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**NASA's SLS (Space Launch System) Super Heavy-Lift Rocket in Process for Artemis II and Beyond**



**Figure 1: The Artemis II SLS and Orion are stacked in NASA's Vehicle Assembly Building at NASA's Kennedy Space Center.**

**ABSTRACT**

NASA is preparing the SLS (Space Launch System) rocket for the Artemis II mission, which will launch the first crew to the Moon since 1972. The mission, launching no later than April 2026, will send four astronauts on a ten-day mission around the Moon and back using a free-return trajectory. Vehicle integration is complete with the two solid rocket boosters, core stage, launch vehicle stage adapter, interim cryogenic propulsion stage, Orion stage adapter, and Orion spacecraft, which the crew named Integrity, stacked on the mobile launcher. The flight software is loaded on the flight computers. Teams are completing the integrated testing on the vehicle before launch. Hardware for Artemis III and subsequent SLS rockets is in various stages of production and processing at NASA and contractor facilities across the country. Test articles for the exploration upper stage, universal stage adapter, and payload adapter that will fly on the SLS Block 1B variant are in testing at NASA's Marshall Space Flight Center in Huntsville, Alabama. Its flight software is also in development. In 2024, NASA and L3Harris Technologies completed the certification test program of the new production RS-25 liquid engines that power the core stage. Acceptance hot fire testing of the first new production engine occurred in June 2025. Development of the evolved solid rocket boosters featured a full-scale test also in June 2025. Hardware progress for multiple Artemis missions and the capabilities of SLS to support the nation's most ambitious missions will be presented.

## INTRODUCTION

NASA's SLS (Space Launch System) is a critical national capability for the country's return of humans to the Moon to establish a permanent presence on the lunar South Pole and in lunar orbit and to test technologies as well as operations needed for crewed missions to Mars. The launch vehicle has tremendous single-launch payload capability. In its initial crew configuration, it can send 59,000 pounds (27 metric tons (mt)) to translunar injection (TLI) in a single launch.

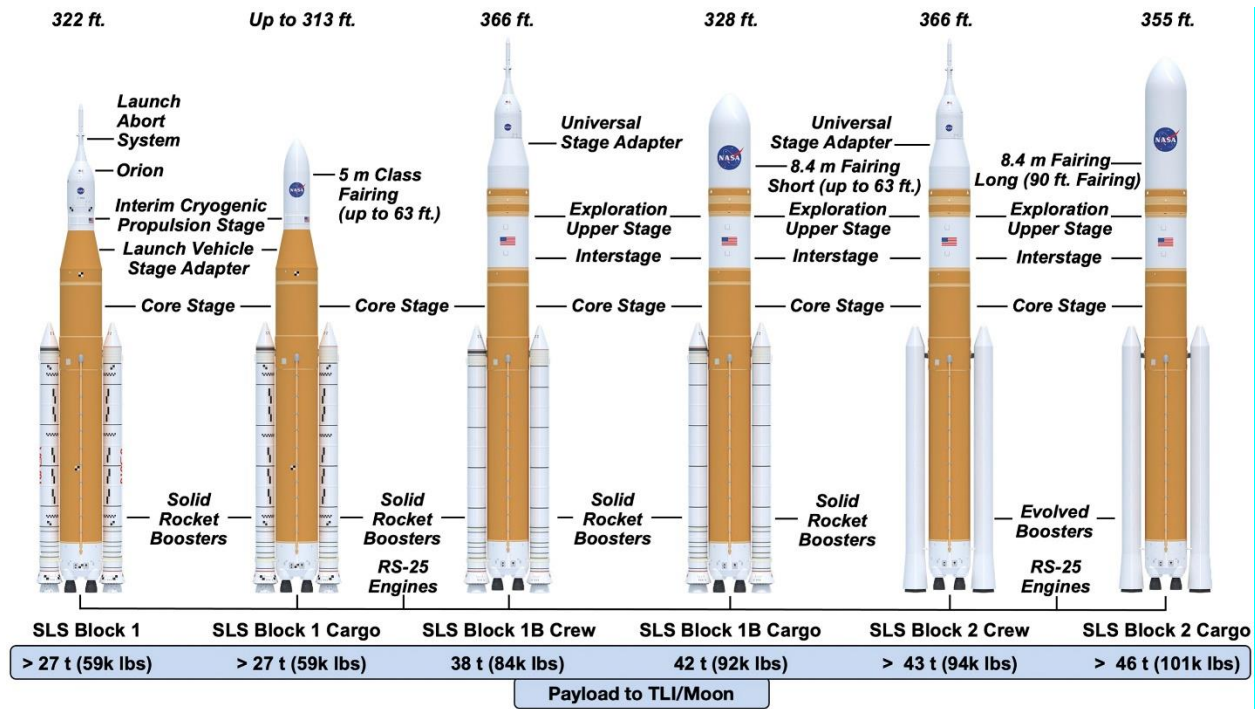
Prior to the successful Artemis I test flight that launched Nov. 16, 2022, the SLS Program put the rocket and its components through an intense, thorough test program. The Artemis I mission launched an uncrewed NASA Orion spacecraft on a 25.5-day, 1.4-million-mile mission into a distant retrograde orbit (DRO) around the Moon and back (Askins 2024).

