



National Aeronautics and  
Space Administration



# SPACE LAUNCH SYSTEM

SEPTEMBER –  
DECEMBER 2021

# TESTING FOR FLIGHT

# ARTEMIS I SPACE LAUNCH SYSTEM IS STACKED



The Artemis I SLS interim cryogenic propulsion stage (ICPS) is stacked onto the launch vehicle stage adapter (LVSA).



The Artemis I Orion stage adapter (OSA) is stacked on top of the ICPS.



The LVSA for the Artemis I SLS is moved into position on the core stage at the Vehicle Assembly Building (VAB).

NASA's Orion spacecraft is secured atop the agency's powerful [Space Launch System](#) rocket, and the integrated system is entering the final phase of preparations for an upcoming uncrewed flight test around the Moon. The mission, known as [Artemis I](#), will pave the way for a future flight test with crew before NASA establishes a regular cadence of more complex missions with astronauts on and around the Moon under [Artemis](#). With stacking complete, a series of integrated tests now sit between the mega-Moon rocket and targeted liftoff for deep space in 2022. Each of the test campaigns will evaluate the rocket and spacecraft as an integrated system for the first time, building upon each other and culminating in a simulation at the pad to prepare for launch day.

Read more: [go.nasa.gov/32Jhqve](https://go.nasa.gov/32Jhqve)

# VIBRATION TESTS FOR MOON ROCKET HELP ENSURE SAFE TRAVELS ON ROAD TO SPACE



Rockets flying through the atmosphere to space, including SLS, have natural frequencies and experience dynamic forces during launch and ascent. Understanding those frequencies is critical to steering SLS and the Orion spacecraft safely through the atmospheric “road” to space. To safely control the rocket’s flight, the flight software and navigation system must distinguish the rocket’s natural frequencies from the vibration frequencies experienced during flight. That’s why teams at [NASA’s Kennedy Space Center](#) in Florida performed integrated modal testing to determine the different modes of vibration with the recently stacked, integrated SLS rocket before launch of the Artemis I mission.

Read more: [go.nasa.gov/2WgarXg](https://go.nasa.gov/2WgarXg)

The Artemis I SLS, stacked with the Orion mass simulator and OSA structural test article, undergoes modal testing.

# NASA'S SPACE LAUNCH SYSTEM ENGINEERING SUPPORT CENTER PREPARES FOR ARTEMIS I



SLS team members work through a launch simulation at Marshall's SLS Engineering Support Center in preparation of the Artemis I mission.

As teams at Kennedy in Florida continue [Artemis I](#) launch day preparations, crews at the SLS Engineering Support Center at [NASA's Marshall Space Flight Center](#) in Huntsville, Alabama, are joining simulations to practice their roles in the exploration of the Moon and beyond. The SLS Engineering Support Center will provide support from the ground during Artemis launches by monitoring data and solving challenges that may occur before and during SLS's Artemis flights. The support center allows the SLS team to connect not only with Kennedy, but also with experts at various locations across the United States to support ground processing, testing, launch, and flight operations for the rocket in real time.

Read more: [go.nasa.gov/32n9T4Z](https://go.nasa.gov/32n9T4Z)

# SLS BOOSTER FIRED UP TO TEST IMPROVED DESIGN FOR FUTURE ARTEMIS MISSIONS



The subscale motor produced 76,400 lbs. (34,654 kg) of thrust during the hot fire test. This test was the first of two tests supporting the advanced booster development effort that includes a new motor design for upcoming Artemis missions after Artemis VIII.

A team of NASA and Northrop Grumman engineers fired a 2-foot-diameter, subscale solid rocket booster on Dec. 2, 2021, at [Marshall](#). This test, conducted in Marshall's East Test Area, was the second of three tests supporting the Booster Obsolescence and Life Extension (BOLE) program, which will have an upgraded design to power the evolved configuration of the SLS rocket on flights after Artemis VIII.

Read more: [go.nasa.gov/3HwnBI7](https://go.nasa.gov/3HwnBI7)

# PROGRESS TO ARTEMIS I LAUNCH AND FUTURE ARTEMIS MISSIONS MAKES GREAT STRIDES IN 2021

NASA and its partners made great strides in 2021 despite the ongoing pandemic and multiple hurricanes that affected key manufacturing and test facilities on the Gulf Coast. Even as technicians assembled the Artemis I vehicle at Kennedy, progress towards numerous Artemis missions occurred across America. Here are the top stories from this year.

