National Aeronautics and Space Administration

NASAfacts

Space Launch System

America's Rocket for Deep Space Exploration

NASA's SLS (Space Launch System) is a super heavy-lift rocket that provides the foundation for human exploration beyond Earth orbit. With its unprecedented capabilities, SLS is the only rocket that can send the Orion spacecraft, four astronauts, and large cargo directly to the Moon on a single mission.

Offering more payload mass, volume, and departure energy than any other single rocket, SLS can support a range of mission objectives, while reducing mission complexity. The SLS rocket is designed to be evolvable, which makes it possible to increase its capability to fly more types of missions, including human missions to the Moon and Mars and robotic scientific missions to other deep space destinations like the Moon, Mars, Saturn, and Jupiter.

On Nov. 16, 2022, SLS launched from NASA Kennedy Space Center's Launch Complex 39B in Florida, making history as the most powerful rocket NASA has ever launched. The successful Artemis I mission ushered in a new era of exploration, as NASA prepares to send astronauts to the Moon as a prelude to human exploration of Mars. Post-flight data reviews determined that SLS met or exceeded performance expectations, and the rocket is ready to support a crewed flight on Artemis II and future crewed missions.

The Power to Explore Beyond Earth's Orbit

To fulfill America's future needs for deep space missions, SLS will evolve into increasingly more powerful configurations. Hardware is currently in production for the next four SLS flights, and development is underway on the more powerful Block 1B and Block 2 variants that will succeed the current Block 1 variant.

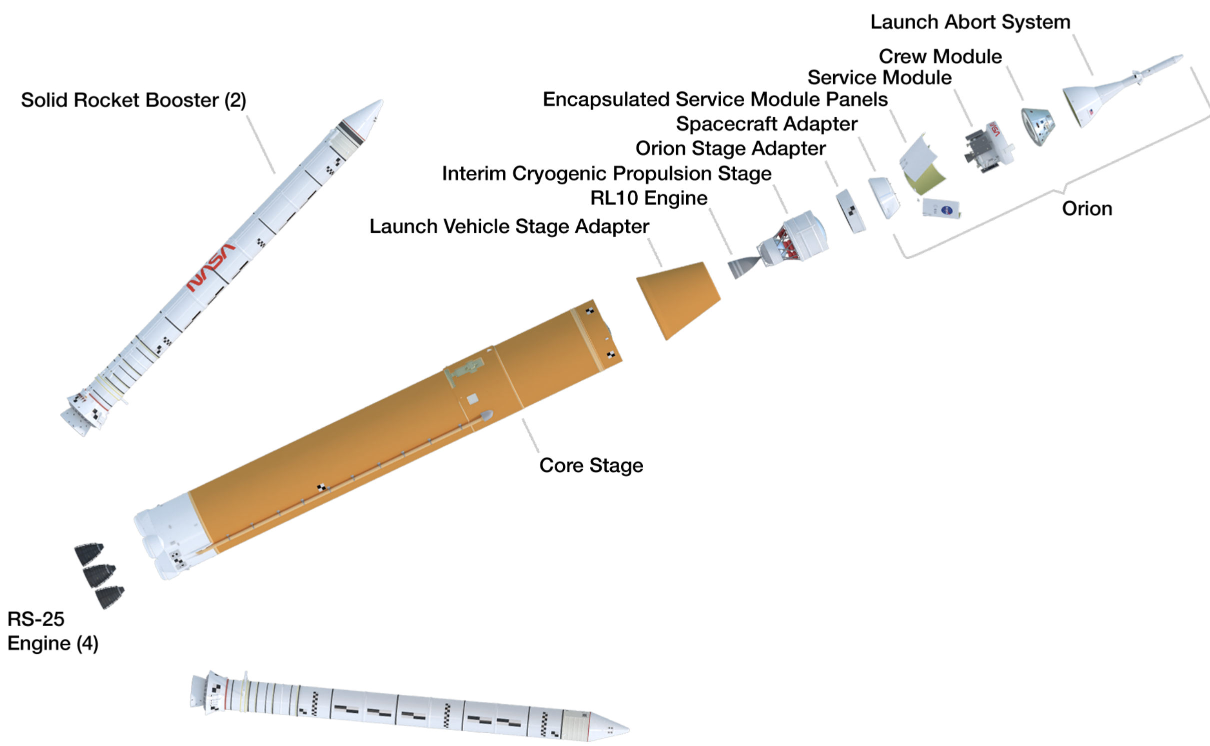
SLS is designed for deep space missions and will send Orion or other cargo to the Moon, which is nearly 1,000 times farther than where NASA's International Space Station resides in Low Earth orbit. The high-performance rocket provides the power to help Orion reach a speed of 24,500 mph—the speed needed to send it to the Moon.

