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AUDIT REPORT

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## STATUS OF NASA'S DEVELOPMENT OF THE MULTI-PURPOSE CREW VEHICLE

OFFICE OF INSPECTOR GENERAL



National Aeronautics and Space Administration

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### Acronyms

- CEV Crew Exploration Vehicle
- ESA European Space Agency
- FY Fiscal Year
- GAO Government Accountability Office
- GSDO Ground Systems Development and Operations
- ISS International Space Station
- MPCV Multi-Purpose Crew Vehicle
- OMB Office of Management and Budget
- OIG Office of Inspector General
- PDR Preliminary Design Review
- SLS Space Launch System

### **OVERVIEW**

### STATUS OF NASA'S DEVELOPMENT OF THE MULTI-PURPOSE CREW VEHICLE

The Issue

In April 2013, NASA announced plans for a mission by 2025 to identify, capture, and relocate an asteroid while emphasizing that Mars is its ultimate destination for beyond low Earth orbit exploration. Some Members of Congress, however, advocate human exploration and landing on the moon as the next step in human exploration for NASA. Whatever the destination, successful development of the crew capsule known as the Multi-Purpose Crew Vehicle (MPCV) is critical to the overall success of NASA's exploration efforts.

Originally known as the Crew Exploration Vehicle (CEV), the MPCV is an outgrowth of NASA's defunct Constellation Program. Following cancellation of the Constellation Program in February 2010, Congress passed the NASA Authorization Act of 2010 requiring the Agency to use, to the extent practicable, the existing contracts, investments, workforce, and capabilities of the CEV to develop the MPCV. The Act also set the goal of achieving full operational capability for the MPCV no later than December 2016.

The MPCV Program has seen its funding reduced from what the Program expected to receive during the Constellation Program, and now anticipates receiving a flat budget profile of approximately \$1 billion per year for the remainder of the 2010s and into the 2020s.<sup>1</sup> Given this budget profile, NASA is using an incremental development approach under which it allocates funding to the most critical systems necessary to achieve the next development milestone rather than developing multiple systems simultaneously as is common in major spacecraft programs. NASA officials expect this approach will allow the Program to make early progress and use test flights to reduce risk on several key systems. However, prior work from the NASA Office of Inspector General has shown that delaying critical development tasks increases the risk of future cost and schedule problems. Moreover, NASA Program officials admit that this incremental development approach is not ideal, but assert that it is the only feasible option in the current budget environment.

As adjuncts to the MPCV Program, NASA is developing a new "heavy lift" rocket known as the Space Launch System (SLS) to launch the MPCV, as well as the Ground Systems Development and Operations (GSDO) Program to support both the capsule and

<sup>&</sup>lt;sup>1</sup> Additionally, in 2009, NASA allocated \$166 million of the \$1 billion it received as part of the American Recovery and Reinvestment Act of 2009 to development of the MPCV.

the rocket. The Agency has also formed a partnership with the European Space Agency (ESA) to provide the MPCV Service Module, a critical component of the new spaceflight system.

We evaluated NASA's management of the MPCV Program in light of the directives in the Authorization Act and subsequent changes in national space exploration priorities, Program focus, and funding profiles. Specifically, we reviewed the Program's development approach, its progress in meeting cost and schedule goals and overcoming technical challenges, and its coordination with the SLS and GSDO programs and ESA. We also reviewed NASA's use of and accounting for American Recovery and Reinvestment Act of 2009 funds. Details on our scope and methodology can be found in Appendix A.

### Results

MPCV is one of three key components of NASA's efforts to continue human space exploration beyond the International Space Station (ISS) and low Earth orbit. Consequently, its successful development is critical to the overall success of the Agency's human exploration efforts. Constrained funding for the MPCV forced Program managers to adopt a less-than-optimal incremental development approach in which elements necessary to complete the most immediate tests are given priority while development and testing is delayed on other important but less time sensitive aspects of the Program. While this may be the only realistic and affordable development approach available to NASA given the Program's current funding profile, such an approach increases risks.

Although we believe MPCV Program officials are managing the Program as effectively as they can within a constrained budget, we are concerned about the future of the Program given the risks associated with incremental development and dependencies on the SLS and GSDO programs and the ESA for delivery of the Service Module. For example, the MPCV Program is beginning to experience testing delays that could result in schedule interruptions and cost increases down the road. Specifically, test dates have slipped 4 years on the Ascent Abort-2 test and 9 months on the Exploration Flight Test-1. NASA has also delayed development of many of the life support systems required for crewed missions. Similarly, reliance on timely progress of the SLS and GSDO programs and the ESA adds risk that is outside the control of the Program and could have a negative impact on the MPCV and NASA's overall exploration mission goals.

Even after the MPCV is fully developed and ready to transport crew, NASA will continue to face significant challenges concerning the long-term sustainability of its human exploration program. For example, unless NASA begins a program to develop landers and surface systems, NASA astronauts will be limited to orbital missions using the MPCV. Under the current budget environment, it appears unlikely that NASA will obtain significant funding to begin development of this additional exploration hardware, thereby delaying such development into the 2020s. Given the time and money necessary

to develop landers and associated systems, it is unlikely that NASA would be able to conduct any surface exploration missions until the late 2020s at the earliest. Finally, we determined that NASA properly tracked and accounted for its use of \$166 million in American Recovery and Reinvestment Act of 2009 funds in developing the MPCV.

### Management Action

Although we made no specific recommendations for corrective action, we encouraged NASA managers to be as transparent as possible when discussing the issues facing the MPCV Program and the risk associated with its incremental development. We believe it vital that Congress and the public recognize that incremental spacecraft development is not an optimal way to sustain a human space program. Further, NASA must continue their efforts to enhance communication between the MPCV, SLS, and GSDO programs to ensure that the schedules for these interdependent programs remain aligned.

The Associate Administrator for the Human Exploration and Operations Mission Directorate agreed with the general observations made in the report and with our description of the risks created by the funding challenges that drove the Program to adopt an incremental development strategy. In addition, he noted that the MPCV Program has made significant progress in mitigating the technical risks highlighted in the report, and that the MPCV, SLS, and GSDO programs actively participate in an integration process and governance structure with direct senior-level participation. Similarly, he stated that the Program is building strong relationships and making progress with ESA to assure its contribution of a service module meets the required schedule. Despite these efforts, the Associate Administrator noted that NASA must continue its efforts to enhance communication between the MPCV, SLS, and GSDO programs to ensure that the schedules for these interdependent programs remain aligned.

