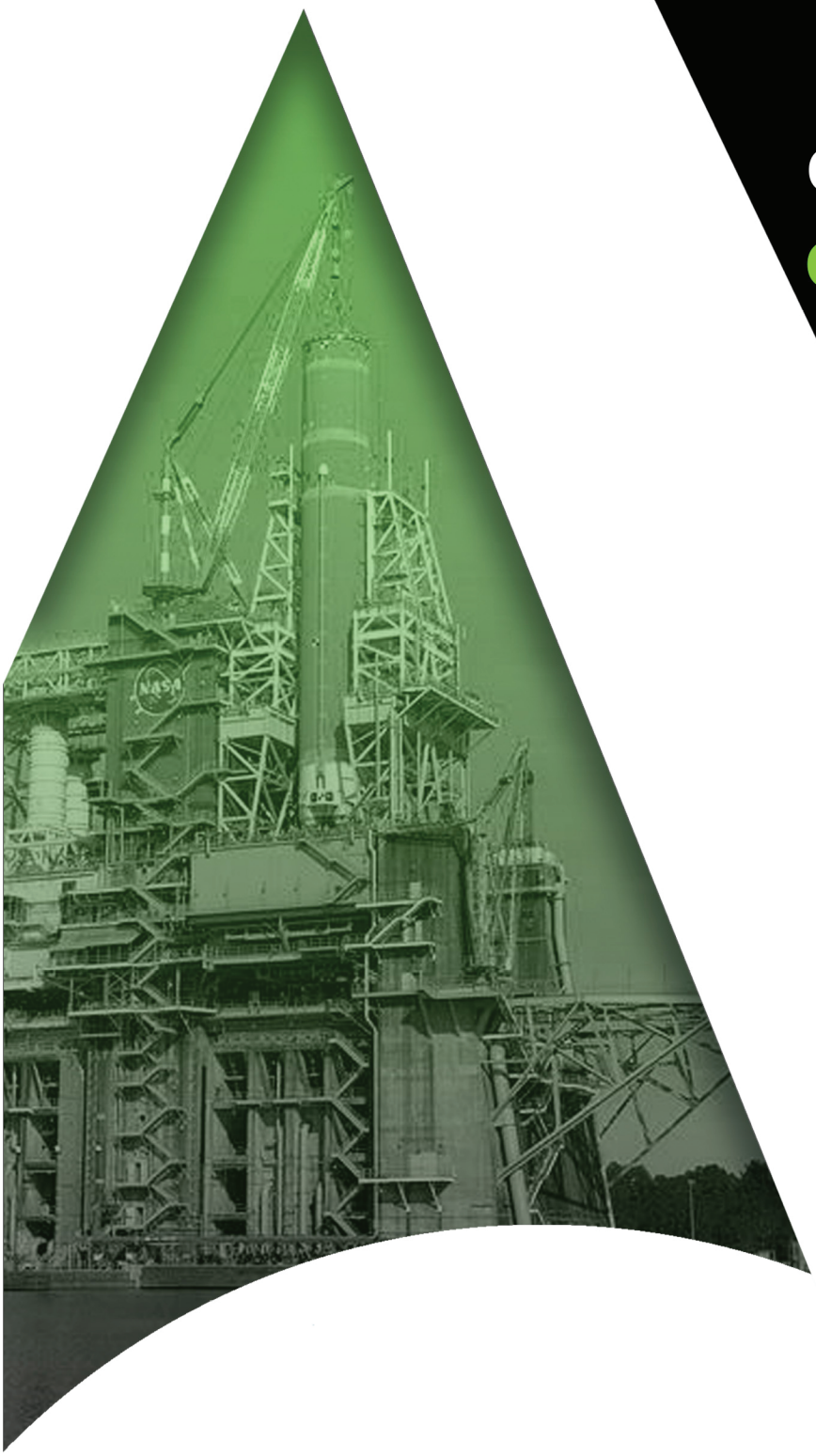
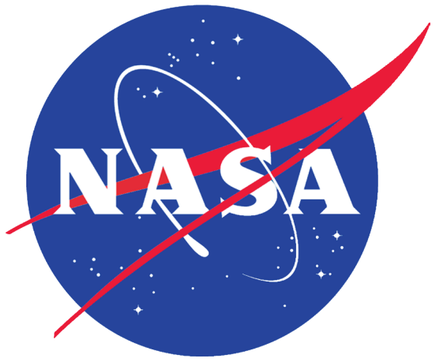
National Aeronautics and
Space Administration



SLS
Core Stage
Green Run
Hot Fire

NASA's Stennis Space Center



As part of the Artemis program, NASA is sending the first woman and next man to land on the Moon in 2024 and establishing sustainable lunar exploration by the end of the decade.

Our powerful Space Launch System rocket is undergoing a series of critical tests to reduce risk on our early Artemis missions. A successful Green Run test series, which culminates in a test of all four rocket engines firing simultaneously, keeps NASA on track to launch the first uncrewed flight test of SLS and our Orion spacecraft in late 2021 and a crewed flight test in 2023.

In addition to supporting our bold goal of returning astronauts to the Moon within four years, the Green Run series is helping prepare humanity for exploration farther into the solar system, including Mars.

NASA Administrator Jim Bridenstine

STENNIS SPACE CENTER AND GREEN RUN TESTING

The Space Launch System core stage installed on the B-2 Test Stand at Stennis Space Center

WHAT IS GREEN RUN?

Green Run is the term used for the **FIRST "FULL-UP" TEST** of the Space Launch System core stage and all of its integrated systems. The testing replicates the launch procedure, even to the point of firing the stage's **FOUR RS-25 ENGINES SIMULTANEOUSLY**, as during an actual flight, generating 1.6 million pounds of combined sea-level thrust.

WHAT IS THE SPACE LAUNCH SYSTEM CORE STAGE?

NASA is building the Space Launch System to carry astronauts on deep space missions to the **MOON BY 2024** as part of the **ARTEMIS PROGRAM** and, ultimately, to Mars. The core stage is the first stage of the rocket that ignites to help power liftoff.

WHY IS IT TESTED?