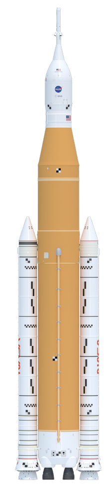
NASA's SLS (Space Launch System) rocket carrying the Orion spacecraft launches on the Artemis I flight test, Wednesday, Nov. 16, 2022, from Launch Complex 39B at NASA's Kennedy Space Center in Florida.

Every SLS configuration uses the core stage with four RS-25 engines. The first SLS vehicle, called Block 1, can send more than 27 metric tons (t) or 59,500 pounds (lbs.) to the Moon. It is powered by twin five-segment solid rocket boosters in addition to the four RS-25 liquid propellant engines. After reaching space, the interim cryogenic propulsion stage (ICPS) sends Orion on to the Moon. Like Artemis I, the SLS rockets that will power Artemis II and III will use the Block 1 configuration with the ICPS.

The Block 1B crew vehicle will use a new, more powerful exploration upper stage (EUS) to enable more ambitious missions beginning with Artemis IV. The Block 1B rocket can, in a single launch, carry the Orion spacecraft along with large cargos needed to support a long-term presence on the Moon.

Block 1 - Initial SLS Configuration





SLS Block 1 Crew

The Block 1B rocket can send 38 t (83,700 lbs.) to deep space, including Orion and its crew. Launching with cargo only, SLS has a large volume payload fairing to send larger exploration systems to the Moon and Mars or robotic science probes on solar system exploration missions.

The final SLS configuration, Block 2, will provide 9.5 million lbs. of launch thrust, compared to the Block 1's 8.8 million lbs. and will be the workhorse vehicle for sending cargo to the Moon, Mars, and other deep space destinations. SLS Block 2 will be designed to lift up to 46 t (101,400 lbs.) to deep space. An evolvable design provides the nation with a rocket able to pioneer new human and robotic spaceflight missions.

Space Launch System Missions

Artemis I, the first integrated flight of SLS and Orion, used the Block 1 configuration, which stands 322 feet — taller than the Statue of Liberty — and weighs 5.75 million lbs. fueled. During launch and ascent, SLS produces 8.8 million lbs. of maximum thrust, 15% more thrust than the Saturn V rocket.

For Artemis I, Block 1 launched an uncrewed Orion spacecraft to an orbit 40,000 miles beyond the Moon, or nearly 280,000 miles from Earth. This successful mission demonstrated the integrated system performance of SLS, Orion, and Exploration Ground Systems prior to a crewed flight.

The Artemis II mission will be the first crewed mission under Artemis and send four astronauts around the Moon and back. Together, Artemis I and II pave the way for landing astronauts on the Moon on Artemis III.

Building the Rocket

NASA is building the rockets needed for several future missions. To reduce cost and development time, NASA is using existing proven hardware and designs from the space shuttle and other exploration programs while making use of cutting-edge manufacturing technology and inspection techniques such as 3D printing and structured light scanning.

Some parts of the rocket are new, and other parts have been upgraded with modern features that meet the needs of deep space missions, which require higher performance levels.

