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AUDIT REPORT

OFFICE OF AUDITS

REVIEW OF NASA'S PROGRESS ON RETIRING THE SPACE SHUTTLE PROGRAM

OFFICE OF INSPECTOR GENERAL



National Aeronautics and
Space Administration

Final report released by:

/signed/
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Inspector General

Acronyms

AMS	Alpha Magnetic Spectrometer
FY	Fiscal Year
GAO	Government Accountability Office
ISS	International Space Station
JICB	Joint Integration Control Board
NPR	NASA Procedural Requirements
NSTS	National Space Transportation System
OIG	Office of Inspector General
STS	Space Transportation System
T&R	Transition and Retirement
TCB	Transition Control Board
ULF	Utilization Logistics Flight

OVERVIEW

REVIEW OF NASA'S PROGRESS ON RETIRING THE SPACE SHUTTLE PROGRAM

The Issue

In January 2004, the “Vision for U.S. Space Exploration” established a new direction for the Nation’s space program. As part of the Vision, the President directed NASA to use the Space Shuttle primarily to complete construction and outfitting of the International Space Station (ISS) before retiring the Shuttle by the end of 2010. A key challenge for NASA in achieving this objective is maintaining the capabilities required to fly the Space Shuttle safely while transitioning real and personal property, critical skills, and related capabilities to support other NASA priorities, including the next generation of human space flight systems.

The objective of our audit was to evaluate NASA’s plans for completing the remaining Space Shuttle flights to support the ISS and retiring the Shuttle Program. To answer our objective, we analyzed the Space Shuttle flight rates and schedules to determine whether the planned manifest appears reasonable and achievable. In addition, we reviewed NASA’s plans for transition and retirement (T&R) activities after the Shuttle Program’s retirement. Details of the audit’s scope and methodology are in Appendix A.

Results

Since early 2004, NASA has maintained Space Shuttle flight manifests designed to sustain and complete construction of the ISS and retire the Shuttle Program by September 30, 2010. NASA has made steady progress in completing the scheduled flights and is working on a timetable to launch the remaining four flights and retire the Program by September 2010. However, our calculations and Agency internal reviews indicate that it will most likely take NASA until early 2011 to complete the last of the four remaining flights. Nevertheless, NASA continues working toward the September 2010 Shuttle retirement date because it could potentially provide the Agency the opportunity to redirect millions of dollars toward other priority programs by limiting the need to fund Shuttle operations at \$200 million a month in fiscal year (FY) 2011.

Further, while NASA has developed clear plans for managing the Shuttle Program’s T&R activities through FY 2010, it has not finalized the organization and governance structure for T&R activities in FY 2011 and beyond.

Completing the Remaining Shuttle Flights by the End of FY 2010 Is Unlikely.

NASA continues to fund and plan for completion of the four remaining Space Shuttle flights by September 30, 2010. According to Shuttle Program managers, the Agency chose to keep this schedule and not plan for flights in FY 2011 because the September 2010 date is still manageable. Since that time, the President's FY 2011 budget request was released and it includes an additional \$600 million to support the Shuttle Program through December 2010.

Based on calculations by the Office of Inspector General, historical flight rates, and internal NASA evaluations, NASA is not likely to meet its September 2010 timetable, and it will most likely take until the second quarter of FY 2011 to complete the last of the planned Space Shuttle flights. For example, a Shuttle Program analysis of flight rates concluded that the estimated completion date for the last of the eight flights remaining as of June 2009 would be between November 2010 and March 2011, with February 2011 as the most realistic estimate. In addition, a September 2009 analysis of launch probabilities conducted by a consultant for the Space Operations Mission Directorate found that the probability for completing the six Shuttle flights remaining at that time by September 30, 2010, ranged from 5 percent to 15 percent. The same analysis found that the probability of completing those flights by the end of December 2010 ranged from 70 percent to 85 percent.

Our calculations show that the chance of completing the remaining flights by the end of FY 2010 is improving. Specifically, with eight flights remaining our analysis concluded that the final Shuttle flight would likely launch in June 2011. However, given that the last four Shuttle flights all launched within the schedule margins, our analysis now predicts that the last of the four remaining Shuttle flights will launch in January 2011.

According to Shuttle Program managers, their philosophy is to manage and work toward accomplishing the demanding launch schedule until the remaining schedule margin for accommodating launch delays is depleted. The managers estimate that accomplishing the work required to complete the remaining Space Shuttle flights by September 2010 will require up to \$54 million in personnel overtime costs. However, they also estimate that the Agency will have to spend about \$200 million for Shuttle Program operations for every month that they need to sustain Shuttle operations in FY 2011. Although the managers are holding to the end-of-FY 2010 retirement date and expect to expend up to \$54 million in overtime costs, they recognize that they may still have to extend Shuttle operations into FY 2011 to complete the schedule due to uncontrollable events. Nevertheless, the managers stated that setting September 2010 as a goal can reduce the amount of time that they will need to sustain Shuttle operations in FY 2011 and potentially provide the Agency the opportunity to redirect millions of dollars toward other priority programs by limiting the need to continue Shuttle operations at \$200 million a month.

NASA Has Not Finalized Post-2010 Transition and Retirement Plans. NASA and the Shuttle Program have clearly defined plans and an organization and governance structure for T&R activities through FY 2010. However, the Agency decided to delay finalizing

plans for T&R activities in FY 2011 and beyond in order to concentrate on completing the remaining Space Shuttle flights by September 2010. Space Operations Mission Directorate management stated that this decision allowed the Shuttle Program's workforce to focus on the launch schedule and the existing T&R organization structure without being distracted by a "parallel" organization that Shuttle Program managers thought would distract the workforce and potentially affect flight safety.