Finally, the Associate Administrator stated that NASA managers are encouraged to be as transparent as possible when discussing the issues facing the MPCV Program and the risks associated with its incremental development. Management's full response is reprinted in Appendix B.

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### **I**NTRODUCTION

### Background

In 2006, NASA awarded Lockheed Martin a contract to begin development of the next generation crew capsule to carry astronauts into space. Together with the Ares I and Ares V rockets and the Altair lunar lander, the vehicle – known as the Orion Crew Exploration Vehicle (CEV) – comprised a key component of the Agency's Constellation Program. NASA began developing the CEV and the Ares I with the goal of transporting crews to the International Space Station (ISS) as soon as possible following retirement of the Space Shuttle Program. In addition, Constellation was supposed to enable human exploration beyond low Earth orbit using the "heavy lift" Ares V rocket. NASA planned to use essentially the same crew vehicle for both Ares I and V types of missions, with the addition of fuel tanks to extend the capability of the CEV for missions beyond low Earth orbit.

The architects of Constellation assumed a funding profile of approximately \$10 billion per year for exploration. However, when both the Space Shuttle and the ISS programs were extended beyond their respective planned ending dates of 2010 and 2016, the money from those programs that was supposed to be redirected to the Constellation Program was no longer available. The shortfall in funding, coupled with technical problems relating to development of the Ares I and CEV, led NASA to delay development of the Ares V and the Altair lunar lander.

In May 2009, while the Ares I and CEV were still early in development, the White House Office of Science and Technology chartered a committee to review NASA's human spaceflight plans, including the Constellation Program. The White House charged the Review of the U.S. Human Space Flight Plans Committee, known as the Augustine Committee, with ensuring that the nation was following the best path forward beyond the Space Shuttle Program and within the President's budget profile. The Committee concluded that without a significant increase in funding – estimated at \$3 billion per year above the President's fiscal year (FY) 2010 \$6 billion budget for exploration – the Program would be unable to deliver a "heavy lift" vehicle until at least the late 2020s.

The Augustine Committee also examined the design and development of the CEV and determined it would be acceptable for use in a human exploration program. However, the Committee was concerned about the CEV's recurring costs, which it estimated at approximately \$600 million for each vehicle produced. The Augustine Committee also predicted that NASA would need an additional 2 years beyond its planned date to complete development of the CEV and Ares I.

In February 2010, President Obama released a FY 2011 budget that eliminated all funding for the Constellation Program. At that point in time, the CEV had completed its Preliminary Design Review (PDR) and was still in the early design phase.<sup>2</sup>

Despite substantial opposition by members from both parties, Congress ultimately agreed to cancel the Constellation Program but directed NASA to develop a new "heavy lift" rocket, crew capsule, and related ground support infrastructure to enable human exploration beyond low Earth orbit. Specifically, the NASA Authorization Act of 2010 (Authorization Act or Act) directed the Agency to develop the Multi-Purpose Crew Vehicle (MPCV) and the Space Launch System (SLS) using the existing contracts, investments, workforce, and capabilities from the Space Shuttle and the Constellation programs "to the extent practicable."

The Act set the goal of achieving full operational capability for the MPCV no later than December 31, 2016, and directed NASA to design the MPCV with the following minimum capabilities:

- serve as the primary crew vehicle for missions beyond low Earth orbit;
- conduct regular in-space operations, such as rendezvous, docking, and extra-vehicular activities in conjunction with payloads delivered to the ISS;
- provide an alternative means of delivery of crew and cargo to the ISS in the event commercial or partner-supplied vehicles are unable to do so; and
- have the capacity for efficient and timely evolution, including insertion of new technologies.

As shown in Table 1, the MPCV Program received a total of \$3.6 billion for FYs 2011 through 2013.

Table 1: Funding Received by MPCV(\$ in billions)			
Fiscal Year	MPCV Appropriations		
2011	\$1.2		
2012	\$1.2		
2013	\$1.2		
Total	\$3.6		

Source: Appropriations Acts for FYs 2011, 2012, and 2013.

<sup>&</sup>lt;sup>2</sup> The PDR is a key milestone in space systems development because it demonstrates that a program's preliminary design meets all system requirements with acceptable risk and within cost and schedule constraints. A successful PDR establishes the basis for proceeding with a program's detailed design stage.

The \$3.6 billion received by the MPCV Program was a reduction of over \$1.8 billion or 34 percent of the funding NASA expected to receive in the last CEV budget request submitted prior to cancellation of the Constellation Program. Moreover, the MPCV Program anticipates a flat budget profile of approximately \$1 billion per year for the remainder of the decade and into the 2020s. Assuming this budget profile and current development schedule, NASA plans to spend approximately \$16.5 billion developing its crew vehicle by the time of the first crewed flight currently planned for 2021.

Recently, the National Research Council echoed the Augustine Committee's concerns about inadequate funding for NASA's human exploration program. In a December 2012 report assessing NASA's strategic direction and agency management, the National Research Council concluded that "there is a significant mismatch between the programs to which NASA is committed and the budgets that have been provided or anticipated. The approach to and pace of a number of NASA's programs, projects, and activities will not be sustainable if the NASA budget remains flat, as currently projected."<sup>3</sup> The National Research Council also noted that it was not clear that even the \$3 billion annual infusion recommended by the Augustine Committee just a few years earlier would be sufficient to cover the exploration missions under consideration, specifically crewed missions to an asteroid and then Mars.

As shown in Table 2, the President's FY 2014 budget requests \$3.1 billion for exploration in FY 2014 and then remains essentially flat each subsequent year through FY 2018.<sup>4</sup> That level of funding is about one-third of the \$9 billion the Augustine Committee concluded would be required annually to develop and maintain a viable human exploration program beyond low Earth orbit.

Table 2: Exploration Research and Systems Development Budget Request Profile(\$ in billions)			
Fiscal Year	President's Budget Request Profile for NASA Exploration		
2014	\$3.10		
2015	\$3.13		
2016	\$3.15		
2017	\$3.21		
2018	\$3.22		

Source: NASA.

<sup>&</sup>lt;sup>3</sup> "NASA's Strategic Direction and the Need for a National Consensus," Committee on NASA's Strategic Direction; Division on Engineering and Physical Sciences; National Research Council, 2012, ISBN 978-0-309-31354-4.

<sup>&</sup>lt;sup>4</sup> Includes funding for the MPCV, SLS, and Ground Systems Development and Operations (GSDO) programs, and funding for Exploration Research and Development, including Human Research and Advanced Exploration Systems.

