projects for its missions. NASA acknowledges that, in coming years, these very skills will be in high demand across the federal government and in the private sector. NASA's senior leaders recognize the need for an effective workforce in achieving mission success and to ensure the agency has the scientific and technical expertise necessary to preserve the nation's role as a leader in aeronautics, earth and space science, and technology. NASA has a strategic human capital plan and Shuttle strategic human capital plan, but more work is needed in workforce planning and deployment. In a separate review requested by Congress, GAO is assessing the extent to which NASA's human framework is aligned with its strategic mission and programmatic goals; whether NASA is effectively recruiting, developing, and retaining critically skilled staff; and what internal or external challenges NASA faces in achieving its workforce needs.

Environmental Disposal and Cleanup

While executing the remaining Shuttle missions, NASA will simultaneously begin the process of disposing Shuttle facilities that are no longer needed and transitioning facilities that can be used by other NASA programs. NASA officials say that a much smaller number of facilities than the current 654 Shuttle facilities will probably be required to support the development or operation of future exploration systems. Environmental management encompasses a wide range of activities, including identifying and mitigating the environmental consequences of program and project activities, informing systems engineering decisions to enhance safety, preventing pollution, correcting environmental damage from past operations, and maintaining compliance with federal, state, and local environmental laws and regulations. Although NASA has an approach for identifying environmental risks, the agency does not have a comprehensive estimate of the environmental cleanup costs associated with the transition and disposal of the Shuttle Program's facilities and equipment. In our report on major challenges facing the nation in the 21st century, we pointed out that frequently the costs associated with environmental cleanup dramatically exceed available funding levels.[5] For example, it cost the Titan IV Program[6] approximately $300 million over 6 years on cleaning facilities, equipment, and tools. Paying for environmental cleanup may require a significant future outflow of funds at the same time that NASA will be facing many other competing demands for its limited dollars, such as development of Orion, Ares I, and other exploration projects.

Transition Cost Estimates

Developing cost estimates is a complex task for a transition of this magnitude. Although NASA has identified its funding needs through fiscal year 2010 for transition activities—such as planning and initial asset/facilities screening and disposition—the total cost of retiring the Shuttle and transitioning to new exploration activities is currently being developed. The last Shuttle flight is scheduled to be flown in 2010, but many transition and retirement activities will occur after that date. Disposal of program facilities, contract closeouts, and transition and/or severance of the remaining workforce are among the tasks ahead. According to NASA officials, such efforts could last through 2020. At this time, NASA does not know the extent of the Shuttle Program's

[5]GAO, *21st Century Challenges: Reexamining the Base of the Federal Government*, GAO-05-325SP (Washington, D.C.: February 2005).

[6]Titan IV was an Air Force program that produced rockets for launching satellites.

environmental liabilities. Paying for such liabilities later may complicate NASA's future fiscal landscape, especially when there will be other competing demands, such as Constellation's crew exploration vehicle, the crew launch vehicle, and other new exploration activities.

In 2006, NASA developed a cost estimate of $2.8 billion for transition and retirement activities through fiscal year 2020. NASA officials say the estimate was based on a preliminary set of assumptions that were not properly validated and was calculated without the involvement of the NASA's space centers and other institutions. Thus, NASA officials consider the estimate immature and, in its fiscal year 2008 budget submission to Congress identifying funding needs for fiscal year 2008 plus the required 4 out-years through fiscal year 2012, NASA elected not to include any funds for transition and retirement activities for fiscal years 2011 and 2012. Without cost estimates, NASA does not have the information needed to support the budget preparation process or assess the costs of addressing its supplier challenges. The Shuttle Program's risk assessment states that not having secured funds for transition and retirement activities for fiscal year 2011 and 2012 is a risk to follow-on programs and institutions and to the agency as a whole.

As stated in NASA's Inspector General report[7] issued in January 2007, NASA's own program and project management guidelines, the Integrated Space Operations Summit Transition Panel Report, and one of the Shuttle's benchmarking studies (the Titan IV Program) all call for the establishment of a detailed cost estimate for the Shuttle's retirement and transition. NASA officials say they are in the process of recalculating the total cost estimate through fiscal year 2020 and are deciding how to budget for transition and retirement activities beyond 2010. NASA officials told us that transition and retirement costs past 2010 will likely be absorbed by the other NASA programs—including the Constellation Program—and the space centers when the Shuttle Program ceases to exist. This will likely affect the scope of those activities as well.