Although NASA senior management has not finalized the post-2010 plans, NASA expects to implement a two-phase approach for the Shuttle Program's retirement. Phase I (FY 2011 and FY 2012) will focus on asset "end-state development," which is technical work to provide the asset in the required condition for disposal. Phase II (FY 2013 through FY 2020) will focus on contract closeouts and any remaining asset disposal. As of March 2010, the organization and governance structure for executing T&R post-FY 2010 was still under development, and the exact organizational responsibility for disposition of Program property after the last Space Shuttle mission had not yet been determined. Finalizing these matters prior to completion of the Space Shuttle Program is critical given the Program's scope and the Agency's estimate that T&R activities for FY 2011 through FY 2015 will cost \$460 million.

Management Action

We made no recommendations concerning NASA's plans to maintain the current Space Shuttle launch schedule given the Agency's goal of attempting to minimize operating costs for the Shuttle in FY 2011.

With respect to T&R activities, we recommended that the Associate Administrator for Space Operations finalize the post-FY 2010 organization structure and plans for T&R activities by July 31, 2010, to facilitate effective implementation of the full scope of T&R activities after the last Space Shuttle flight.

In response to our March 12, 2010, draft of this report, the Associate Administrator for Space Operations concurred with our recommendation and stated that NASA is committed to the effective management of Shuttle T&R activities. The Space Shuttle Transition Manager prepared a draft proposal that establishes roles, responsibilities, and interfaces; describes the management approach and organization structure; and proposes personnel required to manage the final phases of Space Shuttle Program asset dispositions. The Transition Manager expects to obtain approval from the Transition Control Board in April 2010 and finalize the plan by July 31, 2010. The estimated completion date is September 1, 2010. See Appendix B for the full text of management's comments.

We consider the Associate Administrator's proposed actions to be responsive. The recommendation is resolved and will be closed upon completion and verification of management's corrective actions.

CONTENTS

INTRODUCTION

Background _____	1
Objective _____	3

RESULTS

Finding A: Completing the Remaining Shuttle Flights by the End of FY 2010 Is Unlikely _____	4
Finding B: NASA Needs to Finalize Shuttle Post-2010 Transition and Retirement Plans _____	12

APPENDIX A

Scope and Methodology _____	17
Review of Internal Controls _____	19
Prior Coverage _____	19

APPENDIX B

Management Comments _____	20
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APPENDIX C

Report Distribution _____	21
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INTRODUCTION

Background

The President's "Vision for U.S. Space Exploration," announced in January 2004, established a new direction for the Nation's space program. As part of the Vision, President Bush directed NASA to use the Space Shuttle primarily to complete construction of the International Space Station (ISS) and then retire the Shuttle by 2010. In addition to the President's announcement, in 2005 Congress directed the NASA Administrator to develop a plan describing how NASA would implement the President's Vision.¹ NASA's Plan addressed how it would ensure that the Space Shuttle operates safely through its last flight; the planned number of flights before its retirement; other means that may be used to ferry crew and cargo to and from the ISS; the intended purpose of lunar missions; and the extent to which the new Crew Exploration Vehicle would allow for emergency crew escape. Subsequently in 2008, Congress mandated that NASA add two utilization logistics flights (ULFs)² to the schedule (designated as ULF4 and ULF5) and take all steps necessary to schedule a third flight (designated as ULF6) prior to retiring the Shuttle in 2010. On February 1, 2010, the President released the proposed fiscal year (FY) 2011 budget for NASA. The proposed budget provides \$600 million to complete the remaining Space Shuttle flights even if the schedule slips into FY 2011. The budget also supports extension of the ISS until at least 2020.

The Space Shuttle Program comprises four major projects³ and more than 1.2 million pieces of hardware and equipment. The Space Shuttle is the only U.S. human-rated space transportation system. NASA's Space Operations Mission Directorate is responsible for the safe and effective operation of the Space Shuttle; the lead manager for the Shuttle Program is located at Johnson Space Center. The Program employs more than 2,000 civil service and 15,000 contractor personnel, with the majority of the civil service workforce located at Johnson, Kennedy Space Center, and Marshall Space Flight Center.

NASA began dismantling the Shuttle Program during FY 2009, and prime contractors for the Space Shuttle began staff reductions in February 2009. Over the past year, contractors have closed down Shuttle production lines, hardware testing operations, and workstations.

¹ Pursuant to the Authorization Act of 2005, NASA provided Congress with the "Human Space Flight Transition Plan," July 2006.

² ULFs are Shuttle flights dedicated to delivering spare parts and supplies to the ISS.

³ The four projects are the Orbiter, the Space Shuttle Main Engine, the Reusable Solid Rocket Booster, and the External Tank.

As of March 2010, four Space Shuttle flights are planned between April and September 2010. The flights will complete the construction of the ISS and provide supplies for ISS's sustainment through 2015. Upon completion of those flights, NASA will transition and retire the Shuttle Program.

The ISS Program is an international partnership of the United States, Russia, Canada, Japan, and the members of the European Space Agency.⁴ Completion of the ISS is dependent on the Space Shuttle's ability to provide the required assembly hardware, spare parts, and supplies necessary for the ISS to operate through at least 2015. Consequently, completion of the ISS is contingent on the remaining four planned Shuttle flights: one assembly flight and three ULFs. The remaining assembly flight is scheduled to deliver hardware, science payloads, an ammonia tank assembly, and a multi-purpose logistics module. The three ULFs will deliver three carriers containing spare parts such as a radiator,⁵ science experiments, the Russian Mini-Research Module, an integrated cargo carrier, the Alpha Magnetic Spectrometer (AMS),⁶ and a permanent logistics module for supply storage.