Following launch, the program analyzed SLS's flight to understand how well it met pre-flight predicted metrics and to determine whether any modifications were needed to the design on subsequent missions. In summer of 2023, the post-flight assessment determined that the launch vehicle performed its mission to a high degree of precision and accuracy, thus the design was safe to launch astronauts on the Artemis II mission. Teams have stacked the Artemis II SLS and Orion spacecraft, which the crew named Integrity, in the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida (Fig. 1). The approximately 10-day long mission will send four astronauts on a free-return lunar flyby mission to collect vital data on Orion spacecraft performance with humans-in-the-loop. The mission will also deploy four 12U CubeSats as secondary payloads developed by international partners from the Orion stage adapter once the Orion spacecraft is safely out of the vicinity of the upper stage element.

Hardware and software are also in development for Artemis III and the later SLS Block 1B and Block 2 variants. Current progress on the SLS rocket for the Artemis II and III missions, along with development progress for the next variants of SLS, are discussed in this paper.

## SLS ARCHITECTURE

SLS is designed to be a flexible and evolvable platform, taking advantage of proven systems such as the RS-25 liquid hydrogen/liquid oxygen (LH2/LOX) engines, five-segment solid rocket boosters, and RL10 upper stage engine. These heritage systems have been upgraded and/or modified to fulfill their respective roles on SLS, including integration with the newly developed core stage and new flight software. All variants of SLS crew and cargo configurations are powered by a central core stage with four RS-25 engines and a pair of five-segment solid rocket boosters. Maximum thrust in this initial configuration, Block 1, is 8.8 million pounds (39,144 kN). The rocket stands 322 feet (98 m) tall and weighs 5.74 million pounds (2.6 million kg) in the Block 1 crew configuration at liftoff. The vehicle can launch 59,000 pounds (27 mt) to TLI in a single launch. SLS's Block 1B crewed configuration will stand 366 feet tall (112 m), producing 8.84 million pounds (39,300 kN) of thrust, and capable of sending 84,000 pounds (38 mt) of payload to TLI. The Block 2 variant is designed to produce 9.4 million pounds (42,000 kN) maximum thrust and with a capability of sending 94,000 pounds (43 mt) of payload to the Moon in a single launch in crew configuration (Fig. 2).



