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Statement of
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before the

Subcommittee on Space
Committee on Science, Space and Technology
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Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to testify before you about the progress we are making in developing NASA's next generation of human deep-space exploration vehicles: the Orion crew vehicle and the heavy-lift Space Launch System (SLS).

Orion and SLS are part of a larger exploration architecture that will enable multiple missions and destinations over the next few decades, including human missions to asteroids and Mars. Affordable manufacturing and operating costs will be important to the sustainability of SLS and Orion. NASA's near-term strategy for exploration has several interlocking components: using the unique environment of the International Space Station (ISS) to conduct the research and technology demonstrations necessary to keep our crews safe and productive on long-duration spaceflights; partnering with commercial entities to develop the capacity to transport cargo and crew affordably to low-Earth orbit (LEO); working in collaboration with NASA's Science, Space Technology, and Aeronautics Research Mission Directorates to better understand exploration destinations, improve our ability to work there, and understand aerodynamics at Mars and upon Earth return; continuing to work with international partners to jointly explore our solar system; and moving outward to deep space with Orion and the SLS to take us there.

Orion and the SLS are foundational capabilities for the implementation of our integrated human and robotic exploration strategy. We will travel beyond LEO to the proving ground of cis-lunar space where we will expand and test our capabilities with a series of crewed missions with SLS and Orion, including a mission to rendezvous with a redirected asteroid in lunar orbit. The Orion and SLS systems are designed to allow us to build the skills and capabilities necessary for deep-space human exploration in the proving ground of space around the Moon. These steps will build the foundation for further deep-space exploration. With the technologies and techniques we develop, we will enable expeditions to multiple destinations, allowing us to access many other destinations and ultimately pioneer Mars. We are laying the groundwork for extending human presence in the solar system. Conceived in coordination with our international partners, this strategy maintains America's role as the world's leader and foundational partner in space exploration.

Exploration Flight Test-1

Last week's successful Exploration Flight Test-1 (EFT-1) is a critical milestone on our journey to Mars and serves as the pathfinder to validate approaches to space systems development. The test demonstrated spacecraft post-landing recovery procedures and the launch vehicle adapter, which will also be used on the uncrewed Exploration Mission-1 (EM-1) in FY 2018, and the crewed Exploration Mission-2 (EM-2) in FY 2021-2022. EFT-1 tested the Orion heat shield at about 85 percent of lunar re-entry velocity, protecting the vehicle from temperatures near 4,000 degrees Fahrenheit. Data collected during the EFT-1 flight test will reduce or eliminate 13 of the top 17 risk drivers for the first crewed flight (EM-2). The flight test also demonstrated nearly 50 percent of the design, development, test, and evaluation (DDT&E) required for EM-2, and included about 50 percent of the software needed for the first crewed mission. Not only did EFT-1 test hardware and software, but it also tested key processes which will be needed for EM-2.

Orion and SLS: Traveling Beyond LEO

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 Aerojet-Rocketdyne, is making excellent progress toward developing the next capabilities for human and robotic space exploration missions beyond LEO. The first uncrewed launch of Orion on SLS on EM-1 is slated for FY 2018, and the first crewed launch of Orion and SLS on EM-2 for FY 2021-2022. Both Orion and SLS are being designed to enable multiple missions and destinations rather than being optimized for one particular mission or architecture. Early missions will use cis-lunar space as a proving ground to test out capabilities and operations needed for missions to Mars in a safe and sustainable manner. One early demonstration mission in cis-lunar space will be to rendezvous with and return samples from a near-Earth asteroid. SLS is evolvable to provide progressively greater lift capability, and, with Orion, will enable humankind to successfully navigate the proving ground of deep space, ultimately sending humans to a variety of destinations in the solar system, including Mars.

The Orion spacecraft will be capable of taking humans farther into space than ever before, to multiple destinations as needed, and sustaining them in this challenging environment for longer than ever before. The Orion spacecraft includes both crew and service modules, and a Launch Abort System that will provide for improved crew abort capability. Orion can fly a crew of up to four for 21 days. Orion has a focused and rigorous step-wise test campaign to validate these capabilities in the challenging deep-space environment.

