'The clock's already started': NASA counting down to most powerful human spaceflight ever

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The launch clock isn't set yet, but the hardware is lined up for what would become the most powerful rocket to ever send humans into space

during a moonbound trip the likes of which has not happened in more than 50 years.

The biggest piece of the Space Launch System rocket, the 212-foot-long core stage, crept its way into the massive Vehicle Assembly Building on July 24 where work will begin to prepare it for the Artemis II launch set for no earlier than September 2025.

"The clock's already started," NASA SLS program manager John Honeycutt said. "We've got a great deal of work to do to get the rocket ready to go fly."

The core stage sports four RS-25 engines converted by Melbourne-based L3Harris' Aerojet Rocketdyne from the retired stock of the Space Shuttle Program. Two of the engines have previously flown on a combined 20 shuttle missions while the other pair are making their debuts.

Engine 2047 flew on STS-135, the final launch of the program on Space Shuttle Atlantis in 2011.

Also no stranger to KSC are the casings from the two solid rocket boosters fabricated by Northrop Grumman. They had previously supported space shuttle missions but were regularly fished out of the ocean for refurbishment. Those two boosters sit broken down into five segments each just north of the VAB at the Rotation, Processing and Surge Facility.

Combined, the core stage and the boosters provide 8.8 million pounds of thrust on liftoff.

Their next launch will make the SLS the most powerful rocket to ever send humans into space. NASA astronauts Reid Wiseman, Victor Glover

and Christina Koch with Canadian astronaut Jeremy Hansen will ride in the Lockheed Martin-built Orion capsule for what's planned to be a 10-day trip around the moon.

Doug Hurley, a former NASA astronaut and now an executive with Northrop Grumman who flew on both shuttle missions and the first human spaceflight of SpaceX Crew Dragon, has tried to give the astronauts an idea of what their ride might be like.

"The ride on the booster for 126 seconds, I just said it's gonna be the most incredible ride of your life. Because really, the acceleration is eye-watering," Hurley said.

The shuttle rides used boosters made up of four segments versus the five that are stacked for SLS, and with Orion on top of the core stage, it will be more like the Apollo astronauts' rides on the Saturn V rocket.

"Being on the top of the stack and feeling the steering … can't wait to hear the story," he said.

Their goal is to ensure the Orion capsule's life-support systems work, setting up the Artemis III mission no earlier than September 2026. That mission aims to return humans, including the first woman, to the lunar surface for the first time since the Apollo 17 mission in 1972.

The Artemis II quartet, though, will still travel more than 230,000 miles from Earth, and while not landing on the moon, flying beyond low-Earth orbit is a feat that also has not been accomplished by humans since the final Apollo flight. Glover will become the first Black man to make the trip, Koch the first woman and Hansen the first Canadian. All 24 of the astronauts who made the trip during nine Apollo missions to the moon between 1968 and 1972 were white American men. Six of those missions sent 12 of those men to the lunar surface.

Delays and uncertainty

The 2025 launch date for Artemis' first human spaceflight is nearly a year behind the schedule laid out after the successful launch of Artemis I in November 2022.

A roughly two-year gap between the uncrewed debut and the first crewed mission was thought to be enough time to pore over the Artemis I data and work through any issues. But a series of major bumps in the road became evident and one of them has yet to have a final solution revealed by NASA.

That's the fact that the protective coating on Orion's heat shield lost a lot more material, some in fist-sized chunks, than what was expected. The ultimate solution for the Orion capsule will be the major domino holding up the process of stacking the SLS to get ready for launch.

Managers won't begin putting it together vertically until they know there will be a spacecraft coming to top it off, but even though this is the second time around, NASA managers expect to face some hurdles.

"There's always something that happens, you know, something spills on something, some test didn't work as planned," said Chris Cianciola, the SLS deputy program manager. "So you triage it all the way. You don't want to wait 'til you get out to the launch pad to find out you got a problem."

For now, a completed Orion capsule is expected to be delivered to the VAB by Oct. 31. If NASA signals no delay, then the first placement of the solid rocket boosters in the VAB could begin in September. NASA has built in a one-year lifespan limiter for the solid rocket boosters, a clock that starts ticking the moment the second segment is placed atop the first.

That's expected to happen in the late fall, which would keep Artemis II on its launch target timeline.

Another limiting factor in stacking is getting back to the VAB the mobile launcher on which SLS and Orion will sit. Currently parked at KSC's Launch Pad 39-B, it has had to go through a series of repairs after the Artemis I launch tore parts of it to shreds.

"These are the largest solid rocket motors on the planet, and when that vehicle lifts off from the mobile launcher, that plume has to go someplace," said Shawn Quinn, program manager for Exploration Ground Systems (EGS) based at KSC. "As the vehicle gets higher up, that plume spreads out, and it's a very, very strong force. … Forget about the heat for a moment, but if the person was standing there, they'd be blown out to kingdom come."

