

**Statement of  
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**before the**

**Subcommittee on Space and Aeronautics  
Committee on Science, Space and Technology  
U. S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to testify before you regarding the status of NASA's Exploration Systems Development (ESD) Programs: the Orion Multi-Purpose Crew Vehicle (MPCV), the Space Launch System (SLS) heavy-lift launch vehicle, and the necessary launch and processing ground systems. I am pleased to inform you that the dedicated NASA-industry team, working across the Nation utilizing all of the NASA Centers, and our primary industry partners Lockheed Martin, Boeing, ATK, and Pratt Whitney Rocketdyne, is making excellent progress towards developing the next capabilities for human space exploration and scientific missions beyond low-Earth orbit (LEO).

We stand on the shoulders of all those who so tirelessly worked before us to achieve the Apollo Moon landings, to develop and operate the Space Shuttle, to assemble and utilize the International Space Station (ISS), to look deep into the universe with the Hubble Space Telescope, to signal a new era of commercial spaceflight with the ISS docking of the Dragon spacecraft, and, most recently, to successfully accomplish Curiosity's Mars landing. It is particularly fitting that we demonstrate our progress to you as this Nation celebrates the great accomplishments of Neil Armstrong and the entire Apollo team.

## **Introduction**

In line with the NASA Authorization Act of 2010 (P.L. 111-267), the Agency has been moving forward with a space exploration program designed to carry human beings beyond LEO.

The first two major hardware elements of this exploration program are the Orion MPCV spacecraft and SLS heavy-lift launch vehicle. Orion is a four-person spacecraft designed to support exploration missions to multiple destinations beyond Earth orbit, as well as, contingency capability for the ISS. The SLS is a heavy-lift launch vehicle that will transport Orion as well as cargo and other systems, with a range of lift capabilities from 70 metric tons evolving up to 130 metric tons based on future mission requirements.

Orion and SLS fit well within a broader U.S. launch strategy of procuring commercial launches of crew and cargo to the ISS, while concentrating NASA's development efforts on exploration missions beyond Earth orbit. SLS and Orion are fundamental building blocks in a capability-based architecture designed for long-term human exploration of our solar system, particularly the goal of human landing on Mars. Both Orion and SLS are being designed to support multiple missions and destinations rather than being

optimized for one particular mission or architecture. The capabilities we are developing will open a broad range of exciting destinations for human exploration in the solar system. NASA's approach to expanding the human presence into the solar system includes sending humans to an asteroid in the next decade and ultimately sending humans to Mars.

Before speaking in detail about the individual Programs, I would like to give you a status of where we are with regard to the integrated deep space exploration capability. NASA successfully completed an integrated Systems Requirements Review (SRR) in February 2012 for the full-up Orion, SLS, and ground systems capabilities. This milestone demonstrated that the requirements for the integrated programs meet the Agency's goals, and provide a sound basis for the individual development of Orion, SLS, and the ground systems. The Exploration Systems Development Division of NASA's Human Exploration and Operations Mission Directorate directs Program and system integration to ensure that the integrated Orion, SLS, and the ground systems capabilities meet the needs of the Agency's long-term human exploration objectives, function as planned, and remain within the tight cost and schedule constraints.

We have established the guidelines for the management and development approach; identified roles, responsibilities, and accountability; established processes for integration and configuration management, risk management, and program performance reporting; and implemented our procedures for decision making, and cost and schedule management. We have defined Program deliverables, and completed the first phases of the NASA program management process.

We are progressing toward our integrated System Definition Review (SDR) early next year, the associated flow-down processes are properly performed, and the Programs are properly integrated to meet the needs of the human exploration framework. The status of the integrated system will be reviewed and assessed at periodic checkpoints as we proceed through development and into operations. The flight test milestones driving the schedule include the uncrewed Exploration Flight Test-1 (EFT-1) in 2014, the first uncrewed launch of Orion and SLS in Exploration Mission-1 (EM-1) in 2017, and the first crewed launch of Orion and SLS in Exploration Mission-2 (EM-2) in 2021.

Orion was designated as NASA's Multi-Purpose Crew Vehicle in May 2011, and the Ground Systems program office was stood up in June 2011. The SLS vehicle plan was announced a year ago on September 14, 2011.

### **Orion Multi-Purpose Crew Vehicle (MPCV)**

Orion's shape resembles its Apollo-era predecessors, but its technology and capabilities are far more advanced. Orion features dozens of technology innovations that have been incorporated into the spacecraft's subsystem and component design. To support our exploration missions the Orion teams at the Johnson Space Center (JSC) and at Lockheed Martin are developing state-of-the-art life support, propulsion, thermal protection, and avionics systems. Building upon the best of U.S. human spaceflight design and experience, the Orion spacecraft includes both crew and service modules, and a launch abort system that will significantly increase crew safety.

