What Comes Next

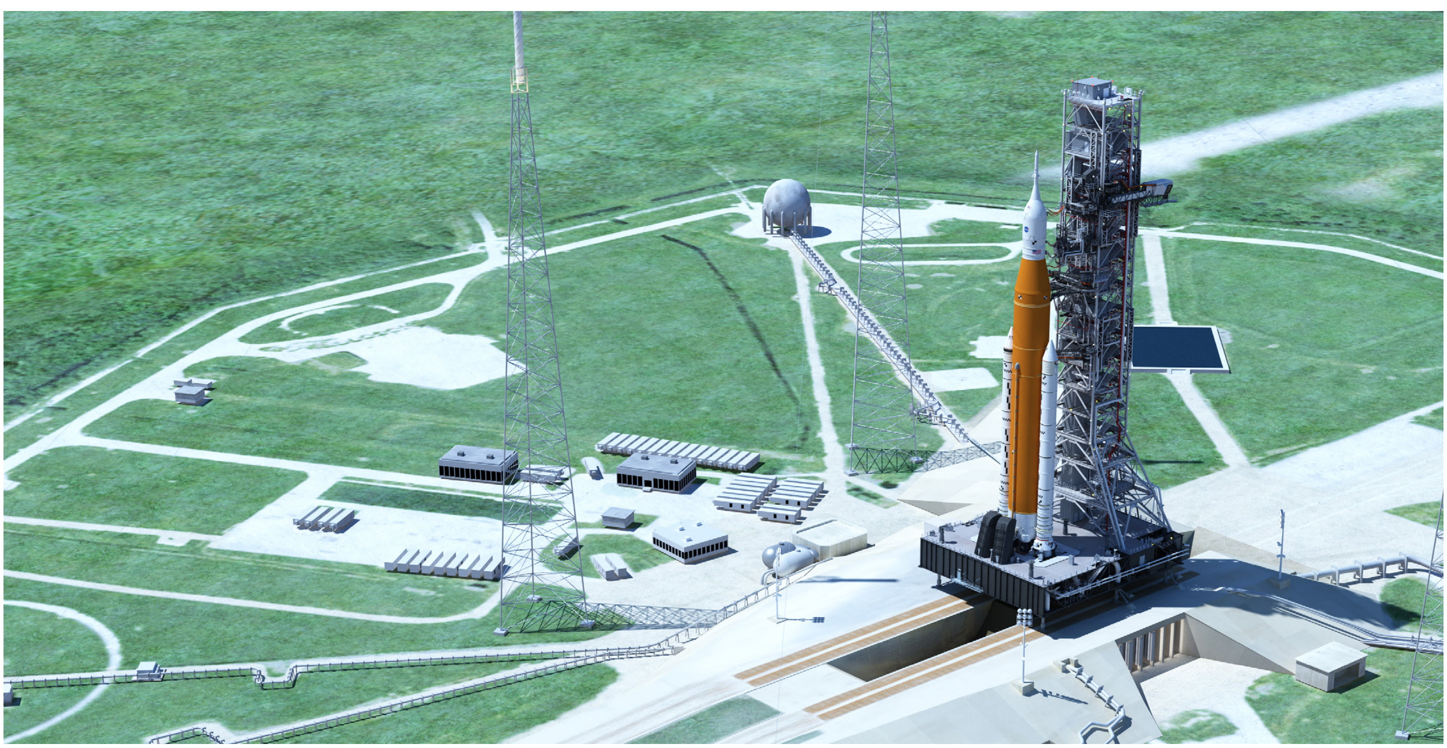
An entire generation grew up with the space shuttle. Under development for most of the 1970s, the space shuttle Columbia made its maiden flight on April 12, 1981. By the time of its retirement in 2011, the space shuttle flew 135 missions and carried more astronauts into space than all other rockets combined. It deployed satellites, sent space probes throughout the solar system, and carried science laboratories and many of the major components of the ISS.The space shuttle was a complex and versatile space launch system and its flights ended when the ISS was fully assembled. What comes next? In the decades of exploration that followed its creation in 1958, NASA expanded our perspective of the universe and humanity's place within it. Many important lessons have been learned, some of them the hard way. It is now time to advance our ability to travel and live in space. Once again, NASA will forge a new era of space exploration.