[7]NASA Office of Inspector General, *NASA's Plan for Space Shuttle Transition Could Be Improved by Following Project Management Guidelines*, IG-07-005 (Washington, D.C.: January 2007).

Conclusions

NASA's transition plans and processes increase the chances that key decisions about the supplier base will be made with sufficient input from the right people with the right expertise. The lack of defined requirements for the Constellation Program is having an impact on supplier transition decisions. Even if all of Constellation's requirements were known today, NASA still may not be prepared to process the myriad of decisions ahead. Only after NASA funnels more supplier decisions through its new processes will the agency be able to declare success or failure. The sheer volume of decisions could create bottlenecks, with some critical suppliers getting lost in the mix, dropping out altogether before NASA makes up its mind, and adding risk that NASA will have nowhere to turn for certain capabilities. Lastly, the costs of transition and managing suppliers will be affected by many decisions yet to be made, including gap funding requirements and environmental remediation efforts. As a result, it is important that NASA begin estimating its transition and retirement costs and continually revisit these estimates to reflect final decisions on requirements and additional knowledge gained on technology development and supplier needs. Such cost estimates also need to be part of NASA's budget submission to ensure Congress and NASA can balance investments and negotiate between competing priorities.

Recommendation

Given the fact that many of NASA's transition and retirement activities will continue to occur following the Shuttle retirement in 2010, it is important that NASA identify and estimate the costs associated with these activities in an accountable and transparent manner. Therefore, we are recommending that the NASA Administrator direct the Exploration Systems Mission Directorate and Space Operations Mission Directorate to jointly develop cost estimates for transition and retirement activities beyond fiscal year 2010 so that, in NASA's fiscal year 2009 budget submission, NASA can include transition and retirement funding needs for the required out-years through fiscal year 2013. We would expect these estimates to be adjusted every year and have more fidelity as NASA gains more knowledge and makes more decisions.

Agency Comments and Our Evaluation

In written comments on a draft of this report (see app. IV), NASA concurred with our recommendation, but stated that NASA management will work with the Office of Management and Budget to determine the appropriate timing for including transition and retirement costs in the President's Budget Proposal. We also received technical comments from NASA, which have been addressed in the report, as appropriate.

We are sending copies of the report to NASA's Administrator and interested congressional committees. We will also make copies available to others upon request. In addition, the report will be available at no charge on GAO's Web site at http://www.gao.gov.

Should you or your staff have any questions on matters discussed in this report, please contact me at (202) 512-4841 or at ChaplainC@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff that made key contributions to this report are listed in appendix IV.

Cristina T. Chaplain
Director, Acquisition and Sourcing Management

Appendix I: Scope and Methodology

(1) To determine what plans and processes the National Aeronautics and Space Administration (NASA) has established to effectively manage its supplier base to ensure both sustainment of the Shuttle Program and successful transition to planned exploration activities, we performed the following:

- Obtained and reviewed documents from NASA describing plans and processes for managing retirement and transition activities, including the Human Space Flight Transition Plan, Space Shuttle Program Transition Management Plan, Space Shuttle Program Transition and Retirement Requirements, and the Space Shuttle Program Risk Management Plan.
- Reviewed various NASA reports and studies on similar retirement and transition efforts elsewhere in the federal government.
- Examined databases relevant to NASA's transition, specifically the Strategic Capabilities Assessment database and the Shuttle Integrated Risk Management Application.
- Reviewed Space Shuttle Management Resource Transition documents and meeting minutes.
- Interviewed NASA's transition management officials at NASA Headquarters and the NASA Centers.
- Compared NASA's plans and processes to GAO's Standards for Internal Control in the Federal Government.

(2) To describe factors that could impact the effectiveness of such plans and processes for managing NASA's supplier base and to (3) identify any other issues that NASA will likely encounter as the agency transitions to and implements its planned exploration activities, we performed the following:

- Reviewed NASA's 2008 Budget Request along with Planning, Programming, Budgeting and Execution Guidance for 2008 and 2009.
- Collected and analyzed information derived from the Strategic Capabilities Assessment Database, including last need dates and key decision dates.
- Interviewed NASA Constellation, Space Shuttle, and International Space Station Program officials for information on coordination between programs.
- Discussed transition challenges with NASA officials at the agency, program, and project level, with prime contractors for the Space Shuttle and Exploration programs, and with representatives of the Aerospace Industries Association.
- Reviewed past GAO testimonies and reports.