Figure 1 illustrates key events in the development of the CEV/MPCV crew capsules.



Figure 1: CEV and MPCV Timeline of Significant Events

Source: NASA.

**Overview of the MPCV**. NASA is building the MPCV to support a four-person crew for up to 21 days on a beyond low Earth orbit mission.<sup>5</sup> Run out of the Johnson Space Center (Johnson), the MPCV is comprised of three elements: the Crew Module, the Service Module, and the Launch Abort System.

- The Crew Module houses the flight crew and functions as the command, control, communications, and navigation center of the spacecraft.
- The Service Module provides propulsion, life support, and power for the Crew Module.
- The Launch Abort System is used in case of an emergency that requires separation of the Crew Module from the launch vehicle and consists of a nose cone, three motors, and a shroud (see Figure 2).

<sup>&</sup>lt;sup>5</sup> Longer missions would require additional modules that would connect to the MPCV in order to sustain life past 21 days.

A Spacecraft Adapter connects the launch vehicle to the Crew Module, Service Module, and Launch Abort System.





Additional Elements of the Human Exploration Program. In addition to the MPCV Program, NASA has established the SLS Program to develop the rocket that will launch the MPCV and the GSDO Program to develop the infrastructure required for processing and launching the SLS and MPCV. The Agency has also formed a partnership with the European Space Agency (ESA) to provide the MPCV Service Module for at least one test flight.

Source: NASA.

*Space Launch System.* The Authorization Act directs NASA to develop the SLS to access space beyond low Earth orbit. NASA plans to use the SLS, which will be the most powerful U.S. rocket since the Saturn V took astronauts to the moon, to launch the MPCV into orbit. NASA expects the SLS to serve as the cornerstone for its future human space exploration to an asteroid or Mars. The Marshall Space Flight Center hosts the SLS Program.

*Ground Systems Development and Operations*. NASA will launch the MPCV from Pad B at the Kennedy Space Center (Kennedy), which hosts the Program. The GSDO Program is developing the launch site infrastructure to prepare, assemble, test, and launch the MPCV and SLS.

Accordingly, the GSDO Program must coordinate closely with the MPCV and SLS programs to connect the crew vehicle to the SLS and transport the integrated vehicle to the launch pad.

*European Space Agency.* In January 2013, NASA and the ESA announced that ESA would supply the Service Module for NASA's Exploration Mission-1 scheduled for 2017 as a means of paying off barter debt ESA owes NASA for ISS operating expenses.<sup>6</sup> ESA will also provide spare hardware for Exploration Mission-1 and sustaining engineering that could be used for Exploration Mission-2.<sup>7</sup>

The ESA plans to model the Service Module on ESA's Automated Transfer Vehicle, which has successfully delivered supplies to the ISS on four occasions. NASA will provide the main engine and other miscellaneous parts for the ESA module and Lockheed Martin, the MPCV prime contractor, will integrate the module with the rest of the spacecraft. Because the Service Module is a vital part of the MPCV, the agreement between the two space agencies puts ESA on the Program's critical path and creates an additional dependency that NASA must manage.<sup>8</sup>

In addition to MPCV, SLS, and GSDO activities, NASA needs to develop additional hardware, such as habitation modules and landers, in order to use the MPCV to perform planetary surface exploration missions. No such hardware is currently in development.

**American Reinvestment and Recovery Act of 2009 (Recovery Act).** NASA allocated \$166 million of the \$1 billion of Recovery Act funds it received in 2009 to the MPCV Program.

<sup>&</sup>lt;sup>6</sup> Bartering is the trading of a product or service for another, generally with no exchange of money.

<sup>&</sup>lt;sup>7</sup> Sustaining engineering refers to activities required to support a program during its operational phase.

<sup>&</sup>lt;sup>8</sup> The term critical path describes a sequential path of tasks in a program schedule through completion. Any significant slippage of tasks in the critical path will increase the program's duration and, most likely, its cost.

### Objectives

We evaluated NASA's management of the MPCV Program in light of the directives in the Authorization Act and subsequent changes in national space exploration priorities, Program focus, and funding profiles. Specifically, we reviewed the Program's development approach, its progress in meeting cost and schedule goals and overcoming technical challenges, and its coordination with the SLS and GSDO programs and ESA. We also reviewed the procedures MPCV officials followed for spending and tracking the \$166 million in Recovery Act funds the Program received. See Appendix A for details of the audit's scope and methodology and our review of internal controls.

### MULTI-PURPOSE CREW VEHICLE PROGRAM FACES SIGNIFICANT RISKS IN MEETING NASA'S HUMAN EXPLORATION GOALS

The MPCV Program faces significant risks in meeting NASA's goal of human exploration beyond low Earth orbit. Foremost is a constrained funding profile that has forced the Agency to adopt an incremental development approach under which it allocates funding to the most critical systems necessary to achieve the next development milestone rather than to developing multiple systems simultaneously as is common in major spacecraft programs. Although the only practical solution given the Program's overall funding level, this approach increases the risk of cost overruns and schedule delays because it postpones critical tests and integration tasks until later in development. In addition, the Program faces significant technical challenges, including heat shield issues, delays in producing engineering drawings, and concerns about vehicle weight. Finally, the MPCV's overall success will rely in great measure on the timing and success of the other elements of NASA's human exploration program – the SLS and the GSDO programs – as well as its partnership with the ESA on the MPCV Service Module. Schedule delays or cost overruns on any of these interdependent components could negatively affect the MPCV Program.

### Incremental Development Approach Increases Risk of Cost Overruns and Schedule Delays

The incremental development approach NASA has adopted for the MPCV puts the Program at risk for increased cost and schedule delays. Prior audit work by the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) has shown that the most effective budget profile for large and complex space system development programs like the MPCV is steady funding in the early stages of development and increased funding during the middle stages of development.<sup>9</sup> As depicted in Figure 3, the GAO Cost Estimating and Assessment Guide illustrates a typical space system lifecycle model and shows a bell-shaped funding curve for research, development, testing, and evaluation because more resources are needed as development progresses and programmatic risks are identified and remediated. In contrast, MPCV's budget profile through at least 2018 remains flat. MPCV Program officials acknowledged that a flat funding trajectory is not optimal and increases the risk that costly design changes may be needed later in the Program when they begin to integrate and test the capsule with other Program elements.

<sup>&</sup>lt;sup>9</sup> NASA OIG, "NASA's Challenges to Meeting Cost, Schedule, and Performance Goals," (IG-12-021, September 27, 2012), and GAO, "GAO Cost Estimating and Assessment Guide," (GAO-09-3SP, March 2009).



