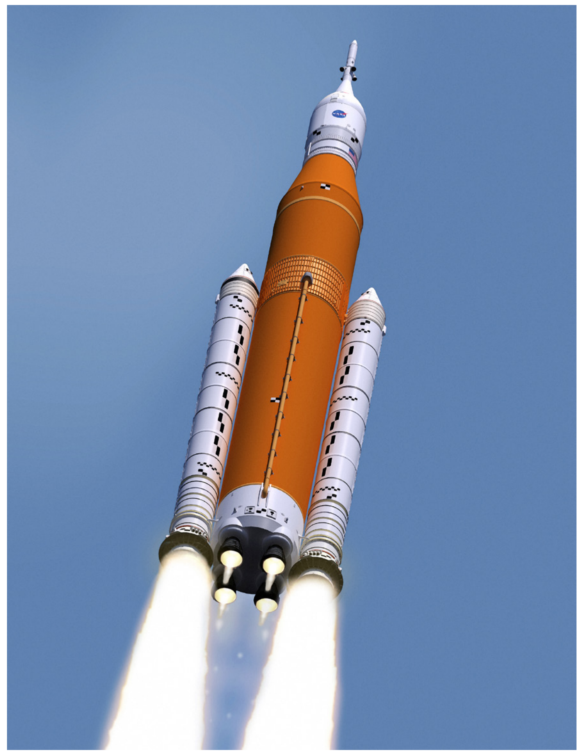
Space Launch System

Building America's New Rocket for Deep Space Exploration



NASA's Space Launch System, or SLS, is a powerful, advanced launch vehicle for a new era of human exploration beyond Earth's orbit. With its unprecedented power and capabilities, SLS will launch crews of up to four astronauts in the agency's Orion spacecraft on missions to explore multiple, deep-space destinations.

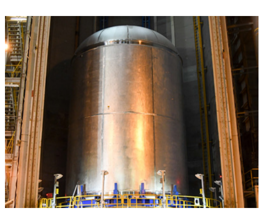
Offering more payload mass, volume capability and energy to speed missions through space than any current launch vehicle, SLS is designed to be flexible and evolvable and will open new possibilities for payloads, including robotic scientific missions to places like Mars, Saturn and Jupiter.

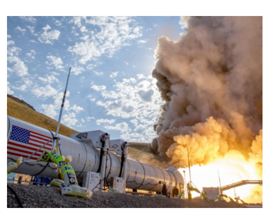
In 2015, NASA completed the critical design review — a first for a NASA human-rated launch vehicle since the space shuttle almost 40 years ago. SLS continues to move forward with production of the first exploration-class launch vehicle built since the Saturn V. Engineers continue to make progress aimed toward delivering the first SLS rocket to NASA's Kennedy Space Center in Florida for its first launch.