**Figure 2: SLS variants and projected performance show increased capabilities with SLS block upgrades.**

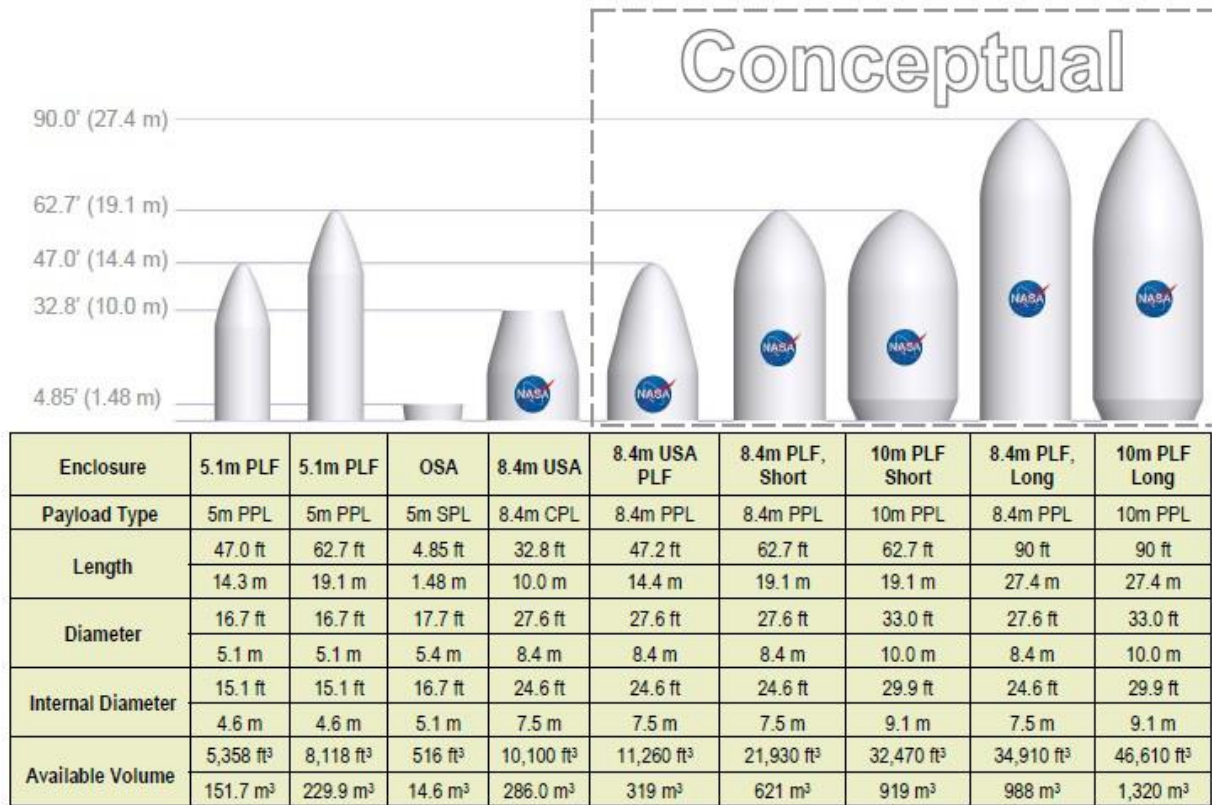
The Block 1 upper stage is called the interim cryogenic propulsion stage (ICPS) – a derivative of the United Launch Alliance (ULA) Delta Cryogenic Second Stage (DCSS). It uses a single RL10 engine and produces approximately 24,750 pounds (110 kN) of thrust. A new upper stage powered by four RL10 engines will debut on the fourth flight. Called the exploration upper stage (EUS), the stage will produce 97,360 pounds (433 kN) of thrust and increase payload mass to TLI from 27 mt to 38 mt in crew configuration.

NASA and the SLS team took advantage of experience and hardware from the Space Shuttle Program for SLS, upgrading the flight-proven components with new materials and manufacturing methods to meet the challenging demands and environments for the new launch vehicle for humans and cargo.

The RS-25 design has accumulated more than 1 million seconds of hot fire operation, including 135 space shuttle flights and ground testing. New production RS-25s will begin flying on the fifth flight of SLS when the supply of 16 heritage engines is exhausted. L3Harris Technologies, the prime contractor for the engines, is already producing the new engines, with 24 currently under contract. In June 2025, the first new flight engine was successfully tested at NASA's Stennis Space Center in Bay St. Louis, Mississippi.

A composite casing booster for future SLS flights has been under development through the Booster Extension and Obsolescence (BOLE) effort. The booster prime contractor, Northrop Grumman and NASA performed a full-scale hot fire test of the new booster in June 2025.

SLS is currently manifested to launch the astronauts on NASA's Artemis missions to the Moon. Its payload capability enables additional payloads to be launched as secondary payloads and co-manifested payloads, depending on vehicle configuration and available mass and volume. SLS can also be used to launch cargo and other non-crewed payloads to destinations throughout the solar system (Figs. 2-3).



COTS: Commercial Off-the-Shelf CPL: Co-manifested Payload OSA: Orion Stage Adapter PPL: Primary Payload  
 SPL: Secondary Payload PLF: Payload Fairing

**Figure 3: SLS payload fairing options provide capability to launch a variety of missions.**

### ARTEMIS II SLS

The SLS for Artemis II is stacked on mobile launcher 1 in the Vehicle Assembly Building at NASA Kennedy. Stacking began in November 2024 with the solid rocket boosters and concluded in September 2025 when the Orion stage adapter was mated (Figs. 1, 4). The Orion spacecraft was lifted and mated in October 2025. Following successful integration of Orion, teams performed the integration tests on the entire vehicle. Rollout to Launch Pad 39B is expected in January 2026 for a tanking test, and launch will follow with the earliest opportunity in February.