NASA'S Vision

We reach for new heights and reveal the unknown for the benefit of humankind

In a few years, space travelers will embark on a wide range of space missions near Earth and into the solar system. A new NASA rocket will take them there. NASA's new SLS rocket will take them there, in the process joining a family of new rockets, some developed by private industry for commercial space transportation involving cargo, astronauts, and tourists. Space will no longer be just the realm of highly trained astronauts.

Yet NASA's SLS rocket is the most ambitious effort of them all. A modular heavy-lift vehicle that can be configured in different ways for different missions, the SLS rocket will carry astronauts into orbit, as well as massive payloads destined for distant places. It will be tested during a series of launches with the first being an uncrewed flight to the vicinity of the Moon called Artemis I. Then an advanced SLS will take flight, thanks to the best ideas and technology of the past, present, and future.



NASA's SLS rocket will stand 322 feet (ft.) [98 meters (m)] tall. It will launch from Kennedy Space Center's Launch Pad 39B.

Space Launch System

America's Rocket for Deep Space Exploration

NASA's Space Launch System, or SLS, is an advanced launch vehicle that provides the foundation for human exploration beyond Earth's orbit. With its unprecedented power and capabilities, SLS is the only rocket that can send Orion, astronauts, and large cargo to the Moon on a single mission.

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 the Moon, Mars, Saturn, and Jupiter.

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. 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 the space station resides in low-Earth orbit. The rocket will provide the power to help Orion reach a speed of at least 24,500 mph [39,425 kph] needed to break out of low-Earth orbit and travel to the Moon. That is about 7,000 mph (11,265 kph) faster than the space station travels around Earth.

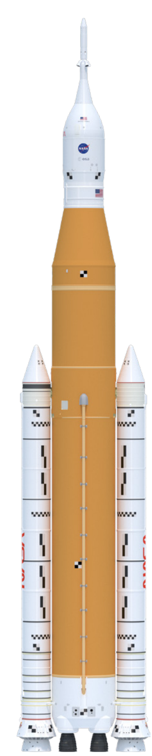
Every SLS configuration uses the core stage with four RS-25 engines. The first SLS vehicle, called Block 1, can send more than 59,000 pounds (lbs.) [27 metric tons (t) (59,000 lbs.)] to the Moon's vicinity. It will be powered by twin five-segment solid rocket boosters and four RS-25 liquid propellant engines generating 8.8 million lbs. [39,144 kilonewton (kN)] of thrust.

After reaching space, the interim cryogenic propulsion stage (ICPS) sends Orion on to the Moon.

The next planned evolution of the SLS, the Block 1B crew vehicle, will use a new, more powerful Exploration Upper Stage (EUS) to enable more ambitious missions. The Block 1B vehicle can, in a single launch, carry the Orion crew vehicle along with exploration systems like a deep space habitat module.