Since May 2011, the Orion Program has pressed forward with the design and manufacture of the first flight test article and design of Orion's critical test program. On July 2, the Program delivered the first flight test crew module structure to the Kennedy Space Center (KSC) for assembly and integration. In addition, the Program has completed significant acoustic and vibration testing in the Lockheed Martin Denver facilities, 19 of 25 water impact tests at Langley Research Center, and 6 of 26 parachute tests in various configurations at the Yuma Proving Grounds. Fabrication of the state-of-the-art heat shield has

been initiated in Denver, and NASA continues to test avionics and software systems. Glenn Research Center is leading the Orion Service Module efforts with Lockheed Martin.

The next step for Orion is to prepare for the EFT-1 in 2014. EFT-1 will be an uncrewed, two-orbit, high-energy-entry test mission that will obtain critical vehicle performance data needed to confirm detailed design of the Orion spacecraft to fly in 2017. EFT-1 will serve as a pathfinder to validate innovative approaches to space systems development to reduce cost, demonstrate spacecraft post-landing recovery procedures, and develop the launch vehicle adapter, which will also be used on the uncrewed flight in 2017 and the first crewed flights beginning in 2021. In the next year, we will continue EFT-1 manufacturing and begin phasing in, at a low level, the design work for the 2017 Orion flight article. Mission planning for the EFT-1 with the JSC Mission Operations Directorate is ongoing.

In the next year, we will continue to press toward the 2014 flight test, ramp up the service module design efforts for 2017, and begin phasing in, at a low level, the design work for the 2017 Orion flight article.

Orion provides our Nation with an approach for multiple-mission capability that builds upon the technology innovations and spacecraft development the NASA-industry team has previously accomplished. In designing for challenging deep space missions, the Orion team will perform rigorous human rating tests and critical certification milestones required for safe, successful human spaceflight. With a proven launch abort system and its inherent design to provide the highest level of safety for the crew during long-duration missions, the Orion MPCV is poised to take on increasingly challenging missions that will take human space exploration beyond Earth orbit and out into the solar system.

### **Space Launch System (SLS)**

The SLS Program, managed at NASA's Marshall Space Flight Center (MSFC) with the Boeing, ATK, and Pratt Whitney Rocketdyne industry partners, is developing the heavy-lift vehicle that will launch the Orion spacecraft, and cargo, for NASA's exploration missions. The SLS vehicle family will start with a lift capability of 70 metric tons (mt) to LEO, with the ability of evolving up to 130 mt based on future mission requirements. The SLS is designed with one overarching purpose: to explore beyond Earth orbit with ambitious mass and propulsion requirements.

The initial 70-mt configuration will consist of an 8.4-meter-diameter core stage building from Space Shuttle and Ares experience, powered by four RS-25D liquid hydrogen/liquid oxygen engines which formerly powered the Space Shuttle Orbiter, and build on the U.S. state-of-the-art capabilities in liquid propulsion. The core stage is being designed for use on future configurations of the SLS with the diameter, materials, and manufacturing processes remaining the same as the vehicle performance evolves. In this configuration, two five-segment solid rocket boosters (SRBs) – a more powerful version of the four-segment boosters used on the Space Shuttle – will be attached to the core stage for the initial boost phase of flight. For the first two missions of SLS, an Interim Cryogenic Propulsion Stage (ICPS) will be used to propel the Orion spacecraft from LEO. NASA has chosen Boeing's Delta IV upper stage as the ICPS for the first two flights, and the contract is expected to be signed in the third quarter of FY 2013. We anticipate having a letter contract by the end of the year, followed by the final contract in the spring.

Since the Administration announcement in September 2011 of the SLS configuration, the SLS team led by MSFC has made tremendous progress. The SLS team successfully completed the required acquisition strategy process and had all contractors working on contract by December 31, 2011. This was a major accomplishment, and it led to significant progress in the design process. The SLS NASA-industry team has successfully completed the Systems Requirements Review, the System Definition Review, and has gained Agency-level approval to proceed to the Preliminary Design Review.

The NASA/Boeing Core Stage element has successfully completed its SRR and SDR. Manufacturing process development has proceeded to support the core stage and vehicle design efforts. NASA has initiated activities to prepare the B-2 test stand at Stennis Space Center (SSC) for Core Stage green run testing that will be performed prior to shipment to KSC for launch in 2017. The Core Stage element is on the critical path for the SLS, and all hands are on deck to achieve the aggressive schedule.