The Power to Explore Beyond Earth's Orbit

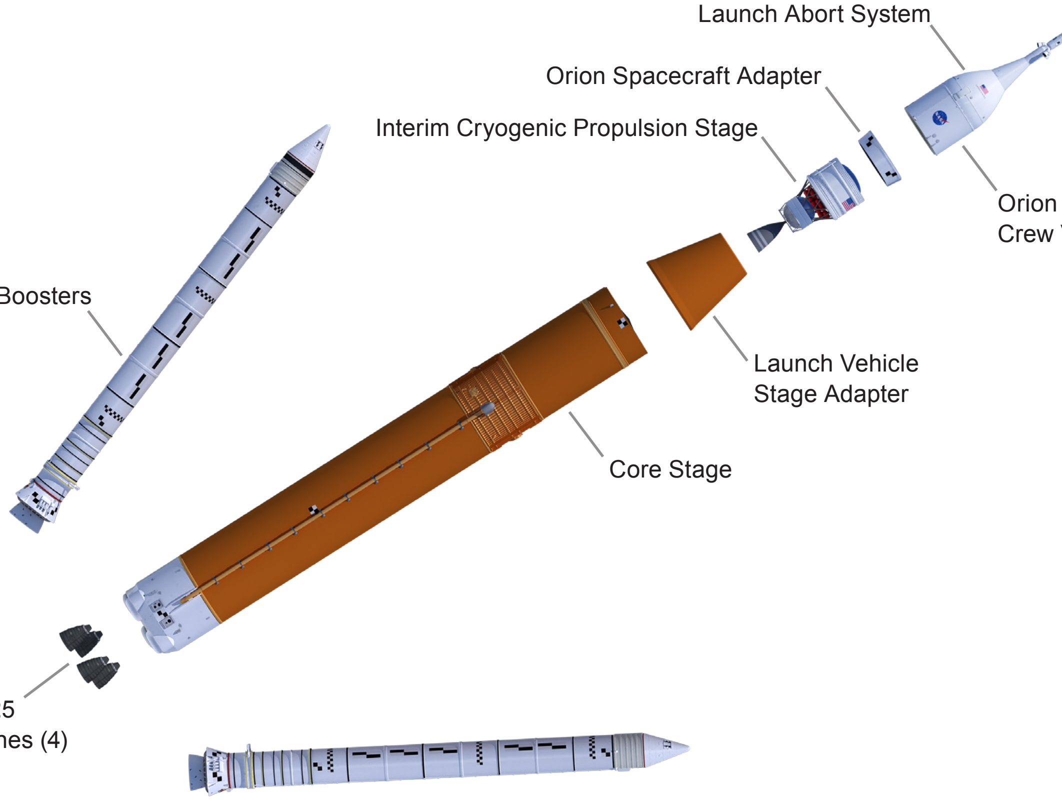
To fit NASA's future needs for deep-space missions, SLS is designed to evolve into increasingly more powerful configurations. The first SLS vehicle, called Block 1, has a minimum 70-metric-ton (77-ton) lift capability. It will be powered by twin five-segment solid rocket boosters and four RS-25 liquid propellant engines, as well as a modified version of an existing upper stage. The next planned evolution of the SLS, Block 1B, will use a new, more powerful Exploration Upper Stage (EUS) to enable more ambitious missions and deliver a 105-metric-ton (115-ton) lift capacity. A later evolution, Block 2, would replace the current five-segment boosters with a pair of advanced solid or liquid propellant boosters to provide a 130-metric-ton (143-ton) lift capacity. In each configuration, SLS will continue to use the same core stage design with four RS-25 engines. An evolvable design allows NASA to

Above: Artist rendering of the SLS Block 1 configuration launch. Below from left: Core stage engine section at MSFC, LOX tank in weld facility, QM-2 solid rocket motor test firing, RS-25 test firing.





SLS Block 1 Initial Configuration



provide the nation with a rocket able to pioneer new human spaceflight missions and revolutionary scientific missions in the shortest time possible, while continuing to develop more powerful configurations. The next wave of human exploration will take explorers farther into the solar system — developing new technologies, inspiring future generations and expanding our knowledge about our place in the universe.

Capabilities and Missions

The initial Block 1 configuration of SLS will stand 322 feet tall, higher than the Statue of Liberty, and weigh 5.75 million pounds fueled. It will produce 8.8 million pounds of thrust at liftoff, equivalent to more than 160,000 Corvette engines. The Block 1 configuration will provide 15 percent more thrust at launch than the Saturn V rocket and carry more than three times the mass of the space shuttle.

Using the Block 1 configuration, the first SLS mission — Exploration Mission-1 (EM-1) — will launch an uncrewed Orion spacecraft to a stable orbit beyond the moon and bring it back to Earth to demonstrate the integrated system performance of the SLS rocket and Orion spacecraft and ground support teams prior to a crewed flight. The second SLS mission, Exploration Mission-2, will launch Orion with a crew of up to four astronauts on a second mission to the vicinity of the moon, farther into space than humans have ever ventured.