The Space Launch System has not yet flown. It is tested prior to its maiden flight in order to identify and address any issues earlier rather than later, to increase the probability of successful missions, and to **ENSURE ASTRONAUT SAFETY**.

WHAT IS NEXT?

Following the hot fire test, operators will perform necessary **REFURBISHMENT WORK** on the core stage and begin putting systems into flight configuration. The stage will travel on NASA's ***Pegasus*** barge to Kennedy Space Center to be mated with other Space Launch System stages and parts. The full rocket then will be moved to a launch pad and prepped for launch of the Artemis I mission.

HOW IS IT BEING TESTED?

The Space Launch System **FLIGHT CORE STAGE** was installed vertically on the B-2 Test Stand at Stennis Space Center in January 2020. It then was anchored in place and all systems connected.

A series of tests have been conducted to ensure stage systems are functioning as needed. These tests have included:

- powering up the core stage's electronic **AVIONICS SYSTEM**.
- performing propulsion system and engine checks.
- conducting hydraulics and **THRUST VECTOR CONTROL SYSTEM** tests.

The thrust vector control system test ensures operators can gimbal engines during a hot fire, just as they must move during launch to maintain the rocket's needed trajectory.

Operators have established and confirmed the correct **"POWER UP" PROCEDURE** for the stage to ensure that all systems and equipment come on line as needed.

The test team has conducted a **"SIMULATED" COUNTDOWN**, in which operators walked through the hot fire procedure without actually flowing propellants through the core stage systems.

A **"WET DRESS REHEARSAL"** was conducted in which propellants were flowed. The test team proceeded all the way up to the point of actual engine ignition before concluding the exercise. Various anomalies were introduced during the exercise to train the team in identifying and addressing issues that may arise.

The concluding **HOT FIRE** will test the core stage just as it must operate during launch. All four RS-25 engines will fire for eight minutes to produce a combined 1.6 million pounds of sea-level thrust.

STENNIS SPACE CENTER HISTORY

The first-ever test at the then-Mississippi Test Facility (now Stennis Space Center) on April 23, 1966, on the A-2 Test Stand.

When President John F. Kennedy issued his 1961 challenge for the United States to send humans to the Moon and back by the end of that decade, a site was needed to test the powerful rocket engines and stages that would propel them on the historic journey.

For NASA officials, the rough terrain of Hancock County, Mississippi, provided five essentials for testing the large Apollo Program engines and stages: isolation from large population centers, water and road access for transportation, available public utilities, supporting local communities, and a climate conducive to year-round testing. The site was selected – and in May 1963, workers cut the first tree to launch a daunting building project. The effort marked the largest construction effort in the state of Mississippi and one of the largest in the United States at the time.

Despite a pressing schedule, inevitable setbacks and even the disruption of Hurricane Betsy in 1965, construction workers prevailed. On April 23, 1966, a Saturn V second-stage prototype was test-fired on the newly completed A-2 Test Stand at the site. With the shake, rattle and roar of the test, south Mississippi was blasted into the space age.

Until 1970, Stennis test-fired first and second stages of the Saturn V rockets used in the Apollo Program. Stennis Space Center then tested main engines for NASA's space shuttle. From 1975 to 2009, the south Mississippi site tested every main engine used to power 135 space shuttle missions.

Stennis now is testing RS-25 rocket engines for the new Space Launch System, being built to carry humans back to the Moon as part of NASA's Artemis Program and, ultimately, to Mars. Stennis also is testing the Space Launch System core stage that will fly on the maiden Artemis I mission. The testing culminates with a firing of the core stage's four RS-25 engines at the B-2 Test Stand.

In addition to that testing, the center is partnering with private companies to test engines and components for various commercial and military missions.

Into its sixth decade of NASA support, Stennis continues to build on its rich history as the nation's largest rocket engine test site – a place where space dreams are powered into reality.

27

Saturn V rocket stages were tested at Stennis Space Center, including stages that carried the first humans to the surface of the Moon during the Apollo 11 mission.

2,307

Space shuttle main engine tests were conducted at Stennis Space Center from May 19, 1975 to July 29, 2009, totaling 820,475.68 seconds of hot fire.