Figure 3: Lifecycle Funding Profile for Space System Development

Note: O&M = operations and maintenance; RDT&E = research, development, test, and evaluations; SV = space vehicle; EOL = end of life; ATP = authority to proceed; IOC = initial operational capacity; and FOC = full operational capacity.

Source: GAO.

The MPCV Program received \$1.2 billion each year for FY 2011 though FY 2013. According to the President's FY 2014 Budget Request, MPCV Program managers expect their budget to be "flat-lined" at \$1 billion per year through at least 2018. In fact, due to inflation, MPCV's flat budget profile actually represents a reduction in out-year purchasing power.





Source: OIG analysis of budget data obtained from NASA.

The MPCV Program has experienced significant budget reductions in the development phase, which Program officials say has made it difficult to plan and execute a viable development schedule. For example, NASA has delayed development of life support systems and some avionics due to budget constraints. The Aerospace Safety Advisory Panel – an advisory group that evaluates NASA's safety performance – considers the MPCV's flat budget profile the Program's biggest risk.<sup>10</sup>

**Incremental Development.** To adapt to MPCV's flat budget profile, Program managers have implemented an incremental development approach under which they allocate available funding to the most critical systems needed to meet the next development milestone. For example, according to MPCV Program managers, current work is focused primarily on the systems needed to achieve the objectives of the first two flight tests, while postponing development and testing of life support systems not needed until the first crewed flight. In addition, lack of adequate funding at this point in the Program's development cycle also requires Program managers to defer an in-flight launch abort test for 4 years.

Given the Program's constrained funding profile, we appreciate that NASA managers have few options apart from an incremental development approach. However, prior work

<sup>&</sup>lt;sup>10</sup> Aerospace Safety Advisory Panel, "Annual Report for 2012," (January 9, 2013). Exploration Systems Development "has a 'flat budget' that by nature causes phasing and integration compromises for a program that needs a classic skewed bell curve for development. NASA should continue to monitor the funding going forward and be prepared to mitigate any mission and safety concerns should future NASA budgets be significantly reduced due to the prevailing fiscal environment."

by the OIG has shown that delaying critical development tasks in complex spaceflight development programs increases the risk of cost and schedule problems and causes development of critical technologies to be deferred to later program phases when integration may be more difficult or the costs of material and labor greater. Shifting tasks to later program phases also results in higher fixed costs, including sustaining a standing work force or adding shifts later in development in an attempt to make up for lost time.

For its part, NASA acknowledges the risks associated with incremental development of the MPCV, noting in its Program Plan that "this cost-driven approach may yield incomplete development, verification, or validation testing and drive the Program to assume much higher risk in achieving human spaceflight objectives."

### **MPCV Program Experiencing Schedule Delays**

While many of the risks inherent in an incremental development approach are not likely to occur until later in development, the MPCV Program has already experienced schedule delays. Most importantly, the Program will not meet the Authorization Act's goals of achieving full operational capability for the MPCV by 2016 or providing a backup to commercial companies to transport crew to the ISS. NASA plans to delay delivery of several systems required to "human rate" the MPCV and, as a result, the Agency does not expect the spacecraft to be available for crewed operations until 2021 (a year later than the currently scheduled retirement date for ISS operations).<sup>11</sup> To achieve a crewed flight in 2019, NASA estimates the MPCV Program would need approximately \$1 billion more in total than it is currently expected to receive during the next 5 years. An additional \$300 million would be required to equip the MPCV with a docking mechanism/hatch, ISS power and communications equipment, and mission unique software and other hardware needed for it to serve as a backup transport vehicle to the ISS.

NASA has planned four flights to test critical MPCV mission systems and demonstrate performance of its various flight systems:

- 1. *Exploration Flight Test-1*: an un-crewed flight planned for 2014 that will orbit the Earth twice before re-entering the atmosphere.
- 2. *Exploration Mission-1*: an un-crewed mission planned for 2017 that will orbit the Moon before returning to Earth.
- 3. *Ascent Abort-2*: test of the abort system that separates the Crew Module from the launch vehicle in a high altitude environment scheduled for 2018.
- 4. Exploration Mission-2: a crewed lunar orbit mission scheduled for 2021.

<sup>&</sup>lt;sup>11</sup> A human-rated system accommodates human needs, controls hazards with sufficient certainty to be considered safe for human operations, and provides the capability to safely recover from emergencies. Human rating is an integral part of all activities throughout the lifecycle of the system.

However, NASA has delayed two key tests of MPCV systems in the near term. As shown in Figure 5, NASA has delayed the Ascent Abort-2 test 4 years and the Exploration Flight Test-1 9 months. Additionally, under the Program's incremental development strategy NASA has delayed development of many of the life support systems required for performing crewed missions. As a result, many of the capabilities needed to sustain life onboard the vehicle will not be fully proven until Exploration Mission-2, the Program's first crewed mission. For example, NASA originally planned to test the air revitalization system that circulates and filters air in the crew module on Exploration Flight Test-1 in 2014. However, MPCV Program managers have delayed testing these systems under flight conditions until Exploration Mission-2, the first crewed flight.



Source: NASA.

Deferring testing of subsystems in complex development programs can result in serious problems not being identified until latter stages of development, requiring significant time, money, and effort to overcome. Although testing delays have not yet resulted in the delay of an SLS planned launch date, pushing out testing has narrowed the cushion of time the MPCV Program will have to address any issues uncovered during testing. Up to this point, the most significant delay was the 4-year postponement of the Ascent Abort-2 test needed to validate the launch abort system as the spacecraft breaks the speed of sound. NASA had scheduled this test for 2014, approximately 3 years before the launch of Exploration Mission-1 and approximately 7 years before the Program's first scheduled crewed flight. However, in light of budget constraints, the test is now scheduled for 2018, 3 years before the first crewed flight. This cuts nearly in half the time the Program will have to address any issues discovered during the test before the crewed flight. MPCV Program managers consider this an acceptable development risk for the abort system given the system maturity demonstrated in the successful first test of the launch abort system in 2010. Nevertheless, MPCV Program managers acknowledge that unanticipated technical issues with the abort test could increase the risk of cost increases and schedule delays for NASA's exploration program.