- Identified obsolescence and supplier viability issues noted in NASA and contractor reports and briefing charts that might impact new exploration activities.

To accomplish our work, we interviewed NASA and prime contractor officials for the Orbiter project at Kennedy Space Center in Cape Canaveral, Florida; NASA and prime contractor officials for the External Tank, Solid Rocket Booster, Reusable Solid Rocket Motor and Space Shuttle Main Engine projects at Marshall Space Flight Center in Huntsville, Alabama; and NASA officials for the Constellation, Space Shuttle and International Space Station programs at Johnson Space Center in Houston, Texas. We also attended the January 2007 Transition Quarterly Program Manager's Review to garner information on the status of transition. At NASA Headquarters in Washington, D.C., we met with the SOMD and ESMD Transition Managers, the Deputy Associate Administrator for Program Integration, the ESMD Special Procurement Advisor, and representatives from the SOMD and ESMD Resources Management Offices.

We conducted our work from September 2006 to June 2007 in accordance with generally accepted government auditing standards.

Appendix II: Space Shuttle Program Critical Single Source Suppliers

Company	Material/part/service
External tank	
Tru-Circle Metal and Tool, Inc.	Manhole Frames
Summa Technology, Inc.	Fittings
AMRO Fabricating Corp.	Thrust Panels
Klune Industries, Inc.	Feedline Fairings
Machine Craft, Inc.	Miscellaneous Detail Parts
GKN Aerospace Monitor, Inc.	Longerons
Chromalox, Inc.	Heaters
Kaiser Aluminum and Chemical Corp.	Diffusers
General Tool Co.	LO2 Elbow, Ball fitting, SRB End Fitting
Goodrich Corp. - Rosemount Aerospace, Inc.	Pressure Transducers
Goodrich Corp. - Simmonds Precision Products, Inc.	Level Sensors
Plastic Fabricating Co., Inc.	Fittings
Tayco Engineering, Inc.	Heaters
Senior Operations, Inc. - DBA Ketema Aerospace	Vent Relief Valves
Senior Operations, Inc.	GH2 Ventline, LH2 Feedline Bellows Assembly
Ecliptic Enterprises Corp.	ET Camera Electronic Box
Arrowhead Products Corp.	Propulsion Lines
Meggitt Thermal Systems, Inc.	Pressurization Lines
Lord Corp.	7450, 391 Adhesives
North Carolina Foam Industries	NCFI 26-007, NCFI 24-57 Foam, NCFI 24-124 Foam
Cytec Olean, Inc.	Conathane
Stepan Co.	BX-265 Foam
Trelleborg Emerson & Cuming, Inc.	Silica Microspheres
National Process Industries	Vitrolube
PRC-DeSoto International, Inc.	MMSK 719 Primer
Orbiter	
Ball Aerospace & Technologies Corp.	PRSD Tank, Vac-Ion Pumps, DC/DC Converters, Solid State Star Trackers
Hamilton Sundstrand Space Systems International, Inc.	Water Spray Boiler, Flash Evaporator Subsystem
Edo Corp. - Antenna Products & Technologies Division	S-Band Preamp
Sypris Data Systems, Inc.	MADS Recorder