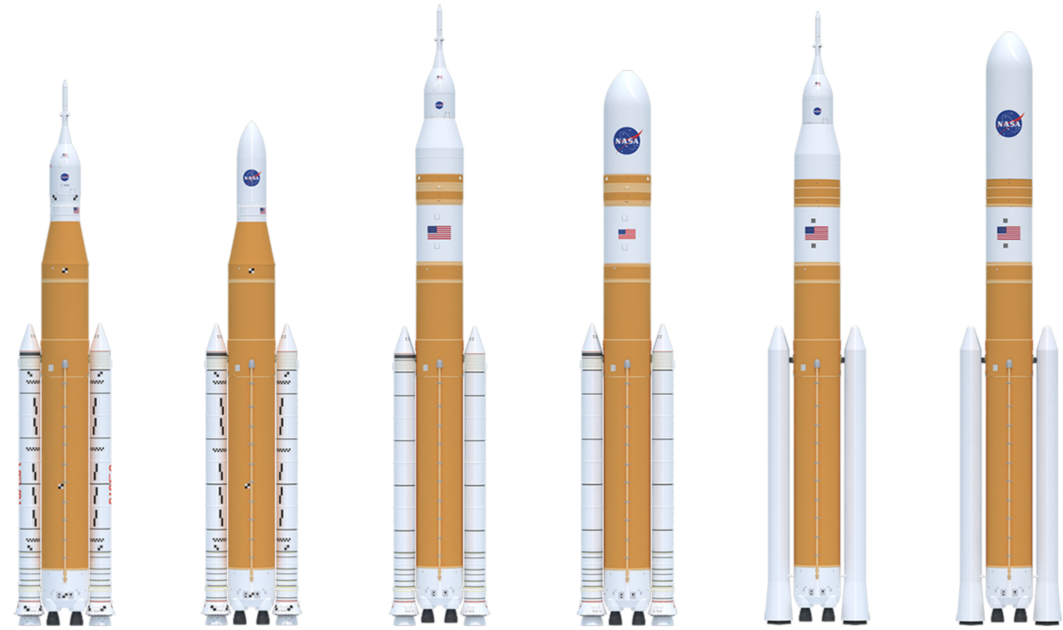
Core Stage

The Boeing Company in Huntsville, Alabama, is the lead contractor for SLS core stage manufacturing, including the flight computers that control the rocket during flight. Towering more than 212 feet with a diameter of 27.6 feet, the core stage stores 733,000 gallons of super-cooled liquid hydrogen and liquid oxygen that power the RS-25 engines.

Core stages are 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. The core stage is the newest part of the rocket.

Boeing is building stages for several upcoming Artemis missions. The SLS avionics computer software is developed at NASA's Marshall Space Flight Center in Huntsville, Alabama.

SLS Evolution



	SLS Block 1 Crew	SLS Block 1 Cargo	SLS Block 1B Crew	SLS Block 1B Cargo	SLS Block 2 Crew	SLS Block 2 Cargo
Payload to TLI/Moon	> 27 t (59.5k lbs.)	> 27 t (59.5k lbs.)	38 t (83.7k lbs.)	42 t (92.5k lbs.)	> 43 t (94.7k lbs.)	> 46 t (101.4k lbs.)
Payload Volume	516 ft³ (14.6 m³)	8,118 ft³ (229.9 m³)	10,100 ft³ (286 m³)*	21,930 ft³ (621.1 m³)	10,100 ft³ (286 m³)*	34,910 ft³ (988 m³)
Maximum Thrust	8.8 M lbs.	8.8 M lbs.	8.9 M lbs.	8.9 M lbs.	9.5 M lbs.	9.5 M lbs.

* DOES NOT INCLUDE ORION/SERVICE MODULE VOLUME

NASA has designed the SLS (Space Launch System) as the foundation for a generation of human exploration missions to deep space, including missions to the Moon and Mars. SLS will leave Low Earth orbit and send the Orion spacecraft, its astronaut crew, and cargo to deep space. A maneuver known as trans-lunar injection, or TLI, accelerates the spacecraft from its orbit around Earth onto a trajectory toward the Moon. The ability to send more mass to the Moon on a single mission makes exploration simpler and safer.

RS-25 Engines

Propulsion for the SLS core stage will be provided by four RS-25 engines powered by liquid hydrogen and liquid oxygen. Aerojet Rocketdyne of Sacramento, California, is upgrading an inventory of RS-25 engines to SLS performance requirements, including a new engine controller, nozzle insulation, and required operation at a maximum of 512,000 lbs. of thrust. The four engines provide about 2 million lbs. of thrust for the eight-minute climb to Earth orbit.

The SLS Program and Aerojet Rocketdyne began test firing heritage space shuttle engines in 2016 using SLS thrust profile and operating environments. The tests included new engine controllers and software, added nozzle insulation for the higher launchpad heating environment, and several new production engine components. By the time Artemis I launched, the test program had amassed 52 tests for 23,171 total seconds.