The Exploration Flight Test-1 delay was largely due to the limited availability of a launch vehicle to conduct the test as well as the need to correct unforeseen technical issues associated with heat shield, avionics, and spacecraft system integration conducted in FY 2012.<sup>12</sup> The extra time and expense in addressing these technical issues could have a cascading effect on the MPCV's Program schedule and the funding available for future tests. Under NASA's incremental development approach, teams will not begin working on Exploration Mission-1 until the first test flight is completed. Consequently, any delays in the first test flight will likely delay the first crewed flight.

MPCV Program managers told us they plan to draw funding from the Program's management reserves to prioritize Exploration Mission-1 development activities in order to meet that mission's FY 2017 test date.<sup>13</sup> While Program officials expect that these extra funds will cover Exploration Mission-1 costs and keep the flight on schedule, they concede that the Program's overall management reserves may not be adequate to cover unforeseen technical challenges associated with Exploration Mission-2. Currently, Exploration Mission-2's internal cost and schedule targets anticipate 1 year of budget and schedule reserve. Of the more than \$1 billion of MPCV budget reserves, approximately \$870 million are budgeted for FYs 2019 to 2021 for Exploration Mission-2. However, these reserves could be dramatically reduced if diverted to the earlier Exploration Mission-1 flight, leaving an inadequate amount of reserves to complete Exploration Mission-2 on schedule.

### **MPCV Program Must Still Overcome Technical Challenges**

Moving forward, the MPCV Program's ability to meet cost, schedule, and performance targets will depend on its ability to overcome technical challenges inherent in any large-scale, complex development program. While NASA has made progress on mitigating risks to the Program, problems persist with mass reduction, spacecraft test verification, heat shields, and engineering drawing release rates.

NASA uses risk management as a tool to identify unanticipated problems that could adversely affect a program's performance, schedule, cost, or safety. The Agency rates risks as high, moderate, or low based on the combination of their likelihood and consequence.<sup>14</sup> The MPCV Program is tracking 248 risks – 61 high, 110 moderate,

<sup>&</sup>lt;sup>12</sup> Program officials explained that although the MPCV Program experienced an approximate 4 month delay in development due to technical challenges, the development challenges were superseded by a 9 month delay (from December 2013 to September 2014) because of the limited availability of a launch vehicle to conduct the test.

<sup>&</sup>lt;sup>13</sup> A management reserve is an amount in a program's budget set-aside for "known unknowns" – previously identified risks such as the heat shield production schedule.

<sup>&</sup>lt;sup>14</sup> The MPCV Program identifies risks and concerns, analyzes them, decides how to address them, and tracks and controls them. Risks are scored and assessed based on likelihood and consequence with likelihood scores ranging from 1 to 5. Consequence scores also range from 1 to 5 using four categories: safety, performance, cost, and schedule. A risk's composite consequence score is the highest value from these four categories. Finally, each risk is given an overall rating of high, moderate, or low based on the combination of its likelihood and consequence scores.

30 low, and 47 that have not yet been rated. The following are examples of significant ongoing technical risks to the MPCV Program:

- Spacecraft Weight. According to Program officials, the MPCV needs to weigh 73,500 pounds or less at lift off to meet Program specifications and safety requirements. When the Exploration Mission-2 mass reduction activity began in FY 12, the projected total weight of the crewed mission was 78,944 pounds, or more than 7 percent over target weight. While MPCV has made progress in identifying and implementing weight reductions, concerns exist that these efforts will not be sufficient to alleviate the issue. Failure to address the weight issue in a timely manner could force NASA to change the mission objectives of Exploration Mission-2 in order to meet the scheduled launch date for the mission. Further mass reductions would then be implemented incrementally on subsequent flights based on actual mission experience.
- Vehicle Test and Verification Plan. MPCV Program officials consider the Vehicle Test and Verification Plan a "high" risk because the Program has eliminated or combined several tests due to funding issues. Generally, eliminating or reducing the amount of planned testing increases the overall risk that a program will not be able to achieve its goals. For example, Program officials eliminated thermal vacuum testing from Exploration Mission-1 and deferred other testing from Exploration Mission-1 to Exploration Mission-2. Changes to the test plans will decrease the amount of integrated testing and increase reliance on individual component and subsystem testing. Program officials said they recognize the lack of integrated testing may increase technical risks to development of the spacecraft's Environmental Control and Life Support System.
- *Cracking of Heat Shield.* The MPCV applies a material known as Avcoat, which • was also used on Apollo spacecraft, to the capsule's heat shield to serve as a protective barrier during re-entry into the Earth's atmosphere. Unfortunately, the material has shown tendencies to crack under thermal conditions similar to those the capsule will experience during the mission in the deep space environment prior to reentering the Earth's atmosphere. Program officials have instituted a number of risk mitigation activities, including material testing, stress analysis, and computer simulation designed to lower the likelihood of surface cracking and to demonstrate heat shield integrity should cracking occur. MPCV officials have also implemented design controls to limit the in-space Avcoat temperature extremes on the Exploration Flight Test-1 heat shield. One of the primary goals of this first flight test will be to validate these efforts and fully demonstrate that the heat shield will meet requirements. If the heat shield cracking degrades below mission requirements, the Program's schedule will be impacted while officials develop a solution.

- *Heat Shield Production Schedule*. The heat shield may not be completed and delivered to Kennedy to begin MPCV assembly, testing, and launch operations activities in time for Exploration Flight Test-1. NASA asked the manufacturer of Avcoat to restart the production line for the MPCV. However, manufacturing has been slow due to the availability of parts, fabrication complexity, and staffing and training issues. NASA is working with the manufacturer to mitigate this schedule risk. Because the Avcoat material is unique, NASA has no alternative for using a substitute material.
- Engineering Drawing Release Rate. Problems with the computer systems that manage engineering data and drawings have caused design engineers to experience 3 to 5 hours of delay per day when performing routine tasks such as extracting drawings from the database. Although the computer system has been upgraded and processes have been refined to help alleviate these delays, there is a risk that not all of the required drawings will be released in time to meet Exploration Mission-1's scheduled flight date of December 2017.

### Dependency on Progress of Other Programs Could Hinder MPCV Development

In addition to its own challenges, the MPCV Program's success relies, in large part, on the success of the other programs integral to NASA's plans for exploration beyond low Earth orbit, specifically the SLS and GSDO programs and the ESA-provided Service Module. The evolving configuration requirements among the programs necessitate close coordination, and significant delays in any component will affect NASA's overall time frame for human space exploration.