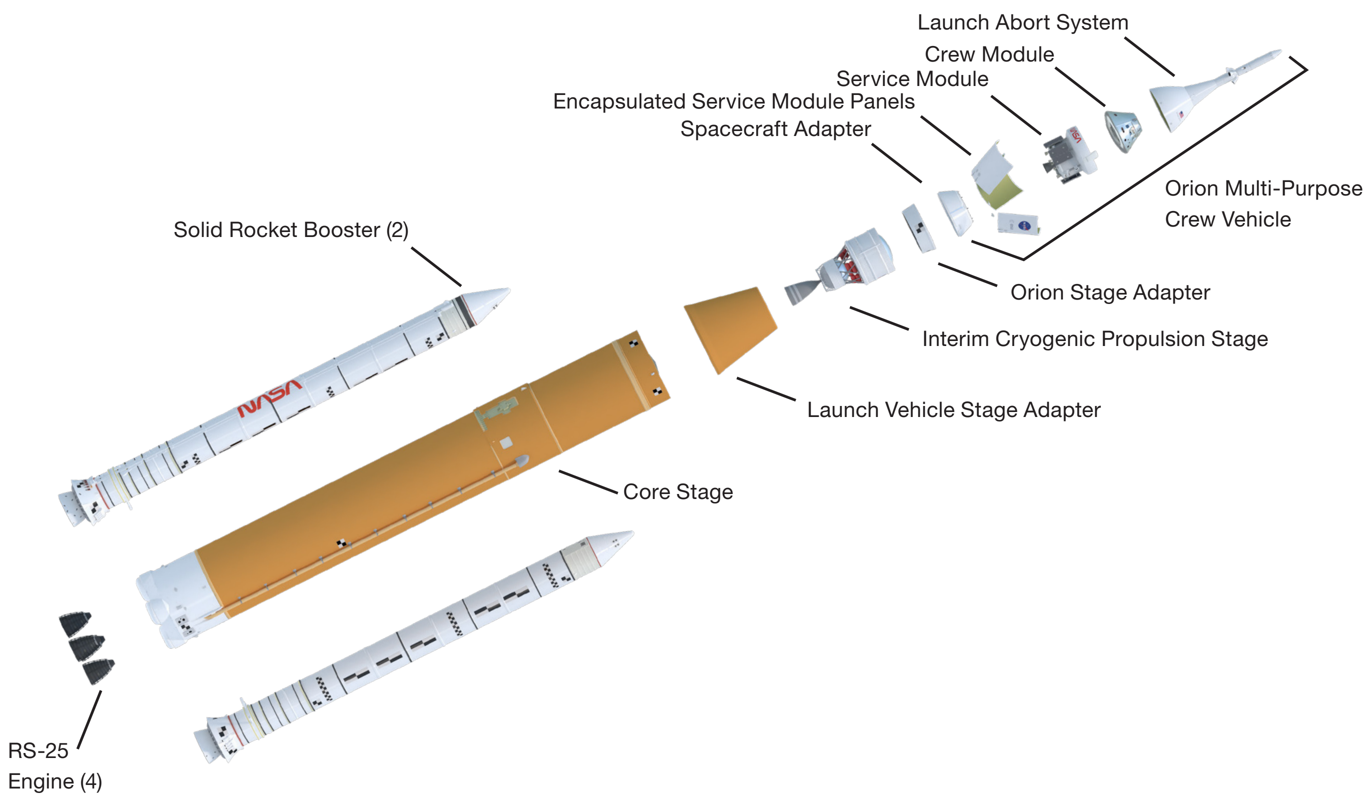
The Block 1B crew vehicle can send approxi-mately 38 t (83,700 lbs.) to deep space including Orion and its crew. Launching with cargo only, SLS has a large volume payload fairing to send larger exploration systems or science spacecraft on solar system exploration missions.

The next SLS configuration, Block 2, will provide 9.5 million lbs. (42,258 kN) of thrust. It will be the most powerful variant and will be used for carrying large payloads to the Moon, Mars, and other deep space destinations. SLS Block 2 crew will be designed to lift more than 43 t (94,700 lbs.) to deep space. The design for SLS Block 2 cargo will allow for over 46 t (101,400 lbs.) to be lifted into deep space. An evolvable design provides the nation with a rocket able to pioneer new human spaceflight missions.