**Figure 4: The SLS core stage for Artemis II was mated with the solid rocket boosters on mobile launcher 1 in March 2025.**

The Artemis II mission will also launch four 12U CubeSats as secondary payloads. The CubeSats, developed by international partners, are installed in the Orion stage adapter (OSA). They will deploy approximately five hours into the mission, once the Orion spacecraft has safely navigated away from the upper stage. The payloads and their respective missions are:

- **ATENEA:** Developed by the Argentina National Space Activities Commission (CONAE), the spacecraft will investigate radiation shielding, orbital design optimization, and long-range communications
- **TACHELES:** Developed by the German Aerospace Center (DLR), it will demonstrate key in-space technologies, including electrical components, for future lunar logistics vehicles and operations
- **Space Weather CubeSat-1:** Developed by the Saudi Space Agency (SSA), the spacecraft will measure various aspects of space weather such as radiation, solar X-rays, solar energy particles, and magnetic fields
- **K-Rad Cube:** Developed by the Korea AeroSpace Administration (KASA), it will measure space radiation and its biological effect across the Van Allen radiation belts (Fig. 5)



- **Figure 5: The K-Rad Cube CubeSat was installed in the Orion stage adapter in September 2025.**

As the hardware is being equipped, Artemis teams responsible for pre-launch, launch, and mission operations are preparing with mission simulations. These simulations are critical to team readiness for nominal and off-nominal situations.

While the major elements of SLS remained consistent from the Artemis I rocket to the Artemis II vehicle, some changes were made. Some of these changes were planned modifications as the program transitioned from an uncrewed test vehicle to a crewed test flight, while others are opportunities to improve the performance of SLS, as found during the Artemis I post-flight analysis cycle.

- **Optical targets on the ICPS and OSA:** The astronauts aboard the Orion spacecraft will use the targets as visual cues as they manually pilot Orion around the upper stage and practice maneuvers to inform docking operations for Artemis III. One target was added to the ICPS for Orion's planned side-approach maneuvers to the stage, and one was installed on the OSA's diaphragm. The latter target will enable centerline maneuvers with the upper stage and adapter
- **Improved navigation and communications:** SLS will fly with an improved navigation system and repositioned antennas. The adjusted location of the antennas on the rocket ensures continuous communications with NASA ground stations and the U.S. Space Force's Space Launch Delta 45, which controls launches along the Eastern Range
- **Emergency detection system on ICPS enabled:** The system allows the rocket to sense and respond to problems and notify the crew. Additionally, the flight safety system adds a time delay to the self-destruct system to allow time for Orion's escape system to pull the capsule to safety in event of an abort
- **Booster separation motor angle adjustment:** The separation motors on the solid rocket boosters were angled an additional 15 degrees to ensure separation clearance from the core stage

- **Booster jettison time adjustment:** SLS will jettison the spent solid rocket boosters five seconds earlier during Artemis II ascent than occurred during Artemis I. Separating the boosters several seconds closer to the end of their burn will give engineers flight data to correlate with projections that shedding the boosters sooner will yield approximately 700 pounds to TLI for future SLS flights
- **Strake addition:** During the Artemis I test flight, the SLS experienced higher-than-expected vibrations caused by unsteady airflow around the forward booster attach struts. To steady the airflow, a pair of approximately seven-foot-five-inch-long strakes flanking the two booster's forward attach points on the SLS intertank will smooth vibrations during ascent, and the rocket's electronics system was requalified to endure higher levels of vibrations
- **Updated core stage power distribution control unit:** Mounted in the intertank, it controls power to the rocket's other electronics and protects against electrical hazards

### ARTEMIS III PROGRESS

Artemis III is targeted to launch no earlier than mid-2027 and will become the first crewed landing on the Moon since Apollo 17 in December 1972. NASA is making great progress on the hardware for that flight, including for the SLS rocket that will launch the Artemis III crew aboard their Orion spacecraft to lunar orbit.

The Artemis III core stage elements have begun integration. In November, the liquid oxygen tank and intertank were mated at NASA's Michoud Assembly Facility in New Orleans. The forward skirt and liquid hydrogen tank will be added to the segment in early 2026 and will complete the core stage four-fifths. The stage's engine section boattail arrived at NASA Kennedy in September 2024, joining the engine section which arrived in 2022 for internal installations. The core stage four-fifths will be transported to NASA Kennedy in Spring 2026 where it will be integrated vertically with the engine section in the Vehicle Assembly Building's High Bay 2. Once integration is complete, the RS-25 engines will be added and the core stage completed. The engines are complete and are in storage at NASA's Stennis Space Center in Bay St. Louis, Mississippi, until they are needed for integration.