**Differences in Stages of Development.** One of the primary challenges facing NASA is that the MPCV is a legacy system from the Constellation Program, while the SLS rocket launch system is based on a platform that is vastly different and not derived from the Ares V heavy lift rocket that was being designed under the Constellation Program. Therefore, the MPCV is much farther along in development than the SLS and GSDO programs. As shown in Figure 6, NASA divides the lifecycle of its spaceflight programs into two major phases – formulation and implementation – that are further divided into phases A through F. Phases A and B consist of formulation and C through F consist of implementation. This structure allows managers to assess the progress of their programs at key decision points in the process. Generally speaking, programs that stay within the parameters of their plans and other governing agreements proceed to the next phase.



### Figure 6: Simplified Lifecycle Phases Simplified Lifecycle Phases

The Constellation Program's CEV Project successfully completed PDR at the end of Phase B in August 2009. This means that the Program demonstrated that its preliminary design met all system requirements with acceptable risk and within cost and schedule constraints.<sup>15</sup> CEV Project managers were preparing to proceed to Phase C of the implementation phase when the Constellation Program was cancelled. On the other hand, the SLS and GSDO programs are still in the early design phases. SLS just completed its PDR in July 2013 while GSDO has not yet completed its PDR.

**Efforts to Coordinate Programs.** Recognizing that the programs are at different stages of development, NASA management has taken action to synchronize the MPCV Program with the development schedules for the SLS and GSDO programs. For example, instead of proceeding to the implementation phase, officials directed the MPCV Program to coordinate its development with the SLS and GSDO programs and remain in the formulation phase until the rocket development and ground system programs were more mature. In extending the formulation phase for the MPCV Program, managers revised the Program's Key Decision Points and other developmental milestones to better align with the SLS and GSDO programs. Figure 7 illustrates the revised development schedule for the CEV Project and the MPCV, SLS, and GSDO programs.

Source: NASA Schedule Management Handbook.

<sup>&</sup>lt;sup>15</sup> A successful PDR establishes the basis for proceeding with a program's detailed design phase.

Milestone Reviews	Crew Exploration Vehicle	Multi-Purpose Crew Vehicle	Space Launch System	Ground Systems Development & Operations	
	CEV	MPCV	SLS	GSDO	
	Lifecycle Phase A				
Key Decision Point A Systems Requirements Review	July 2007 March 2007	February 2012 Not Applicable	November 2011 July 2012	January 2012 August 2012	
		Lifecycl	e Phase B		
Key Decision Point B Preliminary Design Review	April 2008 August 2009	January 2013 April 2014*	July 2012 July 2013	November 2012 January 2014*	
		Lifecycle Phase C			
Key Decision Point C Critical Design Review	Not Applicable Not Applicable	September 2014* April 2015*	September 2014* 2nd Quarter FY 2015*	March 2014* May 2015*	

### Figure 7: Milestone Reviews for CEV, MPCV, SLS, and GSDO Milestone Reviews by Lifecycle

\* estimated completion date

Source: NASA.

MPCV Program managers stated that revising the developmental milestones should help ensure that they can validate integration points and design changes between the CEV and MPCV that resulted from the selection of the SLS as the new launch vehicle. Under the revised schedule, NASA plans to conduct another PDR for the MPCV Program in April 2014, which is after the SLS PDR that was completed.

In addition to aligning schedules, NASA has taken other steps to coordinate the MPCV, SLS, and GSDO programs. For example, the Agency established an Exploration Systems Integration structure that delegates authority to make the majority of cross-program integration decisions by leaders residing in each of the programs. Teams from the three programs communicate requirements, and assess budget and cost implications of changing assumptions and configurations as the programs evolve.

MPCV Program officials must also coordinate with ESA, which is supplying the Service Module for Exploration Mission-1. For the MPCV Program to stay on schedule for the planned 2017 launch of Exploration Mission-1, ESA will have to provide the Service Module by 2016. Although the Module will be based on a proven design that has delivered supplies to the ISS four times, ESA and its industrial partners still need to reduce its weight by approximately 1,200 pounds to meet Exploration Mission-1 requirements. Failure to address the weight requirements in a timely fashion could lead to delays in the delivery of the service module. In general, integration risks remain a concern given the relative immaturity and evolving nature of the SLS and GSDO programs. In addition, delays in delivery of the ESA Service Module or technical issues integrating it with the SLS or other MPCV elements could result in development or schedule delays beyond the control of the MPCV Program.

### **Recovery Act Funds Appropriately Used for MPCV**

The Recovery Act was signed into law in February 2009 to jumpstart the U.S. economy, preserve or create jobs, and spur technological advances in science and health. NASA received \$1 billion from the Recovery Act and allocated \$166 million to the MPCV Program. We found that NASA appropriately used Recovery Act funds for the MPCV Program as intended. In addition, the Program adequately addressed the reporting requirements of the Recovery Act and related Office of Management and Budget (OMB) guidance.

### Conclusion

The MPCV is one of three key components of NASA's efforts to move human exploration beyond the ISS and low Earth orbit. Consequently, its successful development is critical to the overall success of the Agency's human exploration efforts. However, constrained funding levels for the MPCV forced Program managers to adopt an incremental development approach in which only elements necessary to complete the most immediate tests are given priority while development and testing of other important but less time sensitive aspects are postponed. While this may be the only realistic development approach available given the Program's current funding profile, it is far from optimal and runs counter to traditional space development programs.

Although we believe MPCV Program officials are managing the Program as effectively as they can within a constrained budget, we are concerned about the future of the Program given the risks associated with incremental development and the Program's dependency on the progress of the SLS and GSDO programs and the ESA for delivery of a Service Module. The Program is beginning to experience testing delays that could result in schedule interruptions and cost increases down the road. For example, test dates have slipped 4 years on the Ascent Abort-2 test and 9 months on the Exploration Flight Test-1. Similarly, reliance on the progress and effectiveness of integration with the SLS and GSDO programs and ESA adds risk that is outside the control of the MPCV Program.

After the MPCV is fully developed and ready to transport crew, NASA will continue to face significant challenges concerning the long-term sustainability of its human exploration program. For example, unless NASA begins a program to develop additional exploration hardware such as landers and surface systems, NASA astronauts will be limited to orbital missions using the MPCV. Under the current budget environment, it appears that obtaining significant funding to begin development of any such additional

exploration hardware will be difficult and such development is unlikely to begin until sometime into the 2020s. Given the amount of time and money necessary to develop this hardware, it is unlikely that NASA would be able to conduct surface exploration missions until the late 2020's at the earliest.