Company	Material/part/service
Albany International Corp. - DBA Albany International Research Company	Thermal Protection System - Reusable Surface Insulation
Applied Resources Corp.	Round Meters, Switches
PerkinElmer OptoElectronics	Interior Lights
Hamilton Sundstrand Corp. - DBA Hamilton Sundstrand Aerospace	Auxiliary Power Units, Flight Control Hardware
Goodrich Corp.- Universal Propulsion Company, Inc. (UPCO)	Emergency Egress Slide, Thruster Assembly, Window Pyrotechnic Devices
Michelin Aircraft Tire Corp.	Tires
Glenair, Inc.	Connectors & Connector/Protectors
Hi Temp Insulation, Inc.	Insulation
Arrowhead Products Corp.	MPS Feed Lines
Carleton Technologies, Inc.	O2/N2 Sensors, PPO2 Sensors, Valves
Corning Glass Works	Window Panes
Senior Operations Inc. - Metal Bellows Division	ECLSS Waste and Potable Water Tank, Bellows Assembly (Lines, Tanks)
3M Co.	Surface Modifier
Aerojet General Corp. - Propulsion Division	APU Gas Generators, Vernier Thrusters, Small Parts
Ametek, Inc.	Pressure Transducers
Argo Tech Corp. - Carter Ground Fueling Division	Seals, Springs
Barry Controls	APU Isolation Mounts
BASF Corp.	Polyurethane Foam
Cox & Co., Inc.	Heater Lines
Parker Hannifin Corp. - Stratoflex Product Division	Hoses and Fittings; Lift Off QD; Ground Probes
Eldec Corp.	Dedicated Signal Conditioners, Proximity Switch
Endevco Corp.	Low Pass Filter
FMH Corp. - DBA Flexible Metal Hose	Flex Hoses
Florida Seal & Rubber, LLC	Seals
Richards, Gary E	Retainer Bearings
Irvin Aerospace, Inc.	Quick Disconnects
Kirkhill - TA Co.	Seals
Long-Lok Fasteners Corp.	Fasteners
M/A - COM, Inc.	RF Cables
Magellan Aerospace Turbine Services	SSME Interface Seals
Pacific Scientific Co.	Piece Parts – MADS

Company	Material/part/service
Parker Hannifin Corp. - Parker Stratoflex Division	Fluid Disconnects
RBC Transport Dynamics Corp.	Bearing Housings
RDF Corp.	Temperature Transducers
Saint Gobain Performance Plastics Corp. - High Performance Seals Division	Seals
Saint Gobain Performance Plastics Corp. - Coated Fabrics Division	Various Materials
Dover Diversified, Inc. - DBA Sargent Controls & Aerospace	Shell Assembly (Salad Bowl)
Senior Operations, Inc. - DBA Ketema Aerospace	MPS Feed Lines/Gimble Joints/ Re-circulation Manifold, GN2 Isolation Valve
Smiths Tubular Systems - Laconia, Inc.	Pressure Equalization Check Valves
Stillman Seal Corp.	Window Seals
Wyle Laboratories	Connectors
Teledyne Wireless, Inc.	S-Band Switch Assembly
Senior Operations, Inc.	Bellows Assembly for Class I GSE
Wintec, LLC	Filters
Cerac, Inc.	Tetraboron Silicide
Momentive Performance Materials, Inc.	RTVs (Room Temperature Vulcanization Adhesives), Adhesives
Tayco Engineering, Inc.	Sensor, Heater (Thermocouple)
BAE Systems Information & Electronic Systems Integration, Inc.	Multiplexer Interface Adapters, S-MIA, D-MIA
The Boeing Co. - Integrated Defense Systems - NASA Systems Division	Coldplates
PTI Technologies, Inc.	Check Valve and Filter
Lockheed Martin Corp. - Lockheed Martin Missiles and Fire Control	RCC, LESS, RFCA (Used in the Thermal Protection System)
Arkwin Industries, Inc.	Hydraulic 3-Way Valves, Hydraulic Control Valve & Bootstrap Reservoir
Curtiss-Wright Controls, Inc.	Actuators
Eaton Corp,	Valves
Goodrich Corp.	MLG-NLG Landing Gear Production and Storage for Special Tooling/Special Test Equipment
Honeywell International, Inc. - Torrance, CA	Actuators
Honeywell International, Inc. - Clearwater, FL	Controllers
Honeywell International, Inc. - Glendale, AZ	Enhanced Multiplexer/De-multiplexer, Multifunction Electronic Display System
Honeywell International, Inc. - Tucson, AZ	Air Data Transducer Assembly, Annunciator Control Unit
Kearfott Guidance and Navigation Corp.	Inertial Measurement Units (IMU)