In 2014, in addition to completing the first Orion capsule for flight on EFT-1, the program has begun manufacturing components for EM-1, forging elements for the primary structure, building avionics kits, and procuring parts with a long lead time. In addition, the program continues to work with the European Space Agency as it develops the Orion service module for EM-1.

In FY 2015, the program will focus on preparing for Orion's first exploration mission, EM-1. EM-1 is an uncrewed test flight to lunar orbit, and will be the first pairing of Orion with the Space Launch System. The multi-day flight will provide the program with data, which, combined with data gained from EFT-1, will validate spacecraft design and operations. The Orion program will continue fabricating the crew module primary structure, and start to assemble secondary structures and mechanisms such as propulsion systems, and environmental control and life support. It will also complete its series of parachute tests and begin testing spacecraft avionics. Finally, the program will complete key programmatic reviews, ensuring Orion's readiness to progress to the next phase of the development life-cycle, at which point, the Agency commitment to cost and schedule milestones will be established.

The SLS is a heavy-lift, exploration-class launch vehicle that will transport Orion, as well as cargo and other systems, with a range of lift capabilities from 70 metric tons to LEO, evolving to 105 metric tons and eventually up to 130 metric tons, based on future mission requirements. The evolution of the SLS lift capability fulfills specific, important roles within the exploration architecture, with the 130-metric-ton vehicle enabling future crewed missions to the Mars vicinity.

In 2014, NASA has made significant strides in SLS development. With the conclusion of negotiations for the Stages and Interim Cryogenic Propulsion Stage contracts in June and October 2014, respectively, all major elements for the SLS Block 1 are on contract. For the SLS Block 1 configuration to be flown on EM-1, the program successfully cleared the Agency's Key Decision Point C (KDP-C) milestone in August 2014, marking the transition from program formulation into development. This milestone provides a development cost baseline for the 70-metric ton version of the SLS of $7.021 billion from February 2014 through the first launch and a launch readiness schedule based on an initial SLS flight no later than November 2018. The establishment of this Agency commitment to cost and schedule for SLS at the 70-percent confidence level represents the Agency's formal SLS launch readiness commitment, established after a thorough Agency review process, and addresses Government Accountability Office (GAO) recommendations about matching resources to program requirements. NASA continues to hold the SLS program to an internal launch readiness planning schedule that is earlier than the commitment date. NASA is in the process of updating this internal planning schedule based on a better understanding of work and budget phasing. The appropriations that SLS has received to date have enabled the program to effectively manage risks to the internal planning date.

Both the Core Stage and Booster elements completed their Critical Design Reviews (CDRs) in July and August 2014, respectively, which keeps the program on track for the program-level CDR in 2015. Preparation for next year's CDR has been supported by a wide range of important hardware testing across NASA, including the last buffet wind tunnel test at Langley Research Center, testing of the Core Stage flight computers during the spring, and acoustic model testing of SLS during launch at Marshall Space Flight Center (MSFC) throughout the year.

Production of the first pieces of test and actual EM-1 flight hardware is also underway. The structural rings and engine barrel section for the EM-1 Core Stage are being welded at the Michoud Assembly Facility (MAF), and the first complete verification tank has been completed. NASA is utilizing new, state-of-the-art welding tools to increase the efficiency of Core Stage manufacturing compared to processes used to build Space Shuttle External Tanks. The largest of these tools, the Vertical Assembly Center (VAC) tool, was activated at MAF in Louisiana in July 2014, and the first full-duration test weld on the VAC took place in September 2014. The VAC is the final of six major weld tools at MAF that will produce the SLS Core Stage structure using less than half the labor of Space Shuttle External Tank production. The VAC is scheduled to be validated for flight welds by February 2015 and to be ready to support flight hardware manufacturing. Other major SLS facility work in 2014 includes the new structural test stands at MSFC, which broke ground in August 2014, and the B-2 test stand at the Stennis Space Center (SSC), which, through the use of an innovative Center contracting vehicle, continues to run on schedule and on cost in preparation for the start of Core Stage testing in FY 2017.