Previous Audit Work on Transition and Retirement. The NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have previously examined NASA's planning for Space Shuttle Program transition and retirement (T&R) activities. In a 2007 report,⁷ we found that NASA's transition plans did not comprehensively address certain elements that we believed were essential to management and oversight of an activity of the transition's scope and importance.

We made four recommendations in our 2007 report intended to ensure that NASA developed the necessary framework, processes, and supporting infrastructure to manage and oversee the transition. Among them were recommendations that the Agency develop guidance within the NASA Procedural Requirements (NPR) 7120 series that clearly defines and establishes requirements for managing closeout and transition for programs of the Space Shuttle Program's magnitude, revise the Human Space Flight Transition Plan to comply with applicable project management guidelines, and finalize and implement the Plan. NASA management took appropriate action to address all of the recommendations and, in August 2008, addressed transition planning through 2010 and established a structure for decision making to develop post-2010 T&R activities.

⁴ European Space Agency members include Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

⁵ The radiator is a major sub-assembly of the ISS Heat Rejection Subsystem and consists of two radiator wings containing three radiators each. The radiator rejects heat from the ISS ammonia loop, and the panels cool the warm ammonia via radiant interchange with space. The radiator's size and mass is such that the Space Shuttle is the only vehicle that can deliver it to the ISS.

⁶ While the AMS is not necessary for completing and supporting the ISS, the NASA Authorization Act of 2008 requires the Administrator to take all necessary steps to make one additional Space Shuttle flight to deliver the AMS to the ISS prior to retiring the Space Shuttle.

⁷ NASA OIG, "NASA's Plans for Space Shuttle Transition Could Be Improved by Following Project Management Guidelines" (IG-07-005, January 29, 2007).

A 2007 GAO report⁸ found that while NASA had developed plans and processes aimed at managing parts suppliers, several factors could impact NASA's ability to effectively implement those plans and processes. GAO recommended that NASA develop cost estimates for T&R activities post-2010 so that NASA could request the necessary funding in FY 2011 and beyond. In a 2008 report,⁹ GAO stated that NASA faced challenges in defining the scope and cost of Shuttle Program T&R activities. GAO recommended that NASA clearly identify all direct and indirect Shuttle Program T&R costs, noting that the Agency did not know what Program property it needed to retain or the full cost of the transition effort. In addition, GAO found that the Agency had not developed final plans and cost estimates for protecting Space Shuttle artifacts and making them available for public display.

Objective

The audit's overall objective was to evaluate the status of NASA's efforts to complete the remaining Space Shuttle flights to support the ISS and retire the Shuttle Program. See Appendix A for details of the audit's scope and methodology, our review of internal controls, and a list of prior audit coverage.

⁸ GAO, "NASA Supplier Base: Challenges Exist in Transitioning from the Space Shuttle Program to the Next Generation of Human Space Flight Systems" (GAO-07-940, July 25, 2007).

⁹ GAO, "NASA: Agency Faces Challenges Defining Scope and Costs of Space Shuttle Transition and Retirement" (GAO-08-1096, September 30, 2008).

FINDING A: COMPLETING THE REMAINING SHUTTLE FLIGHTS BY THE END OF FY 2010 IS UNLIKELY

Since the President announced his “Vision for U.S. Space Exploration” in January 2004, NASA has planned a Space Shuttle flight manifest designed to complete the ISS, support its sustainment, and retire the Shuttle Program by September 30, 2010. NASA has made steady progress in achieving these objectives, and only four Shuttle flights remained as of March 2010. However, both internal and external analyses indicate that NASA will not complete its final planned Shuttle flight until the second quarter of FY 2011. NASA continues working toward the September 2010 retirement date because it could potentially provide the Agency the opportunity to redirect millions of dollars toward other priority programs by limiting the need to continue Shuttle operations at \$200 million a month in FY 2011.

Presidential and Congressional Mandates

Since 2004, the President and Congress have directed NASA to take a series of actions leading up to the cessation of the Space Shuttle Program. A summary of these directives follows.

President’s Vision. As part of his January 2004 “Vision for U.S. Space Exploration,” the President directed NASA to return the Space Shuttle to flight as soon as practical after the 2003 Columbia Shuttle disaster, use the Space Shuttle primarily to complete the ISS, and retire the Shuttle by 2010.

NASA Authorization Act of 2005. The Act directed the NASA Administrator to use Shuttle Program personnel, capabilities, assets, and infrastructure in developing NASA’s future launch vehicles. The Act also required the Administrator to transmit to Congress a plan describing how NASA would proceed with its future human space flight programs and the retirement of the Shuttle Program. The plan was to include the projected number of flights the Space Shuttle would make before retirement and how NASA would deploy Shuttle Program resources to ensure that the Space Shuttle operates as safely as possible through its final flight. In addition, the Act required that the Administrator ensure that the ISS had sufficient on-orbit capabilities to sustain it through periods when the Space Shuttle or the next generation of space vehicles were unavailable.

NASA Authorization Act of 2008. This Act mandated that NASA add two additional Space Shuttle flights to its planned flight schedule. The Act also required the Administrator to take all steps necessary to make an additional Space Shuttle flight to

deliver the Alpha Magnetic Spectrometer (AMS) to the ISS prior to the Shuttle Program’s retirement.

If NASA determines that it will be unable to launch the AMS flight before the end of December 2010, or that the flight would result in significantly increased costs or unacceptable safety risks, the Act requires the Administrator to notify Congress and remove the AMS flight from the schedule. After such notification, however, Congress or the President may reauthorize the AMS flight by certifying that it is in the national interest. AMS flight (STS-134) is currently scheduled to launch on July 29, 2010.