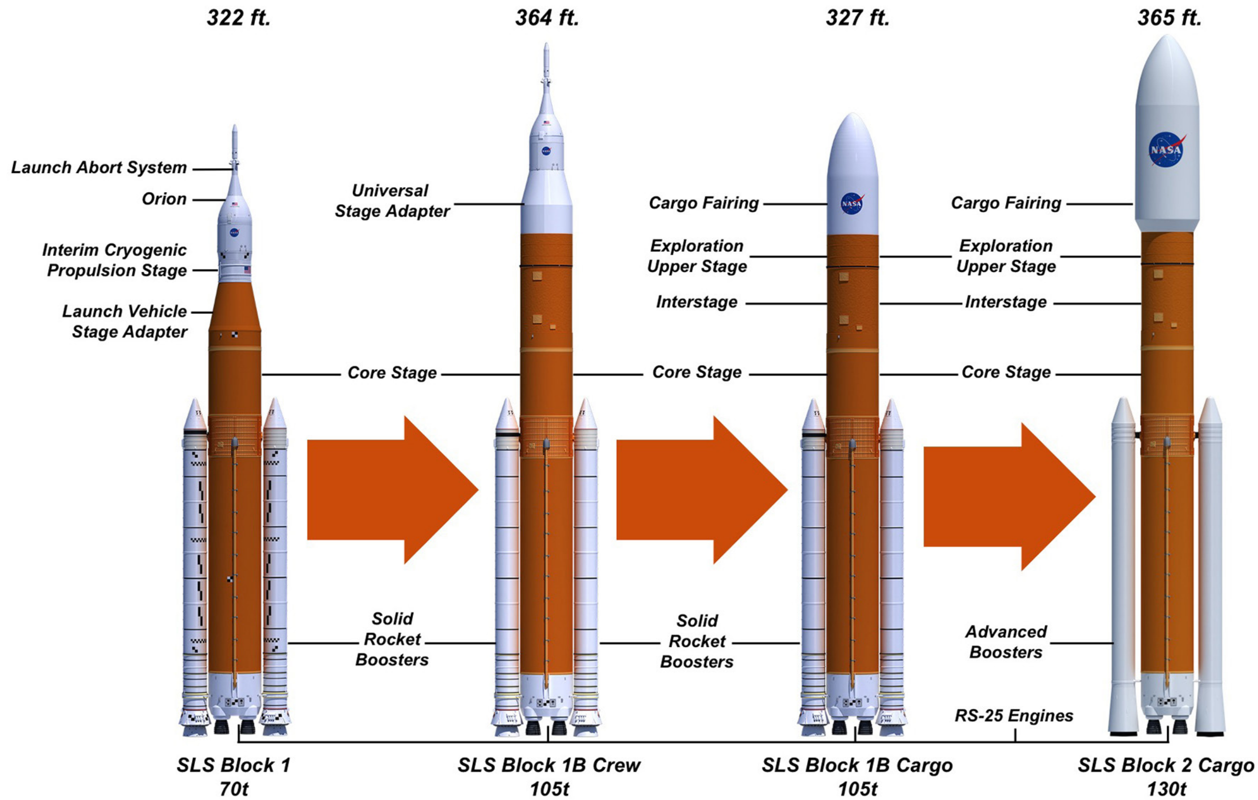
The Block 1B crewed configuration will be approximately 364 feet tall, taller than the Saturn V rocket. The Block 1B vehicle will be used to launch humans on even more ambitious missions to the "proving ground" of space near and beyond the moon, where NASA will test systems needed for the journey to Mars. Using the EUS, the Block 1B vehicle can, in a single launch, carry the Orion crew vehicle along with exploration systems like a small deep-space habitat module, or fly dedicated missions carrying larger exploration systems or science spacecraft under a payload fairing.

The next evolved configuration, called Block 2, will be the workhorse vehicle for assembling a human mission to Mars. It is estimated that Block 2 will provide 9.2 million pounds of thrust at liftoff and weigh 6.5 million pounds.

Building the Rocket

SLS is built on proven hardware from the space shuttle and other exploration programs while making use of cutting-edge tooling and manufacturing technology in order to significantly reduce development time and cost.

SLS Evolved Configurations



Using proven hardware reduces the upfront cost and time needed to develop the Block 1 vehicle and also serves as a basis for upgrading the SLS to provide more capability.

Core Stage

The Boeing Company, headquartered in Chicago, is developing the SLS core stage, including the avionics that will control the vehicle during flight. Towering more than 200 feet tall with a diameter of 27.6 feet, the core stage will store 730,000 gallons of super-cooled liquid hydrogen and liquid oxygen that will fuel the RS-25 engines for the SLS. The core stage is being built at NASA's Michoud Assembly Facility in New Orleans using state-of-the-art manufacturing equipment, including a friction-stir-welding tool that is the largest of its kind in the world. At the same time, the rocket's avionics computer software is being developed at NASA's Marshall Space Flight Center in Huntsville, Alabama.

RS-25 Engines

Propulsion for the SLS core stage will be provided by four RS-25 engines. Aerojet Rocketdyne of Sacramento, California, is upgrading an inventory of 16 RS-25 shuttle engines to SLS performance requirements, including a new engine controller, nozzle insulation and required operation at 418,000 pounds of thrust instead of 395,000 pounds normally used for shuttle.