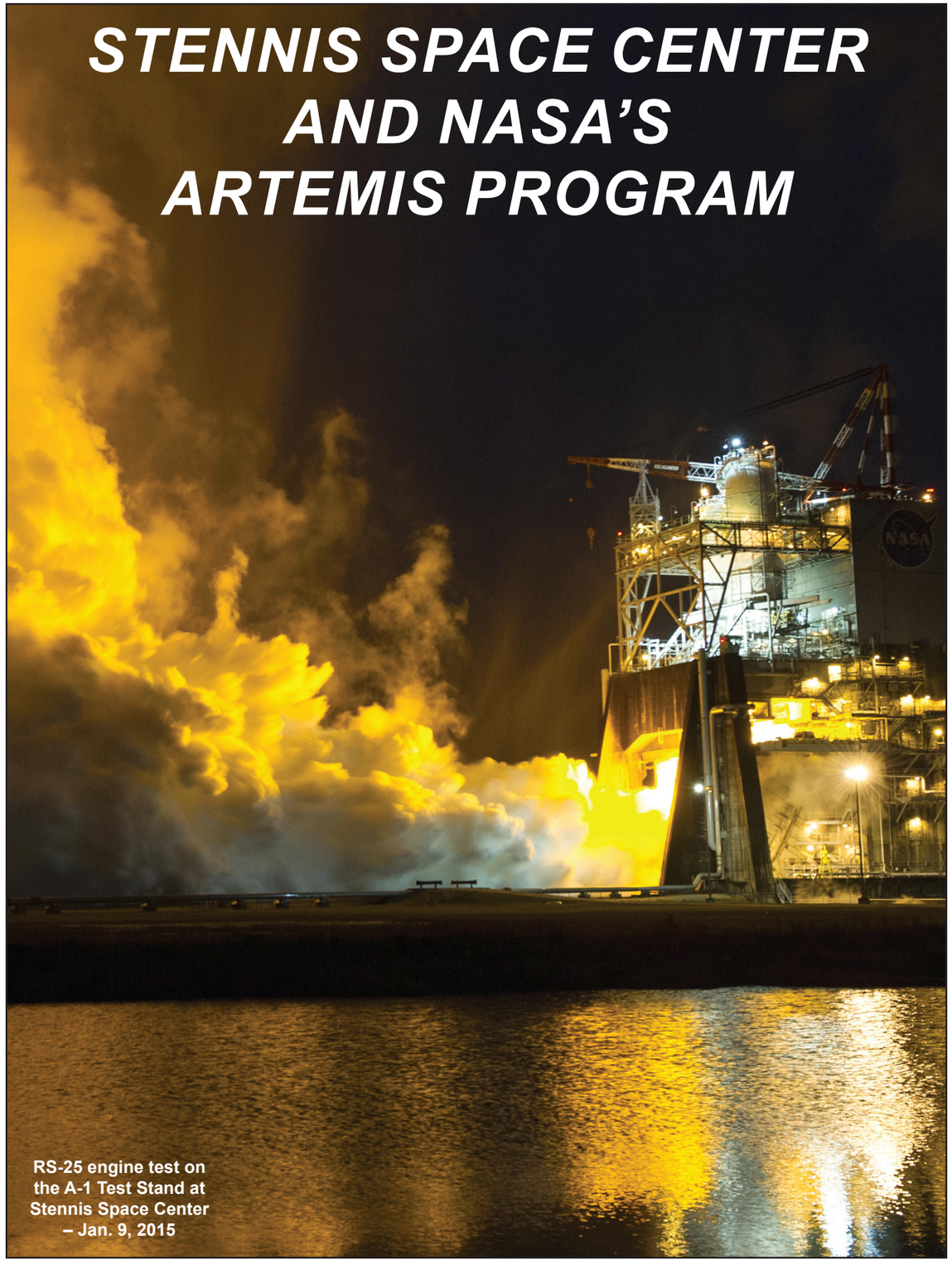
1 MILLION

Seconds of space shuttle main engine hot fire – including tests and launches – was achieved during a test on the A-2 Test Stand at Stennis Space Center on January 24, 2004.

16

On April 4, 2019, Stennis Space Center completed testing of all 16 former space shuttle main engines that will power the first four flights of NASA's new Space Launch System vehicle, including the mission that carries the first woman and the next man to the Moon.

STENNIS SPACE CENTER AND NASA'S ARTEMIS PROGRAM



RS-25 engine test on the A-1 Test Stand at Stennis Space Center – Jan. 9, 2015

THE NEW PROGRAM

NASA's **ARTEMIS PROGRAM**, named for the twin sister of Apollo, will return astronauts to the Moon to establish a strategic U.S. presence. It will send the **FIRST WOMAN** and the next man to the Moon by 2024.

THE NEW VEHICLE

The **SPACE LAUNCH SYSTEM** is being developed as the **MOST POWERFUL** rocket in history to travel deeper into space than ever and, ultimately, to Mars.

THE CORE STAGE

The Space Launch System core stage is powered by four RS-25 engines, firing together to generate **1.6 MILLION POUNDS** of combined sea-level thrust and more than **2 MILLION POUNDS** of altitude thrust.

THE ENGINES

RS-25 engines for initial **ARTEMIS PROGRAM** missions are space shuttle main engines, modified to provide more power and use a new controller. Each engine was **ANCHORED IN PLACE** on the A-1 Test Stand at Stennis and fired just as during an actual launch.

THE FUTURE

Artemis missions will test hardware, technologies, capabilities, and approaches needed for future space missions, including to **MARS**.

THE 'GREEN RUN'

Prior to the **ARTEMIS I MISSION**, NASA is testing the Space Launch System core stage on the B-2 Test Stand at Stennis. For **GREEN RUN**, the stage is installed on the stand and tested – along with all of its related components and systems – **FOR THE FIRST TIME** and in the same way it must operate on a mission. This includes firing all four RS-25 engines simultaneously to generate 1.6 million pounds of combined sea-level thrust.

THE TRADITION

All Saturn V first and second rocket stages that carried astronauts to the surface of the Moon during the **APOLLO PROGRAM** were tested at Stennis Space Center. All space shuttle main engines and the **SPACE SHUTTLE MAIN PROPULSION TEST ARTICLE** – with its three engines – was tested at Stennis prior to the vehicle's maiden flight.

THE ASSIGNMENT

- Test all **RS-25 ENGINES** that will help power the new Space Launch System vehicle.
- Test the Space Launch System **CORE STAGE** prior to its launch on the Artemis I mission.

THE IMPORTANCE

- **PROVE** new engines, hardware, and operating parameters.
- Ensure **ASTRONAUT SAFETY** by identifying and addressing potential issues prior to missions.
- Increase probability of **MISSION SUCCESS.**

THE STATUS

NASA performed the **FIRST RS-25 ENGINE TEST** at Stennis in January 2015. All RS-25 engines and new controllers for the first four Artemis missions have been tested and proven flightworthy at Stennis. The Space Launch System core stage was delivered to Stennis in **JANUARY 2020.** It is installed on the B-2 Test Stand and undergoing a series of tests before being shipped to Kennedy Space Center for preparation and launch on the **ARTEMIS I MISSION**. Stennis also will test new RS-25 engines built by Aerojet Rocketdyne for use on **FUTURE SPACE LAUNCH SYSTEM MISSIONS**.

B-2 TEST STAND

- The B-1/B-2 Test Stand is a dual-position, vertical-firing facility built in the 1960s to test Saturn V rocket stages that carried humans to the Moon during the **Apollo Program**. The B-1 side is equipped for single-engine tests. The B-2 side is designed to test rocket stages.

- NASA conducted the **first-ever hot fire test** on the B-2 Test Stand, a 15-second firing of the Saturn S-IC-T stage, on March 3, 1967.

- Twelve **S-IC flight stages** were tested on the B-2 Test Stand from April 1967 to October 1970. S-IC-4 through S-IC-12 powered Apollo 9 through Apollo 17 missions to the Moon. S-IC-13 launched Skylab into orbit. S-IC-14 and S-IC 15 never flew to space.