## SPACE LAUNCH SYSTEM PASSES KEY TEST, READIES FOR LAUNCH



NASA conducted the final test of the Green Run test series on the Artemis I core stage early in 2021. The final test was a hot fire test, during which the core stage was loaded with cryogenic liquid hydrogen and liquid oxygen and its four RS-25 engines were tested for the full eight-minute duration the stage will see during launch. The first hot fire test was conducted on January 16 but ended after just two minutes. While valuable data were collected, the decision was made to perform a second hot fire test. That test successfully ran for eight minutes on March 18.

Read more: [go.nasa.gov/3IsPhNO](https://go.nasa.gov/3IsPhNO)

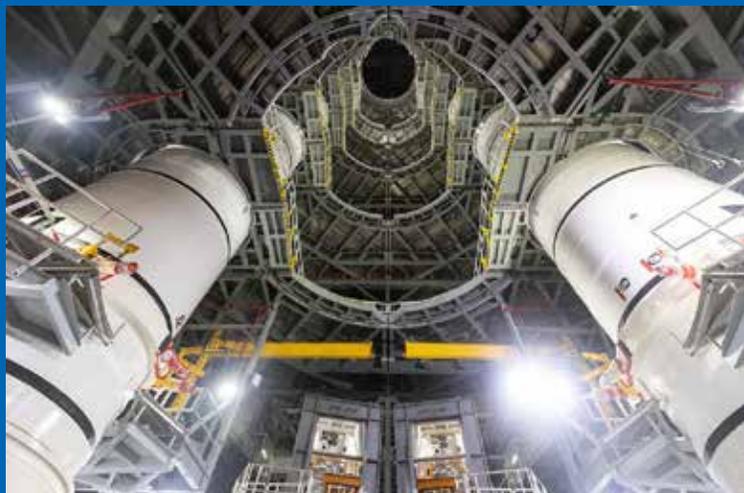
## ARTEMIS I CORE STAGE TRANSPORTED TO KENNEDY SPACE CENTER



Following the successful completion of the Green Run test series at NASA's Stennis Space Center in Bay St. Louis, MS, the Artemis I core stage was removed from the B-2 test stand and loaded on the barge Pegasus for transport to Kennedy. The 212-foot stage arrived in the turn basin on April 27 and was transported into the Vehicle Assembly Building (VAB) two days later. Once in the Vehicle Assembly Building (VAB), teams completed necessary work before stacking the stage between the twin solid rocket boosters.

Read more: [go.nasa.gov/3gNkz11](https://go.nasa.gov/3gNkz11)

## SOLID ROCKET BOOSTERS COMPLETE STACKING ON MOBILE LAUNCHER



In March, the solid rocket boosters completed stacking on the mobile launcher in the Vehicle Assembly Building's High Bay 3. Stacking began in November 2020 and involved putting each of the booster segments on the mobile launcher. Following stacking, teams conducted push-pull tests to collect data on the boosters. The core stage was mated to them in the summer.

Read more: [go.nasa.gov/2TImScN](https://go.nasa.gov/2TImScN)

## ARTEMIS I HITCHHIKER PAYLOADS INTEGRATED ON SLS FOR LAUNCH



Artemis I will have 10 "hitchhiking" payloads that will deploy at various deep space destinations following Orion's separation from SLS. These briefcase-size secondary payloads will launch in the Orion stage adapter and will conduct a variety of studies around Earth, the Moon, and deeper in space. They were successfully integrated into the adapter in the fall and subsequently stacked on SLS.

Read more: [go.nasa.gov/3Ad0M1N](https://go.nasa.gov/3Ad0M1N)

## SIMULATIONS PREPARE TEAM, FACILITIES FOR ARTEMIS I MISSION



The Artemis I launch and mission teams performed multiple simulations throughout the year. These simulations covered every aspect of the mission from the start of the launch countdown through filling the core stage and ICPS with cryogenic fuel and oxidizer, and launch and ascent. The teams became comfortable with the data they will see at the various phases of the mission. They also gained practice solving any problems that might arise during the actual launch.