Company	Material/part/service
L3 Communications Corp.	Frequency Division Multiplexer (FDM)
Lockheed Martin Corp. - System Integration	General Purpose Computer, Multi-function CRT Display System
Lockheed Martin Corp. - Space Systems Company	Pyrotechnic Initiator Controller
Moog, Inc.	Hydraulic Actuators / Power Valve Assembly
Moog, Inc.	Thrust Vector Control Fuel Isolation Valve
Northrop Grumman Systems Corp.	Master Timer Unit
Eaton Corp. - Fluid Conveyance Systems	2-3 Way Valves
Rockwell Collins, Inc.	TACAN, GPS, DDU, HIS (Used for Guidance, Navigation and/or Control)
SEAKR Engineering, Inc.	Modular Memory Unit
Tavis Corp.	Flowmeter
Telair International	Actuators
Telephonics Corp.	Microwave Scan Beam Landing System Decoders, Transmitters, Antenna, RF Assemblies
The Boeing Co. - C3 Networks Division	Advanced Master Events Controller, Enhanced Master Events Controller
UTC Power Corp.	Fuel Cells
Vacco Industries	Filters, Valves, Regulators, Disconnects
Hamilton Sundstrand Management Services, Inc.	Waste Collection System
Smiths Aerospace, LLC	Device Drive Unit (DDU)
Aerodyne Controls, Inc.	Shut Off Valves
Ellanef Manufacturing Corp.	Vent Door Actuators
Gardner Bellows Corp.	Hypergolic & Power Reactant Storage and Distribution Bellow Assembly for Quick Disconnects
Goodrich Corp. - Aerospace Division (Aircraft Wheels and Brakes)	MLG Wheels & Brakes
Goodrich Corp. - Aerospace Flight Systems Division (Optical and Space Systems)	Storage of Miscellaneous Parts
Degussa Corp.	Dimethylethoxysilane (DMES)
Reusable Solid Rocket Motor	
Kayco Composites	Foam Billets
Standard Tool & Die Co. (STADCO)	Case Nozzle Hardware
Krayden, Inc.	Permabond, Sealing Compound, & Molykote 321
SPS Technologies, Inc.	Igniter Fasteners
Glenair, Inc.	Cables
Irvin Aerospace, Inc.	Heater Retainer Straps
Dodge-Regupol, Inc.	Cork (External)

Company	Material/part/service
Unitech Composites, Inc.	Railcar, End Grain, and Nozzle Shipping Covers
Aceto Corp.	MAPO (Inhibitor Curative)
Noveon, Inc.	HC Polymer
Votaw Precision Technologies, Inc.	Nozzle Hardware
Cytec Engineered Materials, Inc.	Glass, Carbon, Silica Cloth
Cytec Engineered Materials, Inc.	Glass, Carbon, Silica Cloth
Highland Industries	Rayon Fabric Weaver (Nozzle)
Alcoa, Inc.	Aluminum Powder
American Pacific Corp.	Ammonium Perchlorate
American Synthetic Rubber Corp. (ASRC)	HB Polymer
Dow Chemical	Liquid Epoxy Resin
Hitco Carbon Composites, Inc.	Carbon Fiber-filled EPDM
Kirkhill - TA Company	EPDM Rubber/NBR
MS Aerospace, Inc.	Nozzle Fasteners
Stellar Technology, Inc.	Igniter
3M Co.	Witness Pad Adhesives
Borden Chemicals Co.	Phenolic Resin (Nozzle)
Dow Corning Corp.	RTV's & Primers
Momentive Performance Materials, Inc.	RTV's & Primers
Loctite Aerospace	Adhesives, Epoxy
Parker Hannifin Corp. - O-Ring Division	Igniter Gaskets
Parker Hannifin Corp. - O-Ring Division	O-Ring, Performed Packing, Gaskets
Resin Technology Group, LLC	Ablation Compound
SGL Polycarbon - USA	Carbonization of cloth
Tayco Engineering, Inc.	Heaters, Sensor Cables
Vacco Industries	Safe & Arm Devices
Solid Rocket Booster	
L3 Communications Corp. - Space and Navigation Division	Integrated Electronic Assembly (IEA), SRB Range Safety Distributor, Command Receiver Decoder, Attitude Switch Assembly
Honeywell International, Inc.	Enhanced Multiplexer/De-multiplexer, Multiplexer/De-multiplexer
Moog, Inc.	Servoactuator
Hamilton Sundstrand Corp.	Auxiliary Power Unit
Aerojet General Corp. - Propulsion Division	Gas Generator
Marotta Controls, Inc.	Gas Generator Valve Module
Parker Hannifin Corp. - Hydraulic Systems Division	Hydraulic Pump
Pacific Scientific Energetic Materials Co.	Frangible Nut, Separation Nuts, Separation Bolts