- The space shuttle **main propulsion test article**, consisting of an external tank and three main engines linked together with a simulated shuttle orbiter, was tested on the B-2 Test Stand from April 1978 through January 1981.

- The RS-68 powered **Delta 4 Common Booster Core** was tested on the B-2 Test Stand from November 1999 to May 2001.

- The B-2 Test Stand was modified to test the core stage of the new Space Launch System, the cornerstone vehicle for NASA's **Artemis Program** that will return humans to the Moon by 2024. Core stage testing culminates with the simultaneous firing of four RS-25 engines, just as will occur during an actual mission. Once tested, the core stage will power the launch of the first Space Launch System mission – **Artemis I**.

- The B-1/B-2 Test Stand is anchored in the ground with 144 feet of steel and concrete. As constructed, the soft core of the B-2 side was about 290 feet tall. The new steel superstructure added for testing of the **Space Launch System core stage** extends that height to almost 350 feet, ranking the stand as one of the tallest structures in the state of Mississippi.

- The main derrick crane atop the B-2 Test Stand was extended 50 feet with an increased load rating of 195 tons in order to lift the Space Launch System core stage, which is larger and heavier than the earlier Saturn V stages. The core stage stands **212 feet tall** with a diameter of 27.6 feet.

- The simultaneous firing of the Space Launch System core stage's four RS-25 engines will generate **1.6 million pounds** of thrust at sea-level, increasing to more than **2 million pounds** at altitude during a launch.

- More than 32,500 5/32-inch holes in the B-2 Test Stand flame deflector direct more than **240,000 gallons of water** a minute to cool engine exhaust during a test. Another **92,000 gallons of water** per minute is sprayed through 92 nozzles to provide vibro-acoustic suppression protection to the core stage during testing.

- More than **100 water nozzles** are arrayed across the test stand to provide a curtain of water over the length of the core stage and across the facility, if needed, to prevent damage in the event of a fire or cryogenic spill.

- The average U.S. home uses about 100,000 gallons of water a year. For a Space Launch System core stage test, the B-2 Test Stand will use that amount **every 18 seconds**.

- The B-2 stand is serviced by the Stennis High Pressure Industrial Water Facility. The original water system has been upgraded due to age and in order to increase the water flow needed for core stage testing. The system now is capable of delivering **335,000 gallons per minute** of water to the B-2 Test Stand via 96-inch pipes. The capacity represents an increase of 25,000 gallons per minute from the original system.

- The B-1/B-2 Test Stand originally was rated for a maximum thrust load of 11 million pounds. However, the stand flame deflectors currently are limited to 3 million pounds of thrust.

SPACE LAUNCH SYSTEM

ARTEMIS TESTING: GREEN RUN CHECKLIST

TESTING THE WORLD'S LARGEST ROCKET STAGE

A total of eight Green Run tests minimize risk to the ARTEMIS I core stage and ensure the flight hardware satisfies design objectives and validates design models:

TEST 1	Apply forces simulating launch to the unpowered, suspended core stage.	✓
TEST 2	Turn on and check out core stage avionics.	✓
TEST 3	Simulate potential issues to test systems that shut down other systems if there's a problem.	✓
TEST 4	Test main propulsion system components that connect to the engines.	✓
TEST 5	Test thrust vector controls and check out all the related hydraulic systems.	✓
TEST 6	Simulate launch countdown to validate timeline and sequence of events.	✓
TEST 7	Load and drain more than 700,000 pounds of cryogenic propellants.	✓
TEST 8	Fire all four RS-25 engines for up to 8 minutes.	☐

#ARTEMIS

The hot fire test of NASA's Space Launch System (SLS) core stage culminates a series of tests to bring the flight unit to life for the first time, allowing engineers to evaluate the new complex stage that will launch the Artemis I lunar mission.

In January 2020, engineers at NASA's Stennis Space Center began activating the stage's components one-by-one through a series of initial tests and functional checks designed to identify any issues. Those tests and checks – collectively called Green Run – conclude with the test fire, replicating the stage's first flight.

"This testing will reduce risks for not only the first flight, but also for the Artemis mission that will land astronauts on the Moon in 2024," said Richard Sheppard, the SLS Stages Green Run Test Lead from NASA's Marshall Space Flight Center in Huntsville, Alabama.

The Green Run series, conducted on the B-2 Test Stand at Stennis, has been a collaborative effort between the SLS program, the Stennis test team, core stage manufacturer Boeing and engine manufacturer Aerojet Rocketdyne.

In mid-March 2020, work was temporarily suspended in response to a rise in COVID-19 cases near Stennis. Prior to pausing, engineers completed the modal test, the first of eight tests in the Green Run series, to understand the vibration characteristics of the core stage. Weeks later, work was slowly and methodically starting back, as workers returned to prepare the facility.

The next month, teams began working through the remaining tests, all designed to minimize risk to the core stage and ensure the stage satisfies design objectives and validates design models. The entire series include eight tests:

- **Test 1 – Modal Test.** The first test in the Green Run series was conducted during installation. The modal test used shakers to impart dynamic forces on the suspended stage to identify primary bending modes of the stage. Information from the modal test helps engineers verify vehicle models needed for the operation of the rocket's guidance, navigation and control systems.
- **Test 2 – Avionics.** The rocket's avionics, which are distributed throughout the stage, were turned on and checked out. This included not only flight computers and electronics that control the rocket but also those that collect flight data and monitor the overall health of the core stage.
- **Test 3 – Fail-Safes.** Engineers checked out all the safety systems that shut down operations during testing. To do this, they simulated potential issues.
- **Test 4 – Propulsion.** Engineers conducted the first test of each of the main propulsion system components that connect to the engines. Command and control operations were verified, and the core stage was checked for leaks in fluid or gas.
- **Test 5 – Thrust Vector Controls.** Engineers ensured the thrust vector control system can move the four engines as needed and checked all the related hydraulic systems.
- **Test 6 – Countdown.** Engineers simulated the launch countdown, including step-by-step fueling procedures. Core stage avionics were powered on, and propellant loading and pressurization were simulated. The test team exercised and validated the countdown timeline and sequence of events.
- **Test 7 – "Wet" Dress Rehearsal.** Engineers demonstrated loading, controlling, and draining more than 700,000 total gallons of cryogenic propellants into the two test stand run tanks and then returning the stage to a safe condition.
- **Test 8 – Hot Fire.** The core stage's four RS-25 engines will fire for up to 8 minutes, generating 1.6 million pounds of thrust, the amount the engines produce at sea level on the launch pad at liftoff.