President’s Proposed FY 2011 Budget. On February 1, 2010, the President released the FY 2011 proposed budget for NASA. The budget requests \$600 million to complete the remaining Space Shuttle flights if flights are delayed into FY 2011. The budget also supports extension of the ISS to at least 2020 and cancels the Constellation Program, which was NASA’s next generation human space flight program.

NASA and OIG Analyses Suggest That Completing the Space Shuttle Flight Schedule Will Take Until Early 2011

NASA is working toward a September 30, 2010, completion date for the remaining four Shuttle flights. However, historical flight rates and flight constraints suggest that NASA will not complete its planned flights until the second quarter of FY 2011 at the earliest, as shown in Table 1.

Table 1. Projected Date of Final Space Shuttle Launch	
Basis of Projection	Date
Historical Flight Rates	February 2011
Manifest Assessment Simulation Tool	March 2011*
NASA OIG Analysis	January 2011

* Source: September 2009 calculations by the NASA consultant.

Historical Flight Rate. In June 2009, NASA was planning to launch eight Space Shuttle missions over a 15-month period (June 2009 through September 2010). For the purpose of comparison, Shuttle Program managers evaluated historical flight rates for two other similar time periods. From June 2006 through November 2007, eight planned Shuttle launches took 20 months to complete. From June 2007 through October 2008, seven planned launches took 21 months to complete. Based on these rates, Shuttle Program managers estimated that the eight Space Shuttle flights remaining as of June 2009 would

be completed between November 2010 and March 2011, with February 2011 as the most realistic estimate.

Manifest Assessment Simulation Tool. The Space Operations Mission Directorate uses the Manifest Assessment Simulation Tool¹⁰ to provide additional analyses of potential Shuttle flight schedules. The Assessment Tool provides a range of probabilities based on “likely case” and “worst case” scenarios.¹¹ In March 2009, the probability of completing the nine flights remaining on the March 17, 2009, manifest by the end of December 2010 was 78 percent (likely case) and 60 percent (worst case) according to the Assessment Tool. In September 2009, the Assessment Tool calculated the probability of completing the six flights remaining by September 2010, December 2010, or March 2011, as shown in Table 2.

Table 2. Probability Results of the Manifest Assessment Simulation Tool (95 percent confidence interval)		
Completion Date of Final Shuttle Flight	Likely Case	Worst Case
September 2010	15 percent	5 percent
December 2010	85 percent	70 percent
March 2011	95 percent	90 percent

Source: September 2009 calculations by the NASA consultant.

NASA OIG. We estimated that the Shuttle Program will complete its four remaining Space Shuttle flights in January 2011. Our projection is based on the 88-day average for the number of days between Space Shuttle flights launched from July 2006 through February 2010. To complete the flights by NASA’s current target date of September 30, 2010, the Shuttle Program would need to reduce the average number of days between Space Shuttle flights to 55 – 33 days less than NASA’s historical average since July 2006, and 60 days less than the Shuttle Program’s average since the Columbia disaster. The smaller schedule margin between Space Shuttle flights in 2010 leaves little room for launch delays. Any delay will likely affect subsequent flights, and completing the flight manifest by September 30, 2010, becomes correspondingly more unlikely.

However, there is still a chance, although small, of achieving the September 2010 retirement date if the Shuttles continue to launch on time or within the small schedule

¹⁰The Manifest Assessment Simulation Tool provides a quantitative estimate on when Space Shuttle missions are likely to take place based on planned flight dates.

¹¹Likely case and worst case scenarios are distinguished by the probability of negative events occurring. For example, the Space Shuttle landing at Dryden Flight Research Center instead of Kennedy Space Center is considered a negative event, as it would add 10 days to the ground processing time required to prepare the Shuttle for its next flight. The probability of this event in a likely case scenario is 1 in 9; its probability in a worst case scenario is 1 in 5.

margins. Our analysis indicates that the probability of meeting the demanding schedule improved by 5 months (from June 2011 to January 2011) when the last four flights launched within their launch window margins. We performed our analysis based on average number of days between Shuttle launches when there were eight flights remaining; seven flights remaining; six flights remaining; five flights remaining; and, finally, four flights remaining. Each time the Shuttle launched within the window margin, the average days between launches decreased and our projection for when the last flight would launch improved.

Table 3 below shows the results of our analysis with eight, seven, six, five, and four flights remaining.

Table 3. NASA OIG Projection for Final Shuttle Flight		
Flights Remaining	Historical Days Between Launches	Projected Last Shuttle Flight
Eight	95	June 2011
Seven	92	April 2011
Six	89	February 2011
Five	88	January 2011
Four	88	January 2011

Factors Affecting the Space Shuttle Launch Schedule

Additional factors in maintaining the flight schedule include how long one launch can be delayed without impacting the next launch (schedule margin), how long it takes to prepare a Shuttle between flights (ground processing margin), and launch windows.

Schedule Margin. The schedule margin between flights is the length of time the Shuttle Program can delay a launch before causing a delay in the next scheduled Space Shuttle flight. With every launch delay, the schedule margins become smaller. Based on the March 2010 launch schedule, the margins between subsequent launch windows ranged from zero to 3 weeks for the four remaining flights (see Table 4). For example, STS-131 has no schedule margin, and any delay in its planned April 5, 2010, launch would cause a delay for the next launch (STS-132, scheduled for May 14, 2010). Similarly, a delay longer than 3 weeks by STS-132 would require recalculation of the launch schedule for at least one of the remaining Shuttle flights into FY 2011.