EGS crews also have had to install emergency exit apparatus such as the zipline cages and crew access arm changes so the humans on board can have a chance to survive if something goes wrong on the pad.

Quinn said that work is "nearly done" and the mobile launcher should be back at the VAB in time for stacking.

Cost and criticism

The Artemis program now controls the majority of NASA's annual budget this year, surpassing the overall science mission budget for the first time as the agency's top-funded segment. The enacted fiscal 2024 budget comes out to more than $7.6 billion of NASA's overall $24.875 billion budget.

Because the Artemis program involves so many commercial partners, it has a lot of support across Congress, which ultimately approves the

budget. So while the science budget request was cut by more than $500 million from the Biden administration request this fiscal year, the Artemis campaign programs were nearly fully funded.

NASA's Office of the Inspector General has continued to audit the growing costs of the Artemis program, with a 2023 report stating that the Artemis III missions will cost the country $93 billion since its inception in 2012.

That's billions more than envisioned with delays and cost increases plaguing the leadup to Artemis I. The SLS rocket represents 26% of that cost to the tune of $23.8 billion, with a giant chunk spent on the first and second launch hardware.

The audit forecasts future SLS launches to cost more than $2.5 billion each, although NASA has laid out a plan to reduce those costs by half, something the OIG deemed "highly unrealistic" and a threat to its deep-space exploration plans.

The audit, though, notes that while SLS is the only viable option now for NASA, competition from SpaceX Starship and Blue Origin's New Glenn rockets may help level the playing field for NASA's plans.

"Although the SLS is the only launch vehicle currently available that meets Artemis mission needs, in the next 3 to 5 years other human-rated commercial alternatives that are lighter, cheaper and reusable may become available," the audit reads. "Therefore, NASA may want to consider whether other commercial options should be a part of its mid- to long-term plans to support its ambitious space exploration goals."

Both SpaceX and Blue Origin already have their hand in future Artemis missions, with each responsible for creating a human landing system that will take astronauts from Orion down to the surface of the moon.

Another company, Axiom Space, is responsible for building the new lunar spacesuits.

"If anything, the success of Artemis I probably brought us closer together with what people would term our 'competimates,'" Honeycutt said. "Because now we're one big team working for a common goal."

NASA's ultimate declared plans for the Artemis program, set during the Obama administration, is still to land a human on Mars by 2040.

A reliable path forward

For all the delays and cost overruns leading up to Artemis I, the SLS was praised for the actual job it performed.

"On Artemis I man, we hit our target within a gnat's rear end in space, which just amazed me," Honeycutt said. "When you got something that's moving 17,500ish mph, and you're able to hit your point in space with a less than 0.03% accuracy."

That meant the hardware for the core stage, its engines and the solid rocket boosters worked as designed and required less changes to move forward with building out the parts for the next missions.

"The confidence level went way up. I mean way up," he said. "The naysayers? I think we needed to show them what the rocket could do first."

Work continues on both the core stage for Artemis III, and then what's called the Block 1B version of SLS for Artemis IV, which is on NASA's launch calendar for 2028. That will give SLS extra capacity with the introduction of a new Exploration Upper Stage that can add 22,000 pounds of cargo on trips to the moon on top of the Orion capsule.

"I would like for us to speed up for (Artemis IV)," Honeycutt said. "I've told my team, based on the resources that we've had, I want to be stacking our hardware like cordwood."

The former shuttle program engines from Aerojet Rocketdyne are at least already on hand through the fourth Artemis mission just waiting to be attached to the core stages as Boeing cranks them out.

Northrop Grumman, meanwhile, has the solid rocket boosters already built through Artemis IV stored at its Utah facilities. It's even had to reduce its pace to match NASA's manifest.

"You start cranking out solid rocket motors, and then it's like, OK, now you've got to figure out where to put these big things," Hurley said. Northrop, though, has already begun test work on what will be the ninth Artemis flight's boosters, which is when the company will have run out of former shuttle casings and will begin making lighter composite boosters.

He said getting the first launch up was important just to show people what SLS could do.

"I'm certain there were a lot of people that watched that launch that had never seen a shuttle—that distinctive crackle of the boosters and how it lit up the sky," he said. "Just knowing kind of where we finally got to with the Artemis I launch, I mean, we've been talking about going back to the moon, as a country, as a space agency, for a long time, and it was good to finally see that launch happen."

He's anxious for SLS to take on the next chapter.

"That was a testament to all the teams both at NASA and private industry just finally making it happen," Hurley said. "So just a lot of

anticipation, excitement, enthusiasm for what's next, which is putting crew on the rocket.