Read more: [go.nasa.gov/3H5fs6P](https://go.nasa.gov/3H5fs6P)

## WEATHER SIMULATION CLEARS THE SKIES FOR ARTEMIS I MISSION



In addition to preparing the hardware, software, and flight controllers for the Artemis I launch, the weather team conducted its own simulations and practice trials. Meteorologists play a vital role in protecting the rocket and helping ensure NASA launches SLS in conditions safe for the rocket, the payload, and the public.

Read more: [go.nasa.gov/3EnhOw2](https://www.nasa.gov/3EnhOw2)

## HARDWARE PROGRESSES FOR ARTEMIS MISSIONS II, III, AND BEYOND



As teams at Kennedy prepare for the first flight of SLS and Orion, the teams at Marshall, NASA's Michoud Assembly Facility in New Orleans, LA, and industry sites around the country are hard at work building components for the Artemis II and III missions. In 2021, the Artemis II LVSA, forward core stage section, and core stage liquid hydrogen tank all reached manufacturing milestones while all 10 Artemis III booster motor segments were cast and welding continued on the Artemis III LVSA, OSA, and core stage components. Components for Artemis V and beyond continued to make progress.

Read more: [go.nasa.gov/32xYYW8](https://www.nasa.gov/32xYYW8)

## NASA SEEKS INPUT TO POSITION MEGA-ROCKET FOR LONG-TERM EXPLORATION

In October, NASA released a Request for Information (RFI) inviting industry to provide feedback on the best ways to produce and operate SLS for its deep space exploration missions. The goal is to gather information to position the agency to support long-term exploration of the Moon, Mars, and beyond by streamlining SLS production and operations, maximizing efficiencies, and making the national capability available to other customers in the government and industry.

Read more: [go.nasa.gov/3sV88qG](https://www.nasa.gov/3sV88qG)



## TWO NEW RS-25 TEST SERIES TEST COMPONENTS FOR FUTURE SLS ENGINES



In January, teams kicked off the Retrofit 2 test series to evaluate components made with cutting-edge and cost-saving technologies for the SLS RS-25 engines. The RS-25 is the powerhouse engine for the rocket's core stage, burning for the entire eight-minute flight to space. The test series concluded in September after seven successful tests. The Retrofit 3 test series began in December and will have three phases. Phase 1 will gather performance data on a developmental engine on components using state-of-the-art fabrication technologies. Phase 2 will feature a certification engine built with brand-new parts from manufacturer Aerojet Rocketdyne. The engine is identical to the new-production engines that will be used after Artemis IV. Phase 3 will use a developmental engine and along with the certification engine will be used to certify engines for flight. In total 27 tests are planned with the Retrofit 3 series.

Read more: [go.nasa.gov/3eiKWdu](https://go.nasa.gov/3eiKWdu)