SLS Block 1

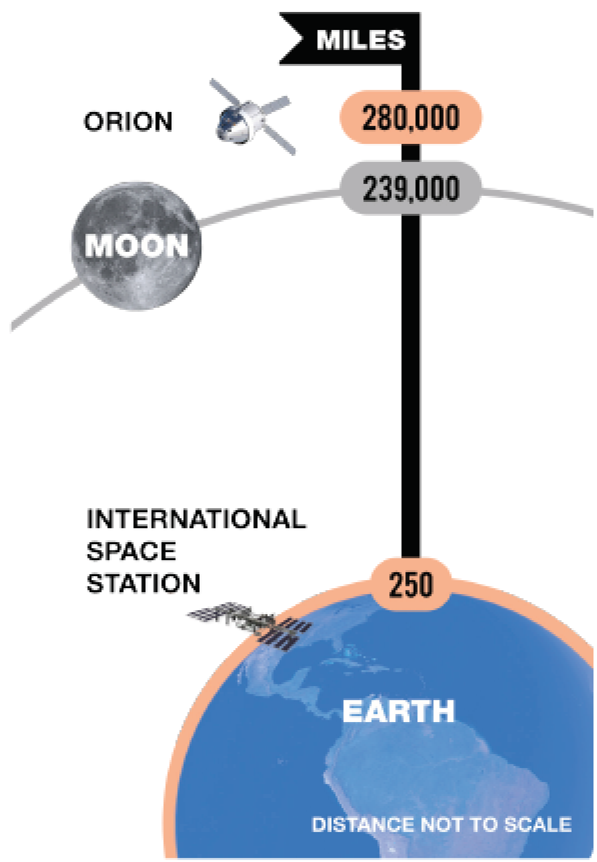
Block 1 - Initial SLS Configuration



Space Launch System Missions

Artemis I, the first integrated flight of SLS and Orion, uses the Block 1 configuration, which stands 322 feet (ft.) [98 m], taller than the Statue of Liberty, and weighs 5.75 million lbs. [2.6 million kg]. SLS will produce 8.8 million lbs. (39,144 kN) of maximum thrust, 15 percent more thrust than the Saturn V rocket.

For Artemis I, Block 1 will launch an uncrewed Orion spacecraft to an orbit 40,000 miles [64,374 kilometers (km)] beyond the Moon, or 280,000 miles [450,616 km) from Earth. This mission will demonstrate the integrated system performance of SLS, Orion, and Exploration Ground Systems teams prior to a crewed flight to send Orion to lunar orbit. SLS will also carry 13 small satellites, each about the size of a shoebox, to be deployed in deep space.



NASA's Space Launch System is powerful enough to send the Orion spacecraft beyond the Moon. For Artemis I, Orion will travel 280,000 miles from Earth—farther in deep space than any spacecraft built for humans has ever ventured.

Core Stage

The Boeing Company, in Huntsville, Alabama, is building the SLS core stage, including the avionics that will control the vehicle during flight. Towering more than 212 ft. (64.6 m) with a diameter of 27.6 ft. (8.4 m), the core stage will store 733,000 gallons (2.77 million liters) of super-cooled liquid hydrogen and liquid oxygen that will fuel the RS-25 engines.

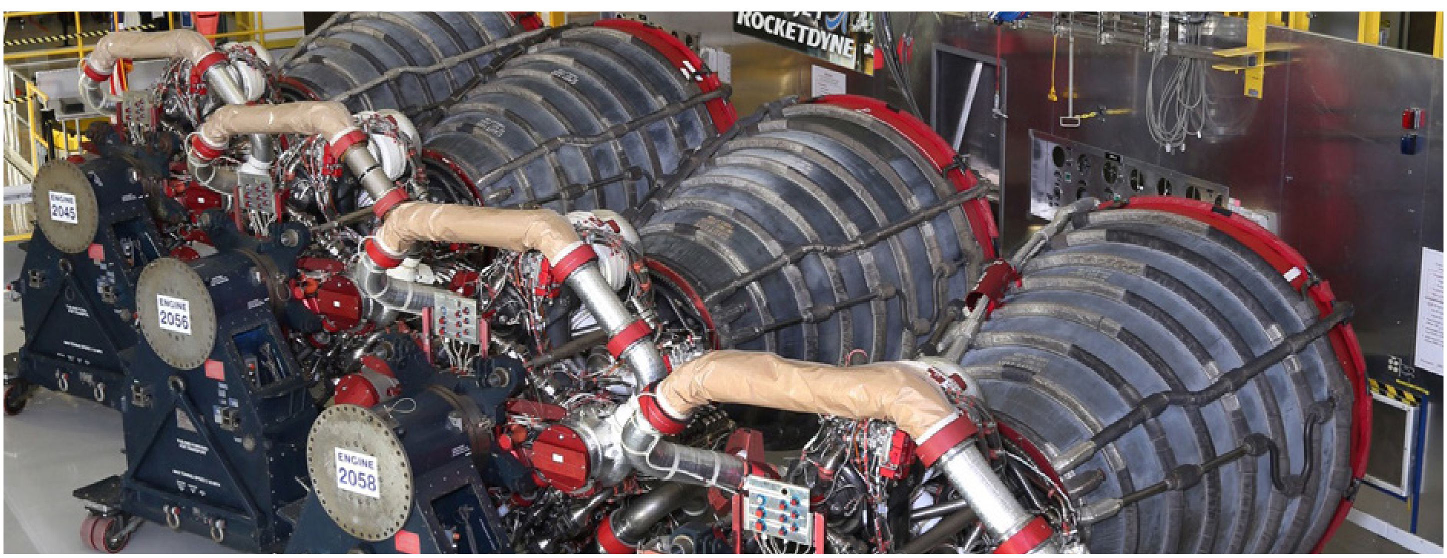
The core stage is being built at NASA's Michoud Assembly Facility in New Orleans using state-of-the-art manufacturing equipment, including a self-reacting friction-stir-welding tool that is the largest of its kind in the world. The SLS avionics computer software is being developed at NASA's Marshall Space Flight Center in Huntsville.