Aerojet Rocketdyne has also restarted engine production with the goal of a 30% cost reduction compared to the shuttle RS-25. It is currently building 24 engines. In early 2023, the engine team began test firing the first new engine to certify the design for flight at NASA's Stennis Space Center near Bay St. Louis, Mississippi.
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Boosters

Two shuttle-derived solid rocket boosters provide more than 75% of the rocket's thrust during the first two minutes of flight. The prime contractor for the boosters, Northrop Grumman's Northern Utah team, has modified the original configuration of four propellant segments to a more powerful five-segment version. The modified booster is 177 feet tall, 12 feet in diameter, weighs 1.6 million pounds, and produces a maximum of 3.6 million pounds of thrust during launch. The design also includes new avionics, propellant grain design, and case insulation, and eliminates the recovery parachutes to allow greater payload to orbit.

The company has completed motor segments for the Artemis II and Artemis III missions and is working on boosters for future missions. Trains transport booster segments from the Utah plant to Kennedy, where they are stacked with forward and aft assemblies to create the largest, most powerful boosters ever built for spaceflight. The boosters' avionics systems are tested at Kennedy and Marshall.

Integrated Spacecraft/Payload Element

The initial capability to propel Orion out of Earth's orbit during Artemis I came from the ICPS, based on the Delta Cryogenic Second Stage used successfully on United Launch Alliance's Delta IV family of rockets.

The ICPS uses one RL10 engine made by Aerojet Rocketdyne. The engine is powered by liquid hydrogen and liquid oxygen and generates 24,750 lbs. of thrust. United Launch Alliance is under contract to produce upper stages for the first three Artemis missions.

Teledyne Brown Engineering of Huntsville, Alabama, builds the launch vehicle stage adapter that partially encloses the ICPS and connects it to the core stage.

The Orion stage adapter (OSA) connects Orion to the ICPS on the SLS Block 1 vehicle. The OSA can accommodate several CubeSat payloads in 6U or 12U sizes, depending on mission parameters. For Artemis I, the OSA carried several 6U-sized CubeSats to deep space for various science and technology demonstration missions.

Exploration Upper Stage

Beginning with Artemis IV, the ICPS will be replaced by the EUS under contract to Boeing. It is powered by four RL10C-3 engines that produce almost four times more thrust than the one RL10B-2 engine that powers the ICPS. This 97,000 lbs. of thrust will allow more than 38 t (83,700 lbs.) for Block 1B crew and more than 42 t (92,500 lbs.) for Block 1B cargo to be sent to the Moon.

With the EUS plus a new universal stage adapter (USA), NASA can use a Block 1B crew configuration to send Orion, astronauts, and large, unique payloads to the Moon or replace the Orion and USA with a payload fairing to send nearly 22,000 cubic feet of payload to the Moon, Mars, or more distant destinations.

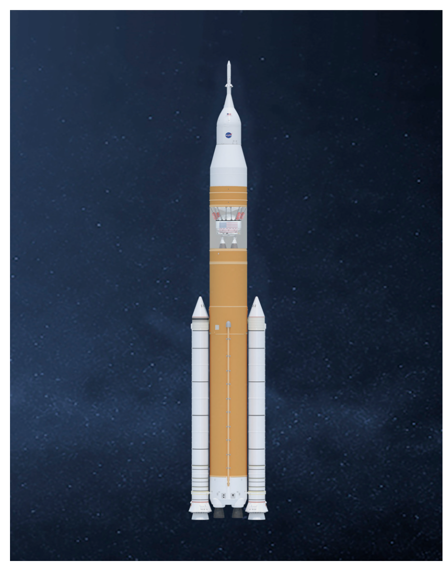
NASA completed the critical design review for the EUS in 2019. Boeing is building the EUS at Michoud. Aerojet Rocketdyne has completed manufacturing and testing of several engines.

The SLS Team

SLS is America's rocket, with more than 1,100 companies from across the U.S. and every NASA center supporting its development. The SLS Program, managed at Marshall, works closely with the Orion Program, managed at NASA's Johnson Space Center in Houston, and the Exploration Ground Systems Program, managed at Kennedy.

Artemis I stacked in the Vehicle Assembly Building at Kennedy

Artemis I launch vehicle stage adapter



SLS Block 1B crew with exploration upper stage cutaway (illustration)

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FS-2023-05-119-MSFC

For more information about SLS, visit:

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