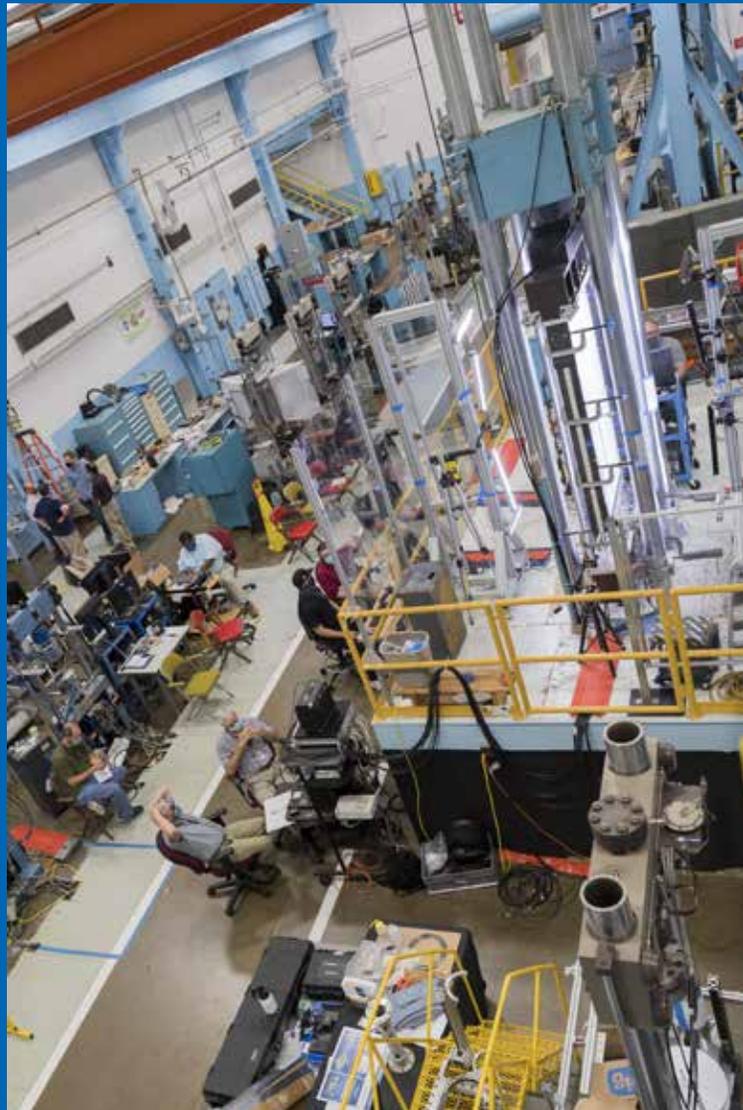
## CONTRACT FINALIZED FOR NEXT GENERATION SOLID ROCKET BOOSTERS



Artemis IX will debut a newly designed solid rocket booster which will make SLS more powerful than ever before. The contract to continue building boosters for missions beyond Artemis III and to begin design, development, and testing of that next generation booster was finalized in December.

Read more: [go.nasa.gov/3mqDSzX](https://go.nasa.gov/3mqDSzX)

## TEST PANELS FOR SLS BLOCK 1B FEEL THE PRESSURE



Artemis IV will debut the Block 1B version of the rocket, featuring a more powerful upper stage and a new Universal Stage Adapter, with volume for co-manifested payloads. Teams at NASA's Langley Research Center in Virginia conducted structural tests on developmental panels made of the same composite materials as the adapter.

Read more: [go.nasa.gov/3eh8oba](https://go.nasa.gov/3eh8oba)

# WHAT'S NEW IN SLS SOCIAL MEDIA

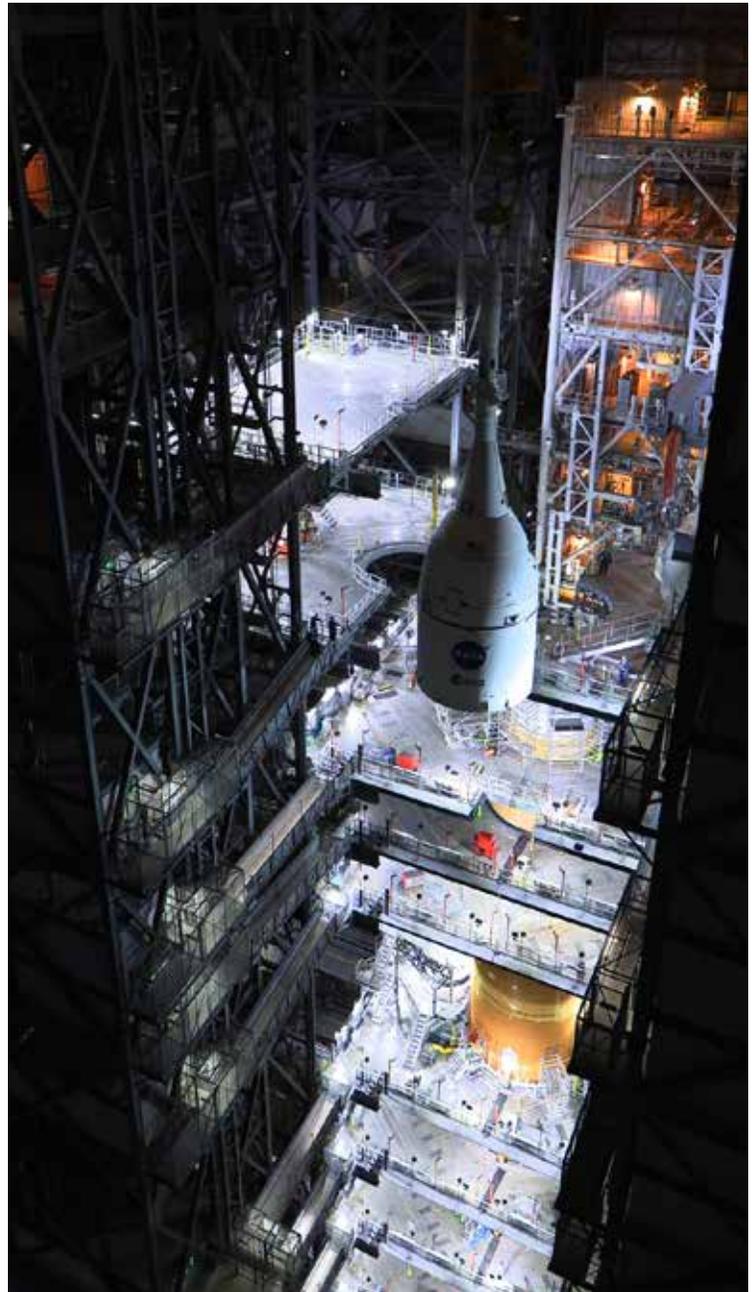
## NASA ARTEMIS I UMBILICAL RELEASE AND RETRACT TEST ENSURES SAFE SEPARATION DURING LAUNCH