The initial segments for the first of two solid booster Qualification Motor tests have been poured at ATK and the 5-segment solid rocket motor is on track for a test firing next May. ATK has delivered booster avionics systems and Boeing has delivered vehicle avionics and software to MSFC for testing. The 15 RS-25D liquid hydrogen/liquid oxygen engines have been delivered to SSC from the KSC in preparation for installation and test on the Core Stage.

SLS is also an integral part of the 2014 EFT-1. SLS is responsible for designing and developing the structure adapter to attach the Orion spacecraft to the launch vehicle. This same structure will be used on the uncrewed flight in 2017 and first crewed mission in 2021. Machining on the first set of metal rings has been completed.

Future exploration missions will require increased launch vehicle performance. We have initiated the first phase for the development of the advanced boosters needed to perform these future missions. In July 2012, NASA selected six proposals as the basis for negotiations to perform engineering demonstrations and risk reduction under an open, competitive NASA Research Announcement (NRA) to improve the boosters' affordability, reliability, and performance. The advanced boosters can be either liquid or solid, and must meet the SLS performance and interface requirements. These initial risk-reduction tasks will be followed by another full-and-open competition for the full scale design and development work leading to an eventual advanced booster for the evolved SLS.

The 70-mt, 105-mt, and 130-mt lift capability SLS vehicle blocks all fulfill specific, important roles within the exploration architecture. The Block 1, 70-mt vehicle will prove out the new Core Stage and integrated stack for the initial exploration missions and can support scientific payloads with requirements beyond commercial lift capabilities. Mission analysis has shown that the Block 1A, 105-mt vehicle provides significant "mission capture" for the next set of human missions beyond LEO. A 130-mt Block 2 vehicle is also being designed consistent with Congressional direction and would be used for full capability asteroid missions and ultimately missions to Mars. This SLS configuration will require a new upper stage with one or two J-2X upper-stage engines—currently in development testing at SSC. J-2X has completed a total of over 3,250 seconds over 29 tests on the engine and powerpack.

In the coming calendar year, SLS will undergo a series of important reviews to ensure its progress toward final design. The Preliminary Design Review (PDR) will be conducted for the integrated SLS Block 1 vehicle, as will the PDRs for the booster and core stage elements.

## **Exploration Ground Systems**

The Exploration Ground Systems effort has also been making significant progress since the September 2011 SLS announcement. The KSC and SLS teams are working very closely to define and develop the necessary interfaces for the launch vehicle. In a similar manner, albeit at a lower level, KSC has been working with the Orion program on the needed prelaunch processing to be performed.

The KSC team has made significant progress on the necessary infrastructure design, development, and refurbishment to support SLS and Orion. Based upon the SLS and Orion needs, KSC is proceeding

through the Systems Requirements and Systems Definition Reviews. The reviews are proceeding well with minimal issues, and we are continuing the Agency review process. KSC is also providing valuable operations expertise to the SLS and Orion teams to address operational issues in the design in order to help reduce eventual production and operations costs.

In terms of the infrastructure and hardware, KSC has completed the first phase of the mobile launcher construction, utilizing significant work accomplished under Constellation. Refurbishment and upgrades to a crawler-transporter are being performed at a pace to support the 2017 flight of SLS and Orion. These upgrades are needed due to the increased mass of the SLS/Orion integrated stack compared to the Space Shuttle configuration.

Work is beginning on the Vehicle Assembly Building and the platforms in High Bay 3 to support SLS. Launch Complex 39-B has been prepared for the SLS/Orion mobile launcher with the Space Shuttle hardware removed, lightning towers in place, and the needed refurbishment to the pad infrastructure with replacement of copper wire with fiber optics and refurbishment of the water deluge supply tower.

## **Conclusion**

The NASA-industry team has made great progress over the past year on Orion, SLS, and Exploration Ground Systems. In an endeavor of this magnitude there will always be challenges. Currently, the major challenges to the programs are not primarily technical. Rather, the challenges are in maintaining program stability while acquiring the Orion and SLS systems so that the next elements of the Exploration enterprise can be developed. Additionally, there will be the typical hardware development, manufacturing, and supply chain challenges. NASA and its industry team are working diligently to identify issues early and address them expeditiously.

In developing the Orion, SLS, and Exploration Ground Systems, NASA is building a National capability for the long-term human exploration of space. By providing more volume and mass for payloads, SLS could enable the simplification of the design and trajectories of future payloads, such as orbiting fuel depots, to support the construction, fueling, and repair of space systems. These capabilities will pave the way for a mission to an asteroid, and ultimately human missions to Mars.

Mr. Chairman, thank you for the opportunity to appear before you today to provide you with our progress and status over the past year as we look forward to the 2014 Orion flight test and the first SLS/Orion test flight in 2017. I would be happy to respond to any questions you or the other Members of the Subcommittee may have.