SLS core stage liquid oxygen tank (top) and liquid hydrogen tank (bottom).

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 512,000 lbs. (2,277 kN) of thrust. During the flight, the four engines provide around 2 million lbs. (8,896 kN) of thrust.

Following the installation of the engines into the fully assembled Artemis I core stage, NASA's Pegasus barge transported the entire stage to Stennis Space Center near Bay St. Louis, Mississippi, for testing. Once testing is complete, Pegasus will take the core stage to Kennedy Space Center in Florida where it will be prepared for launch. Aerojet Rocketdyne has started development testing of new, advanced components to make the engines more affordable and powerful for future missions.



The four RS-25 engines that will power SLS for its first flight.

Boosters

Artemis I booster aft segment.

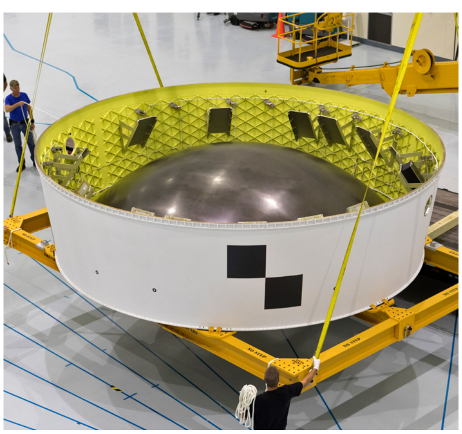
Two shuttle-derived solid rocket boosters will be used for the initial flights of the SLS. To provide the additional power needed for the rocket, the prime contractor for the boosters, Northrop Grumman, of Redondo Beach, California, has modified the original shuttle's configuration of four propellant segments to a five-segment version. The design includes new avionics, propellant design, and case insulation, as well as eliminates the recovery parachutes.

Northrop Grumman has delivered the boosters for Artemis I to Kennedy Space Center. They were carried by train from their facility in Promontory, Utah, and will be stacked with other components. The SLS twin boosters provide more than 75 percent of the total SLS thrust at launch.

RS-25 Engines

The Orion stage adapter will connect Orion to the interim cryogenic propulsion stage (ICPS) on the SLS Block 1 vehicle and is the place where the small satellites will ride to space. Teledyne Brown Engineering of Huntsville, Alabama, has built the launch vehicle stage adapter (LVSA) that will connect SLS's core stage to the upper part of the rocket.

The initial capability to propel Orion out of Earth's orbit for Block 1 will come from the ICPS, based on the Delta Cryogenic Second Stage used successfully on United Launch Alliance's Delta IV family of rockets. It uses one RL10 engine made by Aerojet Rockedyne. The engine is powered by liquid hydrogen and liquid oxygen and generates 24,750 lbs. (110 kN) of thrust.