Boosters

Two shuttle-derived solid rocket boosters will be used for the initial flights of the SLS. Each one provides 3.6 million pounds of thrust. To provide the additional power needed for the rocket, the prime contractor for the boosters, Orbital ATK, headquartered in Dulles, Virginia, has modified them from the shuttle's configuration using four propellant segments to a five-segment version. The design also includes new avionics, propellant design and case insulation, and elimination of the recovery parachutes. Orbital ATK has successfully completed a full-duration booster qualification ground test, and is preparing for a second qualification test firing in 2016.

Spacecraft and Payload Adapter, Fairings and In-Space Stage

Exploration Flight Test-1, Orion's first trip to space in 2014, marked the first use of hardware designed for SLS: a stage adapter that connected Orion to a rocket upper stage. The adapter was developed by the SLS team responsible for integrating the Orion spacecraft and other payloads with the

vehicle. The same adapter design will be used on the EM-1 mission. Another, larger adapter is being built by Teledyne Brown Engineering of Huntsville, Alabama, and will connect SLS's core stage to the upper stage for its first flight.

The initial capability to propel Orion out of Earth's orbit for EM-1 will come from an Interim Cryogenic Propulsion Stage (ICPS), based on the Delta Cryogenic Second Stage used successfully on United Launch Alliance's Delta IV family of rockets. It uses one RL-10 engine powered by liquid hydrogen and oxygen and generates 24,750 pounds of thrust.

Evolving the Launch Vehicle to Increase Capability

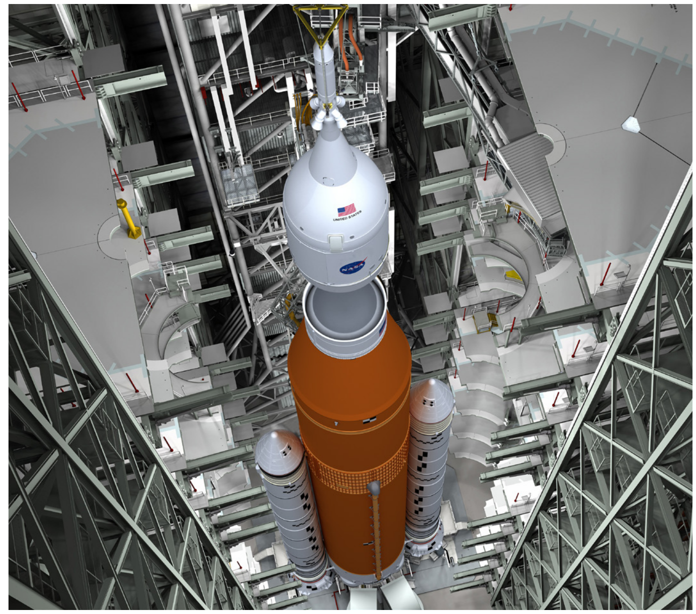
While work progresses on the initial Block 1 SLS, an advanced development team is investing in new systems and technologies that will make SLS even more powerful, while improving affordability and increasing reliability. This evolved, flexible approach lets SLS carry out a wide variety of missions sooner, while incrementally increasing the power of the vehicle. The advanced development team is engaging NASA, the Department of Defense, industry and academia to provide the most innovative and affordable ideas for advanced development in areas including: improvements to structures, materials, manufacturing, avionics, software and analysis techniques. These new technologies not only will continue to define SLS as a cutting-edge launch vehicle, but also will benefit the entire U.S. launch industry.

Exploration Upper Stage

Future configurations of SLS will include the larger EUS, which will lift 105 metric tons (115 tons) and support more capable human and robotic missions to deep space. The EUS will replace the Block 1 ICPS and utilize an 8.4-meter (27.6-foot) diameter forward liquid hydrogen tank and a smaller diameter liquid oxygen tank.

Advanced Boosters

Reaching the full potential of SLS will require advanced boosters with a significant increase in performance over existing boosters. NASA has engaged with industry teams to research benefits, technologies and strategies for liquid and solid advanced boosters that reduce risks while enhancing affordability, improving reliability and meeting performance goals in preparation for an eventual full design, development, test and evaluation advanced booster activity.



Agency Partners

The SLS Program at the Marshall Center has been working closely with the Orion Program, managed by NASA's Johnson Space Center in Houston, and the Ground Systems Development and Operations Program at the agency's Kennedy Space Center. All three programs are managed by the Exploration Systems Development Division within the Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington. All NASA centers have been involved in the development of SLS, providing services including wind-tunnel analysis, engine testing and payload fairing research.

For more information about SLS, visit:

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