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Space Launch System Spacecraft and Payload Elements: Progress Toward Crewed Launch and Beyond

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While significant and substantial progress continues to be accomplished toward readying the Space Launch System (SLS) rocket for its first test flight, work is already also underway on preparations for the second flight – using an upgraded version of the vehicle – and beyond. Designed to support human missions into deep space, Space Launch System (SLS), is the most powerful human-rated launch vehicle the United States has ever undertaken, and is one of three programs being managed by the National Aeronautics and Space Administration's (NASA's) Exploration Systems Development division. The Orion spacecraft program is developing a new crew vehicle that will support human missions beyond low Earth orbit (LEO), and the Ground Systems Development and Operations program is transforming Kennedy Space Center into a next-generation spaceport capable of supporting not only SLS but also multiple commercial users. Together, these systems will support human exploration missions into the proving ground of cislunar space and ultimately to Mars. For its first flight, SLS will deliver a near-term heavy-lift capability for the nation with its 70-metric-ton (t) Block 1 configuration. Each element of the vehicle now has flight hardware in production in support of the initial flight of the SLS, which will propel Orion around the moon and back. Encompassing hardware qualification, structural testing to validate hardware compliance and analytical modeling, progress in on track to meet the initial targeted launch date. In Utah and Mississippi, booster and engine testing are verifying upgrades made to proven shuttle hardware. At Michoud Assembly Facility in Louisiana, the world's largest spacecraft welding tool is producing tanks for the SLS core stage. Providing the Orion crew capsule/launch vehicle interface and in-space propulsion via a cryogenic upper stage, the Spacecraft/Payload Integration and Evolution (SPIE) element serves a key role in achieving SLS goals and objectives. The SPIE element marked a major milestone in 2014 with the first flight of original SLS hardware, the Orion Stage Adapter (OSA) which was used on Exploration Flight Test-1 with a design that will be used again on the first flight of SLS. The element has overseen production of the Interim Cryogenic Propulsion Stage (ICPS), an in-space stage derived from the Delta Cryogenic Second Stage, which was manufactured at United Launch Alliance in Decatur, Alabama, prior to being shipped to Florida for flight preparations. Manufacture of the Orion Stage Adapter and the Launch Vehicle Stage Adapter (LVSA) took place at the Friction Stir Facility located at Marshall Space Flight Center in Huntsville, Alabama. Marshall is also home to the Integrated Structural Test of the ICPS, LVSA, and OSA, subjecting the stacked components to simulated stresses of launch. The SPIE Element is also overseeing integration of 13 "CubeSat" secondary payloads that will fly on the first flight of SLS, providing access to deep space regions in a way currently not available to the science community. At the same time as this preparation work is taking place toward the first launch of SLS, however, the Space Launch System Program is actively working toward its second launch. For its second flight, SLS will be

upgraded to the more-capable Block 1B configuration. While the Block 1 configuration is capable of delivering more than 70 metric tons to low Earth orbit, the Block 1B vehicle will increase that capability to 105 t. For that flight, the new configuration introduces two major new elements to the vehicle – an Exploration Upper Stage (EUS) that will be used for both ascent and in-space propulsion, and a Universal Stage Adapter (USA) that serves as a "payload bay" for the rocket, allowing the launch of large exploration systems along with the Orion spacecraft. Already, flight hardware is being prepared for the Block 1B vehicle. Welding is taking place on the second rocket's core stage. Flight hardware production has begun on booster components. An RS-25 engine slated for that flight has been tested. Development work is taking place on the Exploration Upper Stage, with contracts in place for both the stage and the RL10 engines which will power it. (The EUS will use four RL10 engines, an increase from one on the ICPS.) For the crew configuration of the Block 1B vehicle, the SLS SPIE element is managing the USA and accompanying Payload Adapter, which will accommodate both large payloads co-manifested with Orion and small-satellite secondary payloads. This co-manifested payload capacity will be instrumental for missions into the Proving Ground around the moon, where NASA will test new systems and demonstrate new capabilities needed for human exploration farther into deep space. Beyond the second flight, additional upgrades will be made to the vehicle. The Block 1B vehicle will also be able to launch 8.4-meter-diameter payload fairings, larger than any previously flown, and the SPIE Element will oversee development and production of those fairings. Ultimately, SLS will be evolved to a Block 2 configuration, which will replace the solid rocket boosters on the Block 1 and 1B vehicles with more powerful boosters, and will be capable of delivering at least 130 metric tons to LEO. The Block 2 vehicle will be capable of launching even larger 10-meter diameter fairings, which will enable human mission of Mars. With these fairings, the Block 1B and 2 configurations of SLS will also be enabling for a wide variety of other payloads. For robotic science probes to the outer solar system, for example, SLS can cut transit times to less than half that of currently available vehicles, producing earlier data return, enhancing iterative exploration, and reducing mission cost and risk. In the field of astrophysics, SLS' high payload volume, in the form of payload fairings with a diameter of up to 10 meters, creates the opportunity for launch of large-aperture telescopes providing an unprecedented look at our universe, and offers the ability to conduct crewed servicing missions to observatories stationed at locations beyond low Earth orbit. This paper will provide a description of the SLS vehicle, and an overview of the vehicle's capabilities and utilization potential. It will outline progress toward the first two flights, as well as future launches, with a focus on the work being done by the SPIE Element to prepare SLS for its early flights in beginning a new era of human exploration of space.