Table 4. Space Shuttle Launch Schedule as of March 2010			
Designation	Assigned Shuttle	Launch Date	Schedule Margin*
STS-131	Discovery	April 5, 2010	0 weeks
STS-132/ULF4	Atlantis	May 14, 2010	3 weeks
STS-134/ULF6	Endeavour	July 29, 2010	2 weeks
STS-133/ULF5	Discovery	September 16, 2010	

*Length of time the Space Shuttle Program can delay a launch before causing a delay in the next scheduled flight.

Source: Space Shuttle Program planning documents as of June 2009 and March 2010.

Ground Processing Margin. The ground processing margin is the time it takes to ready a Space Shuttle for its next flight. In addition to the small schedule margins between flights, the Shuttle Program must also manage the margin for ground processing between flights of the same Space Shuttle. During 2009, the Program's schedules allowed for delays of up to 4 weeks. For example, Space Shuttle Discovery was scheduled for flights in August 2009 and March 2010. When the August Discovery launch was delayed by 3 weeks, the Shuttle Program still had 1 week of ground processing margin to prepare Discovery for its March launch, which has subsequently been delayed to April 5, 2010. As a result, there is no ground margin between the remaining two flights for Discovery (April 5 and September 16), so a delay of Discovery's April 5, 2010, launch would result in Discovery's planned September 16 launch slipping into FY 2011.

Launch Windows. The best possible time to launch the Space Shuttle, known as the launch window, is dependent on a number of constraints, such as Solar Beta Angle,¹² launch pad availability, weather conditions, and the presence of other space vehicles at the ISS (such as the Russian Soyuz or Japanese H-II Transfer Vehicle).

NASA's current position that the four remaining Space Shuttle launches could be completed by September 30, 2010, was partly based on an increase in FY 2010 of the number of available flight days, or launch opportunities. Table 5 shows the planned available flight days by fiscal year as of June 2009.

¹²The Shuttle cannot be docked to the ISS during Solar Beta Angle, a recurring condition that happens when the angle between the ISS orbit and the Sun produces unacceptably high temperatures.

Table 5. Planned Number of Available Space Shuttle Flight Days (by fiscal year)	
Fiscal Year	Number of Available Days
2006	92
2007	215
2008	196
2009	180
2010	265

Source: Space Shuttle Program planning documents, June 2009.

As shown in Table 5, NASA was planning on a significant increase in launch opportunities in FY 2010 (85 more days than in FY 2009) and planned the four remaining Shuttle launches in FY 2010 accordingly. The planned increase in launch opportunities for the Space Shuttle resulted from a projected reduction in the number of Russian Soyuz flights to the ISS. However, that reduction did not occur as projected. Consequently, NASA expects that the number of available flight days for the Space Shuttle in FY 2010 will be about the same as FY 2009, further limiting the available launch windows and reducing margins.

Management Decision to Maintain the Current Schedule

To date, NASA managers are still working on a timetable that has the final Space Shuttle mission taking place in September 2010. Shuttle Program management calculates the time it takes to ready the Shuttle for flight using no margin for processing and then schedules the Shuttle for launch in the next available launch window. By so doing, schedule margin is inevitably established by the time between the planned end of processing and the launch window. Although the internal and external analyses conclude that NASA will not meet this timetable, there is still a chance to obtain the September 2010 retirement date if the Space Shuttles launch on time or within the small margins. The last four Shuttles launched within the allowed margins and did not delay subsequent launches, thereby improving NASA's chances to complete the flights on schedule. For example, our original analysis with eight flights remaining showed that the last Shuttle would not launch until June 2011. Because the last four launches occurred within their window margins, our analysis now predicts the last launch date as January 2011. To realize the September 2010 completion date, however, the Shuttle Program will need to continue launching within its very tight schedule margins.

Shuttle Program personnel stated that their schedule management philosophy is to hold to the established retirement date for planning purposes, with the expectation that delays could force flights into FY 2011. Program personnel stated that based on their experience, by managing the Shuttle's launch schedule for completion by September 30, 2010, and not revising it until the schedule margin is depleted, the more realistic

completion date of February 2011 will be met and a final Shuttle flight by December 2010 could well be achieved.

Schedule and ISS Sustainment

In an attempt to preserve the planned September 2010 completion of Space Shuttle flights, the Shuttle Program will spend as much as \$54 million in overtime in FY 2010 to expedite Shuttle processing. The timely completion of the Space Shuttle manifest could potentially provide the Agency the opportunity to redirect millions of dollars toward other priority programs by limiting the need to continue Shuttle operations at \$200 million a month and in addition, help ensure the sustainment of ISS operations through 2015 and beyond.

Overtime Costs to Maintain Schedule. In support of NASA's current Space Shuttle launch schedule, the Agency intends to spend up to \$54 million in personnel overtime costs to facilitate completion of the remaining flights by what all agree is a challenging launch schedule. When we discussed this issue with Shuttle Program personnel, they stated that the \$54 million investment for overtime will help ensure the most expeditious completion of the Space Shuttle flight schedule, even if all launches are not completed by the end of September 2010.

By holding to the end-of-FY 2010 retirement date and spending up to \$54 million in overtime to achieve that goal, Shuttle Program managers expect to complete the scheduled flights months earlier than would be possible if a new flight manifest were created based on a December 2010 retirement date. Because operation costs for the Shuttle Program run about \$200 million a month, completing the remaining flights just 1 week earlier would about equal the Agency's planned overtime investment.