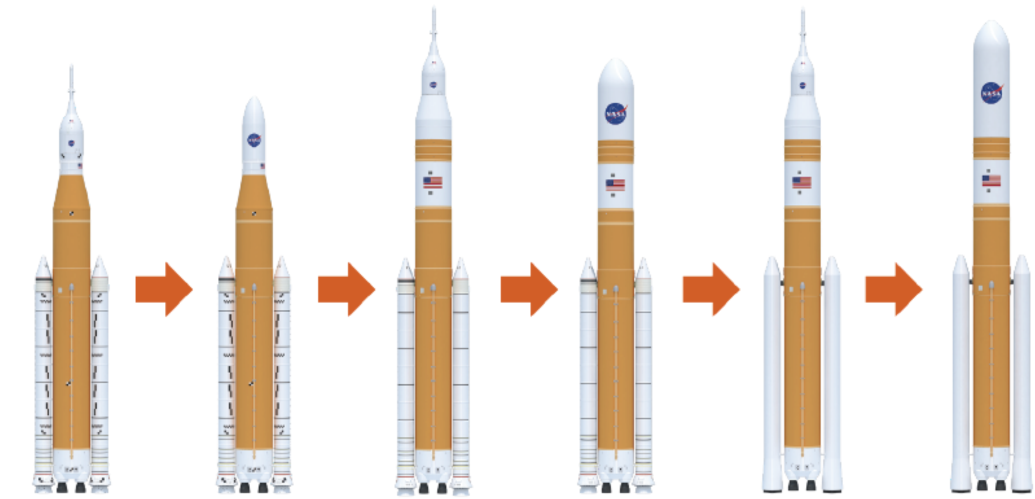
Orion stage adapter.

Launch vehicle stage adapter.

Interim cryogenic propulsion stage.

	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	N/A*	8,118 ft^3 (229.9m^3)*	10,100 ft^3 (286m^3)*	21,930 ft^3 (621.1 m^3)	10,100 ft^3 (286 m^3)*	34,910 ft^3 (988 m^3)
Maximum Thrust	8.8M lbs	8.8M lbs	8.9M lbs	8.9M lbs	9.5M lbs	9.5M lbs

* Not including Orion/ Service Module volume



SLS Evolution

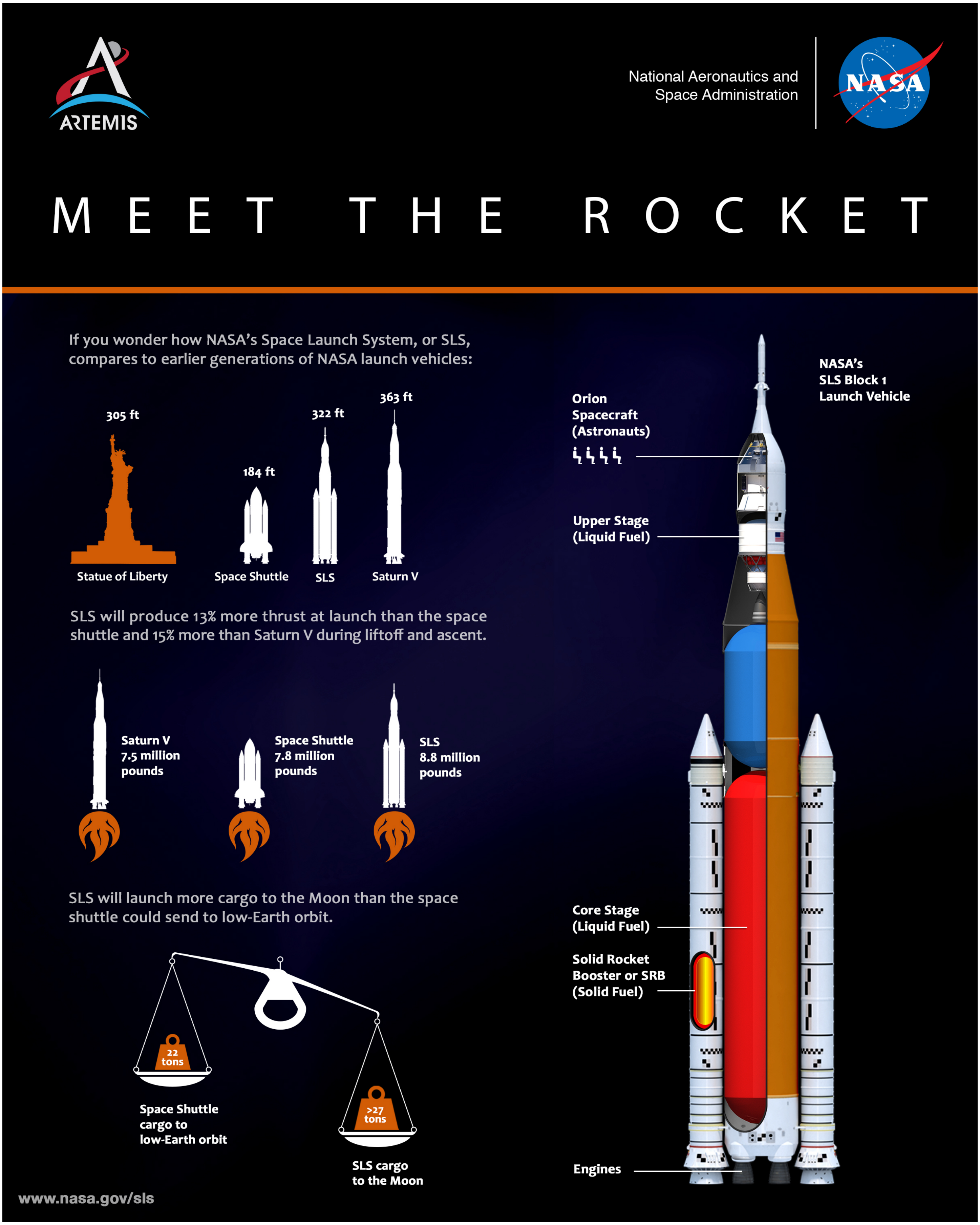
NASA has designed the Space Launch System as the foundation for a generation of human exploration missions to deep space, including missions to the Moon and Mars. SLS will leave low-Earth orbit and send the Orion spacecraft, its astronaut crew, and cargo to deep space. To do this, SLS has to have enough power to perform a maneuver kown as trans-lunar injection, or TLI. This maneuver 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.