After the hot fire test, engineers will refurbish the core stage and configure it for its journey to Kennedy Space Center for launch preparations. The next time the RS-25 engines fire, the Space Launch System will launch in an epic debut of Artemis I – the first in a series of increasingly complex missions that will enable human exploration to the Moon and Mars.

WHAT IS THE RS-25 ENGINE?

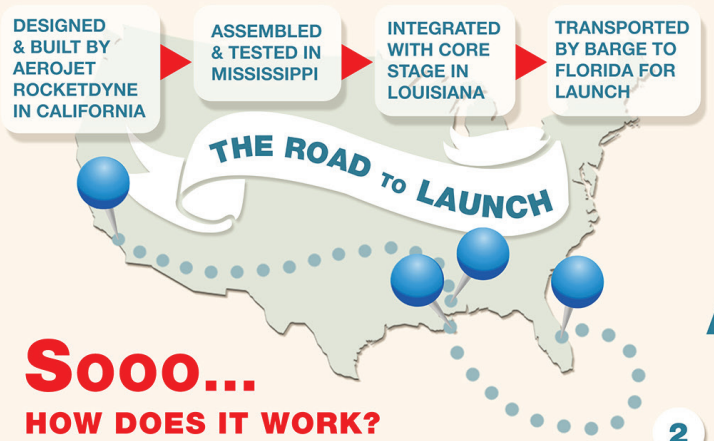
FOR THREE DECADES, THE RS-25 ENGINE PROPELLED THE SPACE SHUTTLE. NOW, THIS POWERFUL ENGINE HAS BEEN SELECTED FOR THE SPACE LAUNCH SYSTEM (SLS) FOR ITS HIGH PERFORMANCE AND RELIABILITY.

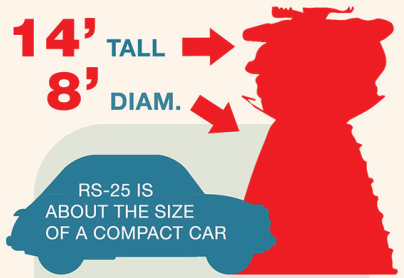
WHEN SLS IS LAUNCHED, ITS **4** RS-25 ENGINES FIRE NON-STOP FOR **8.5** MINUTES.

THESE PROVEN ENGINES, PLUS **2** SOLID ROCKET BOOSTERS, MAKE SLS THE MOST POWERFUL ROCKET IN THE **WORLD**.

FOUR RS-25 ENGINES ON THE CORE STAGE GIVE SPACE LAUNCH SYSTEM

2 MILLION
OF ITS
8.8 MILLION
POUNDS OF MAXIMUM THRUST





AND WEIGHS 8000* LBS

Sooo...
HOW DOES IT WORK?

1 2 3 4 FOUR POWERFUL TURBOPUMPS

PERFORM MUCH LIKE GIANT HEARTS, CREATING IMMENSE PRESSURE THAT CONTROLS THE FLOW OF LIQUID HYDROGEN (LH_2) AND LIQUID OXYGEN (**LOX**) INTO THE COMBUSTION CHAMBER

5 MAIN COMBUSTION CHAMBER

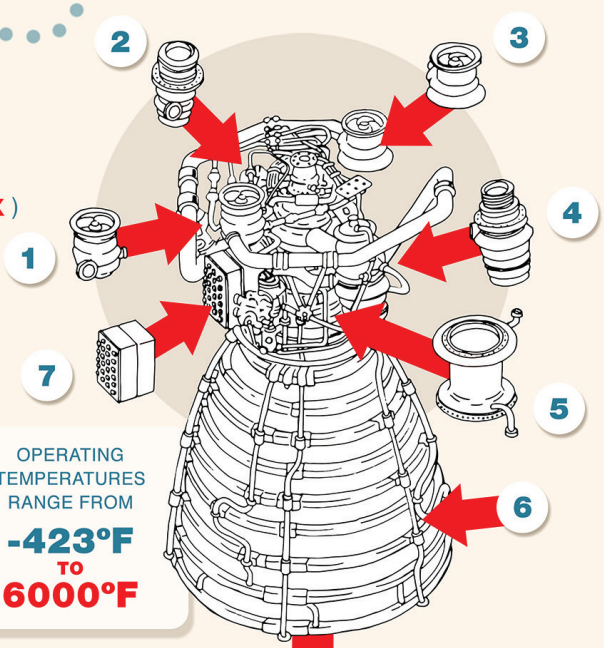
COMBINES **FUEL** AND **OXYGEN** IN THE "BELLY" OF THE ENGINE

6 NOZZLE

DIRECTS THE **FLOW** AND INCREASES THE **VELOCITY** OF THE EXHAUST

7 ENGINE CONTROLLER

MONITORS ENGINE CONDITIONS AND **OPERATES** THE VALVES, PUMPS AND ACTUATORS THAT CONTROL THRUST



OPERATING TEMPERATURES RANGE FROM
-423°F
TO
6000°F

EACH OF RS-25'S FOUR TURBOPUMPS HAS DOZENS OF TURBINE BLADES. JUST **1 BLADE** THE SIZE OF A QUARTER ON THE HIGH PRESSURE FUEL TURBOPUMP GENERATES MORE HORSEPOWER THAN A CORVETTE ENGINE.

FUN FACT:

HOT GASES EXIT THE RS-25 NOZZLE AT **13X THE SPEED OF SOUND**, OR FAST ENOUGH TO TRAVEL FROM LOS ANGELES TO NEW YORK CITY IN 15 MINUTES.