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

Although we made no specific recommendations for corrective action in a draft of this report, we encouraged NASA managers to be as transparent as possible when discussing the issues facing the MPCV Program and the risk associated with its incremental development approach. We believe it vital that Congress and the public recognize that incremental spacecraft development is not an optimal way to sustain a human space program. Further, NASA must continue to enhance communication between the MPCV, SLS, and GSDO programs to ensure that the schedules for these interdependent programs remain aligned.

The Associate Administrator for the Human Exploration and Operations Mission Directorate agreed with the general observations made in the report and with our description of the risks created by the funding challenges that drove the MPCV Program to adopt an incremental development strategy. In addition, he noted that the Program has made significant progress in mitigating the technical risks highlighted in the report, and that the MPCV, SLS, and GSDO programs actively participate in an integration process and governance structure with direct senior-level participation. Similarly, he stated that the Program is building strong relationships and making progress with ESA to assure its contribution of a service module meets the required schedule. Despite these efforts, the Associate Administrator noted that NASA must continue its efforts to enhance communication between the MPCV, SLS, and GSDO programs to ensure that the schedules for these interdependent programs remain aligned.

Finally, the Associate Administrator stated that NASA managers are encouraged to be as transparent as possible when discussing the issues facing the MPCV Program and the risks associated with its incremental development. Management's full response is reprinted in Appendix B.

### **APPENDIX** A

### Scope and Methodology

We performed this audit from October 2011 through July 2013 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.

The audit included reviews of two distinct areas: NASA's management of the MPCV Program and its accounting for use of Recovery Act funds on the MPCV Program. We divided our audit work along these two areas, with separate scopes and methodologies for each.

**NASA's Management of the MPCV Program.** This review evaluated how NASA is managing the spacecraft's development in response to the 2010 Authorization Act (Public Law 111-267) and subsequent changes in national space exploration priorities, Program focus, and funding profiles. For this review, we conducted audit work at Johnson; Kennedy; and Lockheed Martin, the prime contractor.

We discussed the management and progress of the MPCV Program with the Assistant Manager for Strategy Integration and the Special Assistant for Program Integration periodically throughout our review. We also conducted interviews with two NASA Headquarters officials, the Deputy Associate Administrator for Exploration System Development, and the Chief Engineer; several other MPCV Program officials; Johnson officials from the Engineering and Safety and Mission Assurance Directorates; and the MPCV Program Manager and Deputy Program Manager at the prime contractor.

We obtained and reviewed applicable documents and verified compliance with Federal law. The records we reviewed include the following:

- "Multi-Purpose Crew Vehicle Program Plan," July 24, 2012 (Baseline);
- "Final Report Regarding NASA's Space Launch System and Multi-Purpose Crew Vehicle," November 21, 2011;
- "Independent Cost Assessment of the Space Launch System, Multi-Purpose Crew Vehicle and 21st Century Ground Systems Programs, Final Report," Booz Allen Hamilton, August 19, 2011;
- "Preliminary Report [to Congress] Regarding NASA's Space Launch System and Multi-Purpose Crew Vehicle," January 2011;
- MPCV/Prime Contractor Weekly Schedule Review Presentations;

- MPCV Quarterly Program Performance Review Presentations;
- MPCV Vehicle Configuration Matrix, as amended;
- relevant NASA Advisory Council meeting presentations and minutes; and
- relevant Congressional testimony.

To accomplish our review of challenges that might hinder the MPCV development, we reviewed various MPCV budget, cost, schedule, and risk documents and the interdependencies of the MPCV Program with the SLS and GSDO programs.

**Recovery Act Funds Associated with the MPCV.** The review examined the \$166 million in Recovery Act funds NASA used toward the engineering design of ground test articles such as titanium heat shields, engineering design units such as avionics, and technology development for improved crew safety. The scope included NASA's management, distribution, use, reporting, and closeout of these Recovery Act funds. For this review, we conducted audit work at Johnson, the NASA Shared Services Center, and NASA Headquarters.

To accomplish our review, we interviewed appropriate NASA officials, reviewed applicable records, and verified compliance with Recovery Act requirements. NASA officials interviewed included the Agency's Recovery Act Implementation Executive, the MPCV Program Manager, and the Johnson Resource Analyst responsible for tracking Recovery Act funds. We also interviewed the NASA Shared Services Center Accounts Payable Lead responsible for the accounting internal control processes that NASA put into place for Recovery Act compliance.

The records we reviewed included Federal and Agency Recovery Act guidance, fund-related plans, contractual documents, status reports, and billing documents:

- "Updated Guidance on the American Recovery and Reinvestment Act," (OMB M-10-34, September 24, 2010);
- "Updated Implementing Guidance for the American Recovery and Reinvestment Act of 2009," (OMB M-09-15, April 3, 2009);
- "Initial Implementing Guidance for the American Recovery and Reinvestment Act of 2009," (OMB M-09-10, February 18, 2009);
- Procurement Information Circular 09-06H, "Contracting with Recovery Act Funds including deviation to FAR and NFS Quick Closeout Procedures," November 23, 2010;
- "Orion/MPCV Project Plan," May 2009;
- contract modifications under which the Recovery Act-related work was performed;
- monthly technical and financial status reports, as well as quarterly status reports, submitted by the contractor performing the Recovery Act-related work; and
- contractor invoices billing NASA for the Recovery Act work performed.

To assess compliance with Recovery Act requirements we verified that:

- Agency payments and accounting entries matched amounts on contractor invoices for the Recovery Act work,
- quarterly reports were submitted on time using a central government-wide data collection system for Federal Agencies and Recipients of Federal award per the Recovery Act,
- key milestones and deliverables were met,
- Recovery Act funds were expended and final invoices received, and
- MPCV Program status was marked "fully complete" in FederalReporting.gov.

#### **Use of Computer Processed Data**

We did not use computer-processed data to perform the review of NASA's management of the MPCV Program, but did use data from NASA's financial system for the review of Recovery Act funds associated with the MPCV. As part of the review, we compared data from source documents against the data in the financial system. Based on the results of those comparisons, we concluded that the data was valid and reliable for the purposes of the review.

### **Review of Internal Controls**

For the review of NASA's management of the MPCV Program, we reviewed and evaluated internal controls associated with the development of the MPCV, including budgeting, scheduling, and cost assessment controls, as well as compliance with relevant laws and NASA policies and procedures. We considered the reviewed internal controls to be adequate.

For the review of Recovery Act funds used on the MPCV, our review of internal controls included policies, procedures, and practices that the Agency implemented to provide reasonable assurance of compliance with Recovery Act requirements as identified in OMB guidance.<sup>16</sup> Based on the results of our review, we considered the internal controls over the Recovery Act funds associated with the MPCV to be adequate.