ISS Assembly and Sustainment. The final stages of ISS assembly and sustainment depend on the success of the remaining Space Shuttle flights. Without these flights, the likelihood of the ISS operating as intended through FY 2015 or beyond is significantly reduced. The remaining Shuttle flights are scheduled to deliver internal and external orbital replacement units for the ISS, units that are critical to support a six-person ISS crew and reduce the need for continued maintenance on existing equipment. While the ISS can rely on its international partners' vehicles – such as the Russian Soyuz; Progress, the European Automated Transfer Vehicle; and the Japanese H-II Transfer Vehicle – to deliver spare parts and supplies, only the Space Shuttle is capable of delivering certain larger items to the ISS. One such item is a spare radiator that STS-133 is scheduled to deliver to the ISS in September 2010.

Management Action

In light of the Agency's attempts to reduce operating costs for the Shuttle in FY 2011, we are not making a recommendation that NASA adjust its current Space Shuttle flight manifest.

FINDING B: NASA NEEDS TO FINALIZE SHUTTLE POST-2010 TRANSITION AND RETIREMENT PLANS

NASA had clearly defined plans for Space Shuttle transition and retirement (T&R) activities through FY 2010, but has not finalized the organization and governance structure for T&R activities after FY 2010. Although NASA senior management has yet to finalize the post-2010 plans, NASA managers said they expect to implement a two-phase approach for the Shuttle Program's retirement. Phase I (FY 2011 and FY 2012) will focus on asset "end-state development," which is technical work to provide the asset in the required condition for disposal. Phase II (FY 2013 through FY 2020) will focus on contract closeouts and any remaining asset disposal. NASA deferred finalizing the planning for Shuttle Program T&R activities to concentrate on completing Space Shuttle flights by September 2010, but without finalized plans the Agency lacks the necessary framework, processes, and supporting infrastructure to manage the estimated \$460 million that will be needed for T&R activities beginning in FY 2011.

Management of Space Shuttle Program Retirement

In a 2007 report, the OIG addressed NASA's efforts to plan for and manage the Shuttle Program's T&R activities.¹³ The audit found that the Agency's transition plan did not address critical issues, such as who will manage facilities and property disposition or who will make transition decisions after the planned 2010 retirement. We recommended that NASA establish guidance for managing the transition after 2010 because many of the critical property and equipment dispositions will not occur until 2011. In addition, we reported that to effectively manage and successfully complete the Space Shuttle transition, NASA should define the roles and responsibilities for transition activities after the Shuttle Program ends and its managers no longer provide the lead role in the transition.

NASA management concurred with our finding and agreed to define requirements for a final post-2010 Shuttle transition workforce, management structure, and organization. The transition management plan developed in August 2008 addressed transition planning through 2010 and established a structure for decision making to develop post-2010 T&R activities that involved joint planning with NASA Mission Directorates, Centers, program offices, mission support offices, and associated industry contractors.

¹³NASA OIG, "NASA's Plans for Space Shuttle Transition Could Be Improved by Following Project Management Guidelines" (IG-07-005, January 29, 2007).

Agency Lacks Post-Shuttle Program T&R Organization and Plans

NASA defines Space Shuttle T&R activities as the tasks required to identify all Shuttle Program capabilities and either transfer these capabilities to another program or institution or retire the Shuttle Program's capabilities that are no longer needed. Since our 2007 audit of NASA's transition plans for the Space Shuttle, the Agency has made significant progress in managing the Shuttle's retirement while continuing to operate and fly the Shuttle. The current plans use the Shuttle Program's management structure and decision-making boards for T&R activities, and the Agency relies heavily on Shuttle Program management to budget T&R costs within the Shuttle line item. In addition, the Agency is studying alternatives for the post-Shuttle T&R organization to ensure assets are in the proper condition for disposition. However, as of March 2010, the Agency still did not have a clearly defined organization structure or plans for T&R activities after the Shuttle's planned September 2010 retirement date, even though that date was less than 6 months away.

Pre-Shuttle Retirement Activities. Over the past several years, NASA and Shuttle Program managers began planning for the Program's retirement by implementing a series of transition plans:

- National Space Transportation System 07700, Volume XX, "Space Shuttle Transition and Retirement Requirements," February 28, 2007, establishes the program-level requirements for the Shuttle Program's T&R activities.
- "Space Shuttle Program Transition Management Plan," May 9, 2007, describes the organization structure, management approach, processes, products, and tools to manage the transition and retirement of the Shuttle Program's capabilities. In addition, this plan defines how the Shuttle Program is organizing and managing implementation of its end-of-program T&R and align it with the Human Space Flight Transition Plan.
- "NASA Transition Management Plan," August 2008, provides the strategic foundation for the management and execution of transition efforts. This plan contains the Agency-level goals, objectives, roles, and responsibilities necessary to execute the transition efforts.

In addition to these transition plans, the Agency established a working group and control boards between 2006 and 2009 to help ensure that Shuttle Program T&R activities are implemented effectively. Descriptions of the working group and boards follow.

- The Headquarters Transition Working Group performs cross-functional coordination across Agency organizations contributing to or impacted by the retirement of the Shuttle Program, the transition of assets and capabilities to Constellation, or the disposition and disposal of assets and capabilities.

- The Human Space Flight Transition Control Board (TCB) comprises the Space Operations and Exploration Systems Mission Directorates, the Institutions and Management Office, the Safety and Mission Assurance Office, and the Office of the Chief Engineer. The TCB coordinates transition planning, as well as reviews and approves Shuttle Program, ISS, and Constellation Program plans and decisions concerning Shuttle Program resources and how assets are to be transitioned. The TCB charter expires September 30, 2010.
- The Joint Integration Control Board (JICB) provides integrated strategic direction and decision making; determines integrated priorities and risk mitigation strategies; defines budgets, schedules, and Agency-level human space flight development and operation requirements; serves as the Directorate-level inter-organizational forum; and ensures that lessons learned are transferred into the Constellation Program's development and operations. The JICB charter also expires September 30, 2010.
- The Infrastructure Transition Control Board, chaired by the Assistant Administrator, Office of Infrastructure, has authority to institute infrastructure transition policies and procedures, evaluate progress, and direct actions necessary to achieve the Agency's transition goals. The charter for the Infrastructure Transition Control Board expires September 30, 2012.