* WEIGHT IS APPROXIMATE

THE HOW & WHY OF RS-25 TESTING

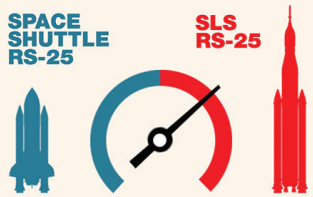
EVEN THOUGH THE RS-25 ENGINES FOR NASA'S SPACE LAUNCH SYSTEM (SLS) HAVE SUCCESSFULLY FLOWN DOZENS OF MISSIONS ON THE SPACE SHUTTLE, THEY NEED TO BE TEST-FIRED ON THE GROUND PRIOR TO THEIR USE ON SLS FOR A NUMBER OF COMPELLING REASONS.

1 ENGINE DEMANDS

RS-25 WILL BE OPERATING AT **109%** POWER VERSUS **104.5%** ROUTINELY FLOWN DURING THE SPACE SHUTTLE PROGRAM.

2 NEW CONDITIONS

PROPELLANT INLET PRESSURES WILL BE **HIGHER**, THE PROPELLANT WILL BE **COLDER**, AND THE NOZZLES WILL GET **HOTTER** AT LAUNCH DUE TO THEIR PROXIMITY TO THE BOOSTER NOZZLES.



3 NEW HARDWARE

ALONG WITH NEW DEMANDS ON THE ENGINE, THE RS-25 ALSO HAS A NEW ENGINE CONTROLLER AND OTHER COMPONENTS THAT HAVE NEVER FLOWN OR HAVE NEVER FLOWN TOGETHER THAT MUST BE TESTED.

4 NEW CORE STAGE

AFTER THE ENGINES AND ENGINE CONTROLLERS ARE INSTALLED, NASA NEEDS TO TEST THE FIRST SLS FLIGHT CORE STAGE TOGETHER WITH ALL FOUR ENGINES FOR THE FIRST TIME, KNOWN AS A "**GREEN RUN**."

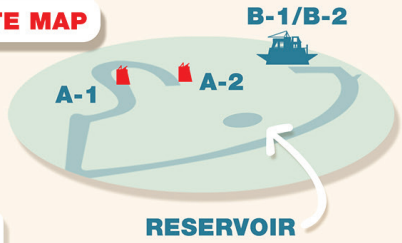
5 TESTING TESTERS

TESTING ALSO COMPARES ACTUAL TEST READINGS AGAINST PREDICTIONS MADE BY HUMANS AND COMPUTERS, THUS ENSURING THE ACCURACY AND RELIABILITY OF THE PREDICTIONS.

BUILT IN 1961, **STENNIS SPACE CENTER** IS NASA'S ROCKET ENGINE TEST CENTER. LOCATED IN HANCOCK COUNTY, MISSISSIPPI, IT HAS THE NATION'S **LARGEST** TEST STANDS.

OF THESE, THE **A-1** TEST STAND AND THE DUAL POSITION **B-1/B-2** TEST STAND WERE BUILT IN THE 1960s FOR NASA'S APOLLO PROGRAM. THEY WERE RE-USED FOR SPACE SHUTTLE PROPULSION TESTING AND NOW SUPPORT VARIOUS PROPULSION PROGRAMS.

SITE MAP



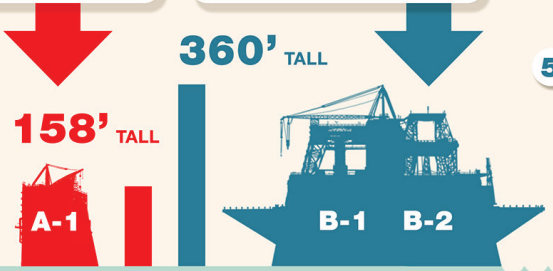
IN THE **1960s** AND **'70s**, WELL WATER WAS PUMPED TO THE B STAND. IN THE **'80s**, WATER WAS DIVERTED FROM A MANMADE CANAL SYSTEM INTO A **66 MILLION** GALLON RESERVOIR.

H_2O

THE STANDS USE WATER TO KEEP THEMSELVES COOL. A FLAME DEFLECTOR HAS THOUSANDS OF HOLES THAT SPRAY WATER TO COOL THE HEAT AND DEADEN THE SOUND.

SINGLE RS-25 ENGINES WILL BE TESTED ON THE **A-1 TEST STAND**

THE FIRST TWO CORE STAGES WILL BE TESTED ON THE **B-2 TEST STAND**



FUN FACT:

RS-25 BURNS CLEAN. ITS EXHAUST IS **WATER VAPOR**, NOT SMOKE. THE EXHAUST IS SO DENSE THAT IT ACTUALLY CAN FALL LIKE RAIN.

A-1 SUPPORTS UP TO **1.1 MILLION** POUNDS OF THRUST (MAXIMUM DYNAMIC LOAD)

B-2 SUPPORTS UP TO **3 MILLION** POUNDS OF THRUST (MAXIMUM DYNAMIC LOAD)

NASA'S A-1 TEST STAND WAS DESIGNATED A NATIONAL HISTORIC LANDMARK IN **1984**

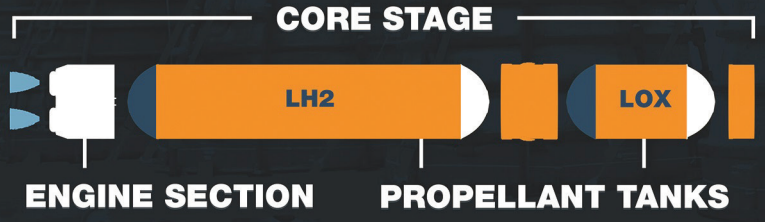
SPACE LAUNCH SYSTEM

ARTEMIS I:
FOUR RS-25 ENGINES

UPGRADED & READY FOR A BOLD NEW MISSION

Shown here from the bottom, looking up at the rocket from below, four liquid hydrogen **(LH2)** and liquid oxygen **(LOX)**-fueled **RS-25 ENGINES** are arranged in a square pattern, like legs on a table, providing stability and even distribution of propulsion forces to the rocket. At launch, they will produce

2 MILLION POUNDS OF THRUST
to help power the Space Launch System.



Including these first four engines, NASA has a total **16 ENGINES** available for the first four missions.

www.nasa.gov/SLS

WHAT'S IN A NUMBER?