Company	Material/part/service
Goodrich Corp. - Universal Propulsion Co., Inc. (UPCO)	Linear Shaped Charges (LSC), Nose Cap Thrusters, Pressure Cartridges, Confined Detonating Fuse Manifold, Range Safety System LSC, Frustum LSC
General Products, LLC	ET Bolt Catchers, Struts, ETA Rings, Spherical Washers
Aerocraft Industries, Inc.	ET Strut Cover & Fairing Assembly, Zinc Anodes
C & M Machine Holding, Inc.	Tunnel Floor Components
Consolidated Hinge & Manufactured Products, Inc. - DBA The Champ Co.	Aeroheat Shield
Eaton Aerospace	K & E Seals
Herley Industries, Inc.	C-Band Antenna/Power Divider/Transponder
LaBarge, Inc.	Range Safety Antenna
Oceaneering International, Inc. - DBA Oceaneering Space Systems - Space and Thermal Division	Thermal Curtains
Parker Hannifin Corp. - Stratoflex Product Division	Dynatube Fittings
Parker Hannifin Corp. - O-Ring Division	Forward Skirt Door Seal, Gaskets
Pneudraulics, Inc.	Fluid Manifolds
PRC-DeSoto CDP, Inc.	PR 855, Sealant 1422
3M Co.	Epoxy Resin (2216)
AMORIM Industrial Solutions, Inc.	P-50 Sheet Cork
Cabot Corp. - Cab-O-Sil Division	Cab-o-Sil, Fumed Silicon Dioxide
Lord Corp.	Primer, Adhesive
Conax Florida Corp.	Sea Water Activated Release (SWAR) (parachute line cutting system), SWAR batteries
E/M Coating Services	Dry Film Lube
Loctite Aerospace	Hysol EA 934 NA (Epoxy Paste Adhesive), Thixotropic Epoxy Adhesive
Maryland Cork Co., Inc.	Granular Cork
Richmond Technology Solutions (RTSI)	RCAS 2400 (Anti-static Packaging Material)
Rust-Oleum Corp.	Top Coat, Primer
LaBarge, Inc.	Cables
Wyle Laboratories, Inc.	Instrumented Hold-down Studs
Air Products & Chemicals, Inc.	K54 Hardener
Everlube Products	LubeLok 1000X
Deft, Inc.	Primer
Dow Corning Corp.	6077 Foam, RTV, DC 1200
Dow Chemical	Instafoam
EMF, Inc - Engravers Metal Fabricators	EPDM Covers
Momentive Performance Materials, Inc.	Adhesive (RTV 133)
Henkel Corp.	Alodine Coatings
Hentzen Coatings, Inc.	Epoxy Primer

Company	Material/part/service
Summa Technology, Inc.	SRB Nose Caps
National Starch and Chemical Co., Emerson & Cuming - Specialty Polymers Division	Glass Ecospheres
Puroflow Corp.	Auxiliary Power Unit Flush & Purge Filter
Pro Battery, Inc.	CBC Batteries
Kirkhill - TA Co.	EPDM
Resin Technology Group, LLC	RT-455
Hexion Specialty Chemicals, Inc.	EPON-828
Gaco Western, Inc.	Hypalon Paint
BST Systems, Inc.	Operational Flight Instrumentation Battery
Space Shuttle Main Engines	
Valley Metals	Tubing Raw Materials
Morgan Advanced Ceramics, Inc. - DBA Wesgo Div.	Precious Metal Braze Alloys
Precision Tube Bending	Tube Bending
Schlosser Forge Co.	Liner - Main Combustion Chamber (MCC), Forging Inlet Manifold Splitter
Hi Temp Insulation, Inc.	Insulation Nozzle Thermal
Le Fiell Manufacturing Co.	Heat Exchange Coil Assembly, Nozzle Coolant Tubes, Nozzle Steerhorn Tubes
Thermal Vac, Inc.	Nickel Plating of Nozzle Tubes
Arcturus Manufacturing Corp.	Forging Jacket MCC, Forging Inducer Low Pressure Fuel Turbopump (LPFTP)
Industrial Tectonics Bearing (ITB) Corp. - (Subsidiary of Roller Bearing Co.)	Stainless Steel Bearings
Magellan Aerospace Turbine Services, LLC	Seals for Pumps
Hoefner Corp.	Machining of Valves
Size Control Plating Co.	Chrome Plating
Precision Castparts Corp. (PCC)	MCC AFT Manifold; FWD Manifold
PCC Airfoils, LLC	Small Castings
Eaton Aerospace, LLC - Aerospace Controls Division - Sensing & Controls	Pressure Sensor
G & N Rubicon Gear, Inc.	Machine Splines
Hemphill Spring Co. A Corp.	Spring, Anti-Flood Valve
Winsted Precision Ball Corp.	Balls for Bearings (Metal & SiN3)
Metal Surfaces Inc. (MSI)	Precious Metal and Nickel Plating
Metalex Manufacturing, Inc.	Complex Machine Parts, Housings
The Balancing Co., Inc.	Balance Components
G & D Industries, Inc.	Protective Covers, Closers, Caps