High Bay 2 was modified to support vertical integration and enable nearly full access to the stage at a single time. Integration of the core stage engine section and engines was moved from NASA Michoud to NASA Kennedy to enable multiple core stages to be in manufacturing and integration at the same, taking advantage of the facilities and workforce at both centers.

The solid rocket booster forward and aft assemblies are at NASA Kennedy, and the propellant-filled motor segments will ship from prime contractor Northrop Grumman's Utah facilities to NASA Kennedy in Spring 2026.

The ICPS is in processing at ULA's Delta Operations Center at Cape Canaveral Space Force Station in Florida. The launch vehicle stage adapter that will connect the ICPS to the core stage is complete and in storage at NASA Marshall. The Orion stage adapter is nearly complete at NASA Marshall and is scheduled to have its diaphragm installed in late 2025. The diaphragm serves as a barrier, preventing any propellant gases from the core stage reaching the Orion spacecraft.



**Figure 6: The engine section for the third SLS is in at the Vehicle Assembly Building at NASA Kennedy.**

### **PATH TO BLOCK 1B AND BEYOND**

While significant progress is being made on the SLS rockets to return humans to the lunar vicinity and lunar surface, notable progress is being made on SLS hardware for future missions. Following Artemis III, SLS will transition to the more powerful Block 1B variant, featuring the new EUS, which will dramatically increase the amount of payload SLS can launch to the Moon and other deep space destinations. The new four-engine upper stage features a combined thrust of 97,360 pounds (433 kN). The structural test article for the EUS and the first flight unit are being manufactured.

Core stage and booster element manufacturing and preparations are underway. In September 2024, the engine section for the fourth flight of SLS arrived at NASA Kennedy (Fig. 6). Other pieces of the core stage are being manufactured at NASA Michoud, and work on the boosters is underway at Northrop Grumman's Utah facilities.

New-production RS-25 engines, which will be used beginning on Artemis V, are currently being manufactured by prime contractor L3Harris Technologies. The two-part certification test series, comprised of 24 total tests, successfully concluded in April 2024 at NASA Stennis. The first new flight engine was successfully hot fired in June 2025. This test was its acceptance test. The engine is now stored until needed. The second new engine had its acceptance hot fire in November 2025 and joins the first engine in storage for future use. Multiple engines remain in the production flow at L3Harris facilities.

The new engine production program is realizing a cost savings of at least 30 percent and reduced production time due to streamlined manufacturing as well as advances in technology, including additive manufacturing.

In addition to the propulsion elements, the new adapters that will connect the elements of the new variants are under development. The payload adapter and universal stage adapter are undergoing numerous test campaigns at NASA Marshall to qualify the hardware as flight units are preparing to be built (Fig. 7).



**Figure 7: The Block 1B and Block 2 payload adapter underwent structural evaluation testing at NASA Marshall. The engineering development unit was then moved into storage.**

The Block 1B flight software is under development, and the systems test labs are being outfitted.

Also under development are evolved solid rocket boosters, which will begin flying on future flights. The boosters are designed with numerous upgrades and changes, including the shift from steel motor segment cases to composite cases. Booster thrust increases from 3.6 million pounds (16,014 kN) per booster for the current five-segment SRB to 4.2 million pounds (18,683 kN) for the BOLE booster. In June 2025, Northrop Grumman and NASA conducted the first full-scale test of the new booster. The test ran approximately 120 seconds and was largely successful. Engineers did see liberation of the nozzle approximately 110 seconds into test and are conducting investigations to understand the mechanisms of failure to improve the boosters for the future flights.

## **CONCLUSION**

SLS is a cornerstone to the country's lunar expedition endeavors. Its unmatched single-launch payload capability to the Moon and other deep space destinations enables it to simplify mission architecture, reduce risk, and optimize opportunities for success in pursuit of the nation's most ambitious exploration. Significant progress is being made on the rockets for Artemis II and III and hardware is being built and developed for flights beyond. Built by tens of thousands of American hands across the country, SLS provides the United States with guaranteed access to deep space.

## **REFERENCES**

Askins, B.R., (2024) Successful First Flight of NASA's SLS (Space Launch System Super Heavy-Lift Rocket Lays Groundwork for U.S.'s Most Ambitious Missions, 71st JANNAP Propulsion Meeting.

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