Each engine has its own number and NASA keeps a history of which engines are used on each mission. For the first SLS flight, they are engines **E2045**, **E2056**, **E2058** and **E2060**.

ENABLING MISSION SUCCESS

These four proven engines contributed to **21** successful shuttle flights over three decades.

- **E2045**: most veteran engine with **12 FLIGHTS** (First flight was STS-89 in January 1998 and last was STS-135 in July 2011); also flew on Astronaut John Glenn's last flight, STS-95
- **E2056**: Total **4 FLIGHTS**, including STS-114, NASA's Return to Flight after Columbia
- **E2058**: Total **6 FLIGHTS**, including first flight of a Swedish astronaut (Christer Fuglesang)
- **E2060**: Total **3 FLIGHTS**, including STS-135, the last shuttle mission

WHAT'S NEW FOR SLS?

- **ENGINE CONTROLLERS** - the brains of the engine
- **HIGHER THRUST** - equates with better performance
- **ADAPTED TO SLS UNIQUE OPERATING ENVIRONMENTS**

SPACE LAUNCH SYSTEM

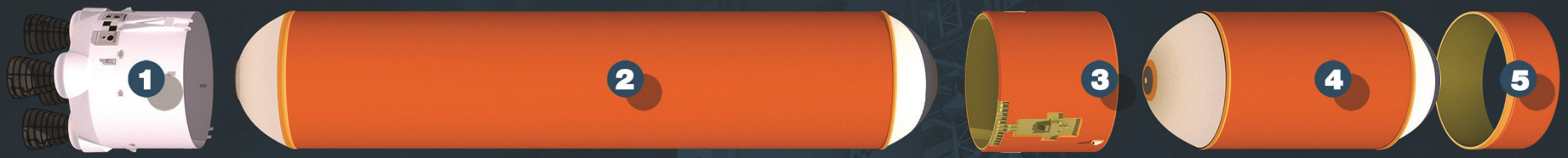
INSIDE THE SLS CORE STAGE

THE BACKBONE OF THE SLS ROCKET

HOW BIG IS THE CORE STAGE?

- **212'** tall and **27.6'** in diameter
- **~2.3M POUNDS** with propellant
- The largest rocket stage ever built
- Fuels the world's most powerful rocket

SLS reaches **MACH 23** (faster than **17,000 MPH**) in just **8.5 MINUTES**.



1 ENGINE SECTION

- Delivers propellants from the LH2 and LOX tanks to **4 RS-25 ENGINES**
- Avionics to steer engines
- Aft booster attach point

2 LIQUID HYDROGEN (LH2) TANK

- Holds **537,000 GALLONS** of liquid hydrogen cooled to **-423°F**

3 INTERTANK

- Joins **LH2** and **LOX** tanks
- Houses avionics and electronics
- Forward booster attach point

4 LIQUID OXYGEN (LOX) TANK

- Holds **196,000 GALLONS** of liquid oxygen cooled to **-297°F**

5 FORWARD SKIRT

- Houses flight computers, cameras, and avionics — the **"BRAINS"** of the rocket

Fuels 4 engines to produce a total **2 MILLION POUNDS** of thrust

733,000 GALLONS of propellant fill the **LH2** and **LOX** tanks together, enough to fill **63** large tanker trucks.

BIGGER TANKS. BOLDER MISSIONS.

www.nasa.gov/SLS

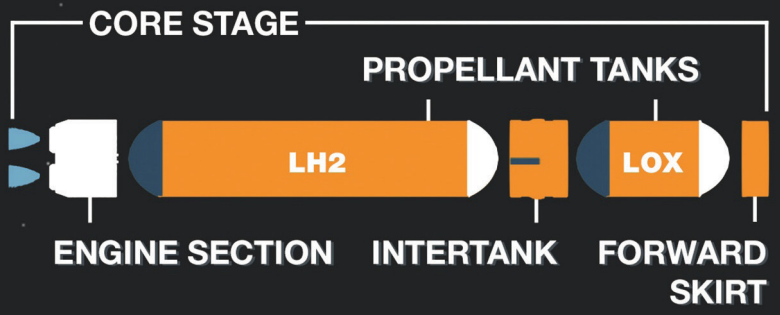
#NASASLS

SPACE LAUNCH SYSTEM (SLS)

ARTEMIS TESTING: TEST LIKE YOU FLY

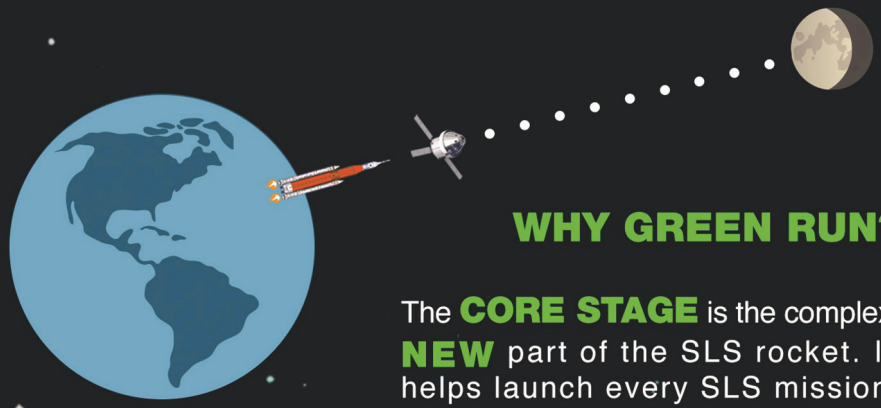
National Aeronautics and Space Administration

TESTING THE WORLD'S LARGEST ROCKET STAGE



GREEN: New, untested rocket hardware

GREEN RUN: First full test of all the SLS core stage **FLIGHT HARDWARE**



WHY GREEN RUN?

The **CORE STAGE** is the complex, **NEW** part of the SLS rocket. It helps launch every SLS mission, beyond Earth's orbit and to the Moon.