Company	Material/part/service
Circlemaster, Inc.	Roll Nozzle Hatbands
GKN Aerospace Chem-Tronics, Inc.	Nozzle Jacket
Coast Plating, Inc.	Hard Anodize of Low Pressure Oxidizer Turbopump (LPOTP) Housing
Dell Aerospace, Inc.	Burst Diaphragms for Valves
Dixon Hard Chrome, Inc.	Chrome Plating
JPM of Mississippi, Inc.	Machining of Bearing Cages
FPI, Inc.	Seals, HPTP Turbine Inlet Bellows
FAG/Aircraft Super Precision Bearings	Silicon Nitride Bearings
Honeywell International, Inc.	Block II Controller
Aerospace Techniques, Inc.	Turbine Blade and Vane Fabrication
Howmet Corp. - Hampton Casting Division	Large Castings for Turbopumps
FMH Corp. - DBA Flexible Metal Hose	Bellows Assembly (Lines, Tanks)
Thermtech Corp.	Fluorinated Ethylene-Propylene Coating for Bearing Cages
HR Textron, Inc.	Propellant Valve/Hydraulic Actuator Main Oxidizer Valve Actuator (MOVA), Main Fuel Valve Actuator (MFVA), Preburner Fuel Oxidizer Valve Actuator (FPOVA), Oxidizer Preburner Oxidizer Valve Actuator(OPOVA), Chamber Coolant Valve Actuator(CCVA)
Pratt & Whitney Rocketdyne	HPOTP, HPFTP (High Pressure Oxidizer and Fuel Turbopumps)

Source: NASA.

Appendix III: Comments from the National Aeronautics and Space Administration

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

July 17, 2007

Ms. Cristina T. Chaplain
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
Washington, DC 20548

Dear Ms. Chaplain:

NASA appreciates the opportunity to comment on your draft report entitled "NASA Supplier Base: Challenges Exist in Transitioning from the Space Shuttle Program to the Next Generation of Human Space Flight Systems" (GAO-07-940).

In the draft report, GAO makes one recommendation to the NASA Administrator:

Recommendation: Given the fact that many of NASA's transition and retirement activities will continue to occur following the shuttle retirement in 2010, it is important that NASA identify and estimate the costs associated with these activities in an accountable and transparent manner. Therefore, we are recommending that the NASA Administrator direct the Exploration Systems Mission Directorate and the Space Operations Mission Directorate to jointly develop cost estimates for transition and retirement activities beyond fiscal year 2010 so that, in NASA's fiscal year 2009 budget submission, NASA can include transition and retirement funding needs for the required out years through fiscal year 2013. We expect these estimates to be adjusted every year and have more fidelity as NASA gains more knowledge and makes more decisions.

Response: NASA concurs with the recommendation. We agree that it is important that NASA identify and estimate the costs associated with NASA's transition and retirement activities, that estimates are required for activities beyond FY 2010, and that these estimates will probably be adjusted in future years and have more fidelity as NASA gains more knowledge and makes more decisions. The Exploration Systems Mission Directorate and the Space Operations Mission Directorate are jointly developing cost estimates for transition and requirements as part of the 2009 NASA Planning, Programming, Budgeting, and Execution cycle. NASA management will work with the Office of Management and Budget to determine the appropriate timing for including transition and retirement costs in the President's Budget Proposal.

Thank you for the opportunity to review and comment on this draft report and for the insight it provides. If you have any question, please contact Mr. Joel Kearns at (202) 358-1223 or Dr. John Olson at (202) 358-3626.

Sincerely,

Shana Dale
Deputy Administrator

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Cristina T. Chaplain, (202) 512-4841 or ChaplainC@gao.gov

Acknowledgments

In addition to the contact named above, James L. Morrison, Assistant Director; Lily Chin; Hillary Loeffler; Jeffrey Niblack; Shelby S. Oakley; Sylvia Schatz; and John P.K. Ting made key contributions to this report.

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