Shuttle Program managers also said they have made progress on pre-FY 2011 T&R activities through the following:

- Creating a Strategic Capability Assessment database that categorizes Shuttle Program assets and defines capability requirements through the end of the program. The capability assessment defines the last date each capability is needed, facilitating management decisions on whether to retain, transfer, preserve, or dispose of the capabilities.
- Tracking major transition milestone schedules that include the Shuttle Program decommissioning review.¹⁴
- Managing a single-source supplier list to manage its supplier base through the retirement of the Shuttle Program. NASA uses the list to monitor the unique capabilities provided by suppliers.
- Implementing the Space Shuttle Management Resource Transition Document process as a primary tool for ensuring that credible, consistent, and accurate information is provided to management for decision making.

¹⁴The Shuttle Program will perform a decommissioning review, planned for August 2010, to confirm the decision to terminate or decommission the Program and assess the readiness of the Program to dispose of its assets.

Final Planning for Post-Shuttle T&R Activities Delayed

The Agency decided to delay finalizing plans for managing an estimated \$460 million of T&R activities in FY 2011 and beyond in order to concentrate on completing the Space Shuttle flight manifest. Space Operations Mission Directorate management stated that this decision allowed the Shuttle Program's workforce to focus on the launch schedule and the existing T&R organization structure without being distracted by a "parallel" organization that Shuttle Program managers thought would distract the workforce and potentially affect flight safety. Although NASA senior management has yet to finalize the planned post-FY 2010 organization, NASA managers said they expect to implement a two-phase plan for the Shuttle Program's retirement. Phase I (FY 2011 and FY 2012) will focus on asset "end-state development," which is technical work to provide the asset in the required condition for disposal. Phase II (FY 2013 through FY 2020) will focus on contract closeouts and any remaining asset disposal. During Phase II, the Centers will dispose of Shuttle assets using normal NASA and Center procedures.

Ensuring that the plan for post-FY 2010 T&R activities is approved and formalized prior to the Shuttle Program's retirement is important because many of the critical dispositions will occur in FY 2011 and beyond. As of March 2010, the organization and governance structure for executing T&R post-FY 2010 was still under development. In addition, the charters for both the TCB and JICB expire at the end of FY 2010. Although Shuttle Program managers included budget estimates for FYs 2011–2012 T&R activities as part of the FY 2011 budget submission process, the exact organizational responsibility for disposition of Program property after the last Space Shuttle mission has not yet been finalized. In December 2009, we initiated an audit to evaluate the reasonableness of Shuttle Program's cost estimate of T&R activities. Because those estimates were largely based on transition to the Constellation Program, which is proposed for cancellation in the President's FY 2011 budget, we have suspended our review until NASA evaluates and establishes a new cost estimate.

Recommendation, Management's Response, and Evaluation of Management's Response

We recommended that the Associate Administrator for Space Operations finalize the post-FY 2010 organization structure and plans for T&R activities by July 31, 2010, to facilitate effective implementation of the full scope of T&R activities after the last Space Shuttle flight.

Management's Response. The Associate Administrator for Space Operations concurred with the recommendation and stated that the post-FY 2010 organization structure and plans should be finalized by July 31, 2010. Specifically, the Associate Administrator stated that the Space Shuttle Transition Manager prepared a draft proposal that established the Level II Transition Program Office roles, responsibilities, and interfaces; describes the management approach and organization structure; and proposes the fulltime

personnel equivalents required to manage the final phases of transition and retirement of Space Shuttle assets. According to the Associate Administrator, the Transition Manager intends to present this plan to the Transition Control Board in April 2010 and finalize it by July 31, 2010. The plan will be included in an update of the National Space Transportation System 60576, *SSP Transition Management Plan*. The estimated completion date is September 1, 2010.

Evaluation of Management's Response. The Associate Administrator's response and planned actions are responsive to the recommendation. Therefore, the recommendation is resolved; however, it will remain open until we review the Agency's final transition plan.

APPENDIX A

Scope and Methodology

We performed this audit from May 2009 through March 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. We performed our audit work at Johnson Space Center and NASA Headquarters.

To evaluate NASA's plans for completing the remaining Shuttle flights, completing and supporting the ISS, and retiring the Shuttle Program, we reviewed the following Federal laws and NASA regulations, policies, and procedures:

- "Omnibus Appropriations Act, 2009," Public Law 111-8, March 11, 2009
- "National Aeronautics and Space Administration Authorization Act of 2008," October 2008
- "National Aeronautics and Space Administration Authorization Act of 2005," December 2005
- NASA's "Fiscal Year 2011 Budget Estimates," February 1, 2010
- NASA Procedural Requirements (NPR) 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007
- NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," March 26, 2007, and NASA Interim Directive, November 4, 2008
- "NASA Transition Management Plan For Implementing the U.S. Space Exploration Policy," August 2008
- National Space Transportation System (NSTS) 60575, "Space Shuttle Program Transition and Retirement Environmental Plan," June 15, 2007
- NSTS 60576, "Space Shuttle Program Transition Management Plan," May 9, 2007
- NSTS 07700, Volume XX, "Space Shuttle Program Transition and Retirement Requirements," February 28, 2007

In addition, to gain an overall understanding of NASA's plans for retiring the Shuttle Program, we reviewed the following plans and reports:

- "International Space Station Program Plan," September 22, 2003 (ISS Program Office)
- "Space Shuttle Program Plan," May 9, 2008 (Space Shuttle Program Office)
- "Program Implementation Review Management Briefing," July 21, 2008 (Space Shuttle Program Office and ISS Program Office)
- "Space Shuttle Program Transition and Retirement Personal Property Disposition Plan," November 2008 (Space Shuttle Program Office)
- "Extending the Space Shuttle Program Beyond 2010, draft," February 9, 2009 (Space Shuttle Program Office)
- NASA's "Aerospace Safety Advisory Panel Report for 2008," April 15, 2009
- NASA's "Aerospace Safety Advisory Panel Annual Report for 2009," January 15, 2010
- Congressional Budget Office Report, "The Budgetary Implications of NASA's Current Plans for Space Exploration," April 2009
- NASA's "Impacts of Suspending Activity before April 30, 2009 That Would Preclude Extending Space Shuttle Operations," April 2009
- NASA's "Report on Costs for Space Shuttle Transition and Retirement Activities Pursuant to FY 2009 Omnibus Appropriations Act (P.L. 111-8)," July 6, 2009

We interviewed the Space Operations Mission Directorate's Transition Manager and Shuttle Program personnel from the Flight Operations and Integration Office, the Business Office, and the Management Integration and Planning Office. We also interviewed ISS Program personnel from the Program Integration Office, Mission Integration and Operations Office, and External Integration Office.

We analyzed the current and historical flight rates to determine whether the planned Shuttle flight schedule is reasonable and achievable. We reviewed NASA's costs incurred for retirement and the estimated costs associated with T&R activities post-2010. We also reviewed the Shuttle Program's FY 2011 budget submission.

Use of Computer-Processed Data. We did not perform a detailed assessment of the reliability of the values and information reported in the Space Shuttle and ISS risk databases. We reviewed these databases to determine whether the programs identified risks for meeting the current Shuttle flight schedule and whether mitigation strategies

were in place to ensure successful completion of the manifest. For ISS risks, we reviewed estimated costs for mitigation of the risks, but did not validate those values. We used the probability results from the Manifest Assessment Simulation Tool as additional support for estimating a schedule completion date. However, we did not perform a detailed review on the assumptions incorporated into the tool.

Review of Internal Controls

We reviewed internal controls for the Shuttle Program’s mission and T&R activities related to authority, responsibility, and organization structure; policies and procedures; and oversight functions. “NASA Transition Management Plan,” August 2008, defined roles and responsibilities and provided for a transition governance structure; however, the plan did not address post-FY 2010 Shuttle Program organization and governance structure. The recommendation in this report, if implemented, should improve the internal controls over the T&R process.

Prior Coverage

During the last 5 years, the NASA OIG and GAO have issued three reports related to the subject of this report. These reports can be found on the Internet at <http://oig.nasa.gov/audits/reports/FY10/index.html> and <http://www.gao.gov>.

Office of Inspector General, National Aeronautics and Space Administration

“NASA’s Plan for Space Shuttle Transition Could Be Improved by Following Project Management Guidelines” (IG-07-005, January 29, 2007)

Government Accountability Office

“NASA: Agency Faces Challenges Defining Scope and Costs of Space Shuttle Transition and Retirement” (GAO-08-1096, September 30, 2008)

“NASA Supplier Base: Challenges Exist in Transitioning from the Space Shuttle Program to the Next Generation of Human Space Flight Systems” (GAO-07-940, July 25, 2007)

MANAGEMENT COMMENTS

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001



MAR 23 2010.

Reply to Attn of. **Space Operations Mission Directorate**

TO: Assistant Inspector General for Auditing
FROM: Associate Administrator for Space Operations
SUBJECT: Response to Office of Inspector General's Draft Report "Review of NASA's Progress on Retiring the Space Shuttle Program (SSP)" Assignment A-09-012-00

Thank you for the opportunity to provide comments to the draft report regarding the retirement of the SSP. Your report reflects the immensity of this effort, and we appreciate the interactions of your team with the SSP to examine the rationale for maintaining the current manifest designed to sustain and complete the International Space Station and retire the Shuttle Program in a timely manner. It is the intent of the SSP to complete the manifest without any sacrifice to safety or mission success. Additionally, we appreciate your interest in ensuring the orderly completion of Shuttle Transition & Retirement (T&R) activities following the final Shuttle mission. We are committed to the effective management of Shuttle T&R activities and concur with the recommendation, which states:

Recommendation: We recommend that the Associate Administrator for Space Operations finalize the post Fiscal Year 2010 organization structure and plans for T&R activities by July 31, 2010, to facilitate effective implementation of the full scope of T&R activities after the last Space Shuttle flight.

Response: Concur. The Space Shuttle Transition Manager has prepared a draft proposal that establishes Level II Transition Program Office roles, responsibilities and interfaces; describes the management approach and organization structure; and proposes the fulltime equivalents required to manage the final phases of transition and retirement of Space Shuttle system assets. The Transition Manager intends to present this plan to the Transition Control Board in April 2010 and finalize it by July 31, 2010. This plan will be included in an update of the National Space Transportation System 60576, *SSP Transition Management Plan*. We will provide your office a copy of the plan once it is finalized, and expect to request closure of this recommendation by September 1, 2010.

If you have any questions regarding this response, please contact Mr. John Casper, Associate Manager, for SSP. Mr. Casper can be reached at (281) 483-3191.

A handwritten signature in black ink that reads "William H. Gerstenmaier".

William H. Gerstenmaier

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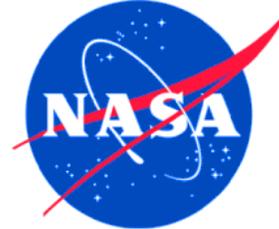
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