WHAT IS TESTED?

- Three flight computers, more than 50 avionics units, navigation and control systems, and flight software controlling the first **8 MINUTES** of flight.
- Two propellant tanks containing more than **700,000 GALLONS** of fuel.
- Propulsion systems with **18 MILES** of cables and more than 500 sensors and systems. These complex systems feed fuel to **4 RS-25 ENGINES** that fire at the same time to produce **1.6 MILLION LBS OF THRUST**.

OBJECTIVE: Ensure success of the first flight of SLS and the Orion Spacecraft—Artemis I—and future missions to support landing astronauts on the Moon in **2024**.

WHERE IS THE TEST?

NASA's **B-2 TEST STAND** at Stennis Space Center in Mississippi.

www.nasa.gov/SLS

SLS CORE STAGE ARRIVES, ROLLS OUT

The first Space Launch System core stage arrived at Stennis Space Center early in 2020, reaching the B-2 Test Stand on Jan. 12. The stage – which will be used to launch the Artemis I mission – was built at nearby Michoud Assembly Facility in New Orleans. It was transported to Stennis aboard NASA's *Pegasus* barge. The stage was rolled out onto the B-2 Test Stand tarmac soon after its arrival. Crews then began preparing to lift and install the stage on the stand for a series of Green Run tests.

SLS CORE STAGE INSTALLED

The first Space Launch System core stage was lifted onto the B-2 Test Stand at Stennis Space Center on Jan. 21-22, 2020, during optimal weather and wind conditions. Once the stage had been lowered into position, test crews began fully securing it in place and connecting it to stand systems for a series of Green Run tests.

GREEN RUN TESTING BEGINS

Following a temporary suspension of activity due to COVID-19, teams members began returning to Stennis Space Center in mid-May 2020 to resume Green Run testing of the first core stage for NASA's new Space Launch System. Teams already had completed the first test of the core stage Green Run series (top photo). Once returned, they ensured all was set to resume the integrated tests of the stage's complex systems.

IT TAKES A (REALLY BIG) VILLAGE

Hello there! You may not know me. I am *alligator mississippiensis*, sort of the official unofficial Stennis Space Center mascot.

In 1965, Stennis folks were looking for a mascot to boost morale during those hard construction days. Someone suggested a water moccasin or an armadillo. Can you imagine? One can kill you, and the other sleeps all but eight hours out of every day. Besides, *alligator mississippiensis* says it all right there in the name. What other mascot could there be for a NASA rocket engine test site in Mississippi? Forget the long moniker, though – just call me Gator.

I have seen a lot of years go by here – and a lot of good people performing a lot of good work. I remember the Apollo years when Stennis first tested large rocket stages used on the lunar missions. Then came the space shuttle years and a whole lot of other test projects along the way.

What is happening now as a combined team of folks complete Green Run testing of the first flight core stage for NASA's new Space Launch System (SLS) rocket is just as exciting as any of those days. And goodness, there are a whole lot of people with reason to get excited.

Folks often say "it takes a village" when talking about a group effort, but in the case of Green Run testing, "it takes a metropolis" would be a more fitting description. Think about it. Of course, there is the team that is actually conducting the various tests in the series. It includes NASA personnel from Stennis, as well as Marshall Space Flight Center. The team also includes SLS Program personnel, as well as employees from Aerojet Rocketdyne, Boeing and facility operations contractor Syncom Space Services.

But the test team is only part of those involved with Green Run. There are teams – with NASA and contractor personnel alike – at the High Pressure Gas Facility, High Pressure Industrial Water Facility, Cryogenic Storage Facility, and E Test Complex that will supply critical support for the hot fire of the stage's four RS-25 engines.

There are the ground and marine transport teams that handled and delivered the core stage to Stennis. There is the data acquisition team that will collect the critical information needed to evaluate the stage's performance during hot fire. There is the safety team working to ensure the health and safety of personnel at the B-2 Test Stand and elsewhere on site. There is also the security team, which is responsible for monitoring and controlling access to the stand.

All the folk involved with these teams are making visible contributions to the success of Green Run. However, there are still others – not so visible – who need to be included when counting the population of the Green Run metropolis.

One should include the medical clinic team and the fire department team, on call to respond as needed. Be sure to include the procurement and accounting teams that are ensuring delivery of needed cryogenics and gases as well. Ditto the center operations team, the communications team, the design team, the construction team, the shop team, the lab team. It also would be proper to include the grounds and janitorial teams, as well as the food services folk and all the others ol' Gator has surely missed who perform tasks that make it possible for those directly involved with test activities to focus fully on the work at hand.

Count every single one of these groups and every single person involved with them. They all are performing work that somehow facilitates or impacts Green Run. Together, they are a centerpiece example for the Unity Campaign launched last year "to unify the NASA workforce in working toward unified agency goals."

They also remind me of the multitude of jokes that ask – "How many so-and-so does it take to change a light bulb?" When it comes to Green Run testing, though, the question is no joke.

Think about it. How many people ***does*** it take to Green Run test the SLS core stage?

You know the answer. It takes all of them.

In my 29 years of working for NASA, with a lot of experience testing rocket engines at Stennis Space Center, the Green Run hot fire is the most exciting moment of my career. I have always looked forward to the chance to witness a test stand firing of a multi-engine rocket built to take humans to the Moon and beyond. I am very proud of the Stennis workforce and the part we play to help power the historic deep space missions of tomorrow.

Dr. Richard J. Gilbrech
Director
NASA's Stennis Space Center
Bay St. Louis, Mississippi

Building, testing, and flying the Space Launch System rocket is critical to the nation's plans to return to the Moon. The Artemis lunar exploration campaign will expand our understanding of Earth's formation, serve as a proving ground for technologies for pushing deeper into the solar system, and inspire a new generation. We couldn't do any of that without an incredibly talented team. It's a challenging job, but it's also an exciting time to be part of what I believe will be NASA's greatest adventures yet.

John Honeycutt
Space Launch System Program Manager
NASA's Marshall Space Flight Center
Huntsville, Alabama


ARTEMIS