Teams at Kennedy conducted the Umbilical Release and Retract Test in September. The test ensured that the umbilicals, which supply the rocket with fuel, oxidizer, power, and commands while on the launch pad, properly separate during launch.

Watch the full video here: [go.nasa.gov/3J9GDzj](https://go.nasa.gov/3J9GDzj)

## ORION IS LIFTED INTO PLACE ON SLS



In October, the Artemis I Orion capsule was lifted into High Bay 3 at the Vehicle Assembly Building and stacked atop SLS.

Read more: [go.nasa.gov/3FnhiQa](https://go.nasa.gov/3FnhiQa)

# SLS ON THE ROAD



NASA SLS and NASA Marshall team members participated in the Huntsville Science Festival STEAMfest 2021 in Huntsville, AL, on Oct. 20, 2021, where they shared the SLS story and excitement with members of the community. STEAMfest included numerous organizations and companies to encourage the public – young and old – to be engaged and excited in science, technology, engineering, art, and mathematics (STEAM).



SLS team members joined members of the Huntsville community for the ARTEMIS Walk October 8. Visitors learned about SLS, the Artemis missions, and even saw a flyover of the International Space Station.

# SPACEFLIGHT PARTNERS:

*Kirkhill Inc.*

**NUMBER OF EMPLOYEES:** 550

**LOCATION:** *Brea, California*

## WHAT THEY DO FOR SLS:

*Kirkhill Inc. produces insulating materials for the SLS solid rocket motors. Materials include silica-filled EPDM, silica-filled NBR, PBI-filled NBR, and natural rubber. Kirkhill insulating materials were used on the Flight Support Booster-1 that successfully test-fired in September 2020. The insulation in the booster motors protects the cases and igniters' metal hardware from the harsh internal motor environment. It also protects the external motor joints from weather on the launch pad and from heating during flight. Kirkhill's engineered, high-performance elastomer products are used on commercial, military, and business aircraft around the world as well as rockets and satellites. Kirkhill Inc. is a valuable partner in ensuring the consistency, dependability, and safety of the SLS Program and has been a key team member for many years.*

# GET THE LATEST SLS UPDATES SENT TO YOUR INBOX EACH MONTH!



## Top Three Countdown

*What you need to know right now*

- 3... Expert launch support — Crews at the SLS Engineering Support Center are training for their major role in the Artemis I launch. [Read more](#)
- 2.. A new outfit — The launch vehicle stage adapter for the Artemis II mission is ready to be outfitted for launch. [Read more](#)
1. From the top — NASA has completed assembly of the upper part of the core stage that will send the Artemis II crew on their lunar mission. [Read more](#)

## Picture of the Month

*We know how to wow*



Teams at NASA's Michoud Assembly Facility in New Orleans completed joining the upper part of the core stage that will send the Artemis II crew on their lunar mission. The 66-foot-tall portion of the 212-foot-tall rocket stage consists of the forward skirt, the liquid oxygen tank, and the intertank.

Every day, the SLS rocket gets closer to launch. Get updates in your inbox each month by subscribing to [SLS in 3..2..1.](#)



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