Spacecraft Structures

Every pound that is carried to space requires fuel, whether that pound is cargo, crew, fuel, or part of the spacecraft itself. The more the vehicle and fuel weigh, the fewer passengers and smaller payload the vehicle can carry. Designers try to keep all the parts of the vehicle, including the skeleton (or structure), as light as possible. To design a lightweight structure is very difficult because it must be strong enough to withstand the tremendous thrust (or force) of the engines during liftoff. Throughout the history of space vehicles, engineers have used various strategies for the structure.

In order to make the SLS spacecraft as light as possible, NASA engineers are constructing it with lightweight, strong materials, such as aluminum alloys and composites. NASA engineers also design structures that use as little material as possible to achieve the strength and rigidity they need. So, for example, they machine a waffle grid pattern into the inside of the core stage panels to keep them rigid with minimum weight.

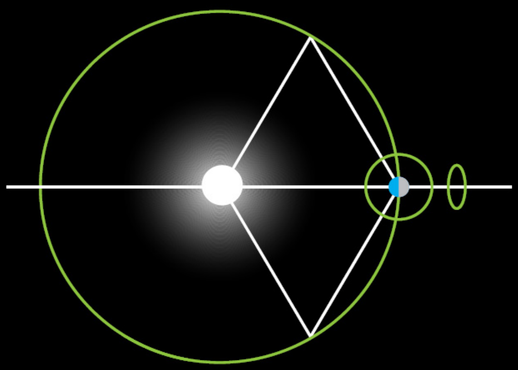
This engineering design challenge focuses on the thrust structure, which attaches the four liquid fuel engines to the body of the rocket. The thrust structure is an essential part of the spacecraft, which must be kept lightweight. As they burn, the four RS-25 engines on the SLS produce about 2 million lbs. (8,896 kN) of thrust. The thrust structure must not only withstand this force, it must transfer it to the vehicle in a balanced way, without damaging the vehicle.



NASA's Space Launch System is powerful enough to send the Orion spacecraft beyond the Moon.

Orbit, Moon, Mars, and All Points Between and Beyond

NASA's SLS heavy-lift rocket is being developed alongside many commercial rockets and spacecraft to open the solar system for exploration. All points are possible. The many benefits to be gained from this endeavor are still coming into view, but one thing is clear. The SLS rocket is bringing advanced capabilities within reach at last, inspiring the next generation of scientists, technicians, engineers, and mathematicians – students in today's classrooms – to greatness.



Potential Benefits

- Geosynchronous-Earth Orbit
- New microgravity destinations
- Space construction, fueling, repair
- Space telescopes and Earth observatories

The Moon

- Witness to the birth of Earth and the inner planets
- Critical resources

Mars/Phobos/Deimos

- Life beyond Earth?
- Permanent base
- Witness to the birth of Earth and the inner planets
- Critical resources