Progress continues on the other elements of SLS as well, reflecting both the challenges of advanced spaceflight hardware and the resiliency and innovation of the Government and contractor teams to overcome these challenges. The first SLS flight hardware, the Multipurpose Crew Vehicle Stage Adaptor (MSA), was completed in May 2014 for flight on EFT-1. At SSC, preparations continue to install and test an RS-25 engine in the A-1 test stand, the first time one of these engines (previously known as the Space Shuttle Main Engine) has been tested in over five years. The first hotfire of the RS-25 should take place in early 2015. For the Booster element, a complex chemical and mechanical interaction between the propellant and a new case liner resulted in unexpected voids that posed a testing risk; through an intensive focused effort by the team, new production processes were introduced and a new aft segment, PSA-2, is void-free and ready to support Qualification Motor 1 (QM-1) testing in Spring 2015. SLS remains on track for its program CDR next year.

The Ground Systems Development and Operations (GSDO) team at Kennedy Space Center (KSC) continues to make significant progress on the necessary Exploration Ground Systems (EGS) infrastructure design, development, and refurbishment to support SLS and Orion. KSC also is 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. This is a key aspect of assuring long-term sustainability for deep-space human exploration. In 2014, construction of new platforms in the Vehicle Assembly Building at KSC will enable SLS and Orion stacking and preflight processing as planned. Refurbishment and upgrades to a crawler-transporter, which will accommodate up to the 130-metric-ton version of SLS – a vehicle more powerful than the Saturn V – are being performed to support the FY 2018 EM-1 flight of SLS and Orion.

Orion, SLS, and EGS teams are using the latest in systems and manufacturing technology with the intent of developing the safe, affordable, and sustainable systems this country needs to extend human presence to Mars. For example, the Orion team is using time-triggered Ethernet and is taking advantage of the standards for this technology that are used in the automotive industry. Both Orion and SLS are utilizing friction-stir welding (including on large structures, such as the SLS Core Stage), culminating in the most advanced and largest friction-stir weld machine in the world. The EGS team has stripped out the old copper cables from Pad 39B and replaced them with the latest in fiber optics. These are three simple examples of how NASA's Exploration Systems are utilizing and advancing the latest in technology.

In developing the Orion, SLS, and EGS, NASA is seeking to build a sustainable national capability for the long-term human exploration of space. NASA is keeping each element of the program – SLS, ground systems, and Orion – moving at its best possible speed toward the first integrated launch, optimizing each element effort's schedule while being aware of the overall plan. This is best achieved when each element is allowed to progress on its own schedule, rather than being linked too tightly to the others. When tasks related to EM-1 are completed, the workforce can progress to EM-2. NASA is on a solid path toward an integrated mission and making progress in all three programs every day.

The evolving capabilities of these systems will provide the nation with flexibility over the long term to achieve a variety of goals. As we move further into the solar system to establish footholds in a variety of locations, having such flexibility will be important, as future missions can be built on what our astronauts and robotic probes learn in successive expeditions.

Conclusion

NASA's exploration strategy is designed to pioneer multiple destinations in the solar system. Over time, we will move beyond conducting limited-duration forays and begin to lay the groundwork to establish outposts in cis-lunar space. From there, we can expand human presence in the solar system and to the surface of Mars, and utilize *in situ* resources as we extend the reach of humanity. The key to realizing this goal will be to channel all of the factors that have enabled our space achievements to date in a way that will ensure a sustainable foundation on which future generations can continue to build. With the continued support of Congress, this long-term effort will expand the sphere of human life and activity, and draw upon the pioneering spirit and ingenuity, in the face of the seemingly impossible, that have helped make the United States the exceptional nation that it is.

Mr. Chairman, thank you for the opportunity to appear before you today to provide you with a status of our progress on Orion and SLS. NASA has a robust strategy that extends human presence into the solar system in an affordable and sustainable manner, and Orion and SLS are key initial steps in that strategy. I would be happy to respond to any questions you or the other Members of the Subcommittee may have.