### **Prior Coverage**

During the last 5 years, NASA OIG and GAO have issued reports of particular relevance to the subject of this report; these reports are listed below. Unrestricted reports can be accessed over the Internet at <u>http://oig.nasa.gov/audits/reports/FY12</u> (NASA OIG) and <u>http://www.gao.gov</u> (GAO).

<sup>&</sup>lt;sup>16</sup> OMB, "Updated Implementing Guidance for the American Recovery and Reinvestment Act of 2009," (OMB M-09-15, April 3, 2009); "Initial Implementing Guidance for the American Recovery and Reinvestment Act of 2009," (OMB M-09-10, February 18, 2009); and "Updated Guidance for the American Recovery and Reinvestment Act," (OMB M-10-34, September 24, 2010).

### NASA Office of Inspector General

### <u>MPCV</u>

"NASA's Challenges to Meeting Cost, Schedule and Performance Goals," (IG-12-021, September 27, 2012);

"NASA's Plans to Modify the Ares I Mobile Launcher in Support of the Space Launch System," (IG-12-022, September 25, 2012);

"NASA's Constellation Standing Review Boards Established Without Due Regard for Member Independence Requirements," (IG-09-011, February 25, 2009);

"Addendum to Final Memorandum on the Standing Review Board for the Orion Crew Exploration Vehicle Project," (IG-08-018, February 9, 2009);

"More Stringent Entrance Criteria Needed for Project Lifecycle Reviews," (IG-09-004, October 31, 2008); and

"Final Memorandum on the Standing Review Board for the Orion Crew Exploration Vehicle Project," (IG-08-018, April 28, 2008).

#### Recovery Act

"NASA's Management of Small Business Innovation Research and Small Business Technology Transfer Contracts Funded by the Recovery Act," (IG-12-009-R, February 2, 2012);

"NASA's Use of Recovery Act Funding for the James Webb Space Telescope Project," (IG-11-014, March 3, 2011);

"Audit of NASA's Recovery Act Procurement Actions at Johnson Space Center, Goddard Space Flight Center, Langley Research Center, and Ames Research Center," (IG-10-017, July 27, 2010); and

"Final Memorandum on Review of Open Audit Recommendations Affecting Recovery Act Activities," (IG-10-014, May 20, 2010).

### **Government Accountability Office**

### MPCV

"NASA: Assessments of Selected Large-Scale Projects," (GAO-13-276SP, April 17, 2013);

"NASA: Assessments of Selected Large-Scale Projects," (GAO-12-207SP, March 1, 2012);

"Additional Cost Transparency and Design Criteria Needed for National Aeronautics and Space Administration (NASA) Projects," (GAO-11-364R, March 3, 2011);

"NASA: Assessments of Selected Large-Scale Projects," (GAO-11-239SP, March 3, 2011);

"NASA: Issues Implementing the NASA Authorization Act of 2010," (GAO-11-216T, December 1, 2010);

"NASA: Assessments of Selected Large-Scale Projects," (GAO-10-227SP, February 1, 2010);

"NASA: Constellation Program Cost and Schedule Will Remain Uncertain until a Sound Business Case Is Established," (GAO-09-844, August 26, 2009); and

"NASA: Ares I and Orion Project Risks and Key Indicators to Measure Progress," (GAO-08-186T, April 3, 2008).

#### Recovery Act

"Recovery Act: Status of Science-Related Funding," (GAO-12-279T, November 30, 2011), and

"Recovery Act: Contracting Approaches and Oversight Used by Selected Federal Agencies and States," (GAO-10-809, July 15, 2010).

### **MANAGEMENT COMMENTS**

		Headqua	Aeronautics and Space Administration arters ton, DC 20548-0001					
			August 13, 2013					
	Reply to Attn of:	Human Exp	ploration and Operations Mission Directorate					
		TO:	Assistant Inspector General for Audits					
		FROM:	Associate Administrator for Human Exploration and Operations Mission Directorate					
		SUBJECT:	Response to OIG Draft Audit Report, "Status of NASA's Development of the Multi-Purpose Crew Vehicle" (Assignment No. A-12-002-00)					
		opportunity	The Human Exploration and Operations Mission Directorate (HEOMD) appreciates the opportunity to review your draft report entitled "Status of NASA's Development of the Multi-Purpose Crew Vehicle" (Assignment No. A-12-002-00).					
			NASA's response to the suggestion addressed to the Associate Administrator for Human Exploration and Operations Mission Directorate follows:					
		NASA concurs with the general observations made in the report. Incremental development is a strategy that the Orion Program adopted to effectively operate within the budget constraints, and the report accurately describes the program risk impacts created by the funding challenges.						
		The Orion Program has made significant progress in mitigating the technical risks highlighted in the report. In every example cited, the program experience in developing and implementing the Exploration Flight Test-1 spacecraft has enabled practical resolution of the technical problems sufficient to fly the test in 2014 and is proving design refinements that will be incorporated in later builds of Exploration Mission (EM)-1 and EM-2. This approach of discovering real technical and integration problems on early flight tests, with final resolution in later events, is fundamental to the success of the incremental development strategy being employed by the Orion Program.						
		Orion has experienced some delays during our execution of this aggressive development plan. However, most of the schedule movement identified in the report results from optimizing the timing of specific program scope elements to fit within the funding cap commensurate with the highest priority program objectives.						
<u>.</u>		interactions	notes that the successful development of Orion requires continual and effective with the Space Launch System (SLS) Program and the Ground Systems nt and Operations (GSDO) program. Under the leadership and authority of the					

2 Exploration Systems Development (ESD) Divison, the three programs actively participate in an integration process and governance structure with direct senior level participation. These integration activities are reviewed continually, and adjustments are made as needed to assure effective communications and enable real time decisions to keep the program execution plans moving. Similarly, the Program is building strong relationships and making progress with the European Space Agency to assure their contribution meets the required schedule. Further, NASA must continue its efforts to enhance communication between the Multi-Purpose Crew Vehicle (MPCV), SLS, and GSDO programs to ensure that the schedules for these interdependent programs remain aligned. We encourage NASA managers to be as transparent as possible when discussing the issues facing the MPCV Program and the risks associated with its incremental development. We believe it vital that Congress and the public recognize that incremental spacecraft development is not an optimal way to sustain a human space program. Again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Michelle Bascoe at (202) 358-1574. the for William H. Gerstenmaier

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Subcommittee on Oversight
Subcommittee on Space

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AUGUST 15, 2013

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