NASA's Orion spacecraft, seen here perched atop a Delta IV Heavy rocket at Cape Canaveral, was designed to carry humans farther into space than ever before. Testing continues on the ship and its components; a crewed mission around the moon is planned for 2022.
KIM SHIFLETT, NASA

REACHING THE RED PLANET

Orion spacecraft program takes things a step at a time on its journey toward one really giant leap for mankind

Matt Alderton
Special for USA TODAY

For millennia, humans stood on Earth and looked up at the moon. On July 20, 1969, humans stood on the moon and looked back. As astronauts Neil Armstrong and Buzz Aldrin took the first steps on the lunar surface, the course of human history took a sharp turn. We were no longer bound to just one world.

It was a seminal moment, watched on TV by an estimated 600 million people worldwide — at the time, the largest audience for any event in history. Grainy images from the moon filled young and old alike with wonder and fired imaginations around the globe with the idea that anything was possible.

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At NASA, there are blueprints for another such moment, in the form of the Orion spacecraft that may one day carry people to Mars.

"When we sent humans into space, it influenced a lot of people — including people who have nothing to do with aerospace," says NASA flight director Mark Kirasich, who resolved to join the space program after watching the moon landing when he was 9 years old. "For those of us who were kids, it captured our imaginations and taught us we can do things that seem impossible."

Kirasich manages the program that's developing Orion, a vehicle intended to transport human beings farther into space than ever before, culminating, eventually, in a Mars mission that could make Armstrong's "one giant leap for mankind" look like a bunny hop. "Orion is going to do for the next generation what the Apollo program did for mine," Kirasich says. "It's going to recapture the world's attention and inspire the next generation to do some really big things."

The road to Mars is long and full of obstacles. To get there, NASA must first tame the wilds of deep space. Orion will clear the way.

Shooting for the Moon

Before it was halted in 1972, the Apollo space program landed 12 astronauts on the moon on six missions (a seventh landing had to be aborted because of a malfunction). After that, political support for human space exploration waned. The space race, many said, had been won. Others, however, yearned to continue where Apollo left off.

"People never gave up on the dream of human space exploration — even when the Apollo program ended," Kirasich says. He says Orion was hatched in 2004 when President George W. Bush outlined a new vision for NASA, calling on the agency to "prepare for new journeys to the worlds beyond our own."

Bush's "Vision for Space Exploration" explicitly tasked NASA with developing a new manned exploration vehicle to explore beyond Earth's orbit. And legislation this year officially added human exploration of Mars to NASA's mission.

The vehicle known as Orion has three components: a service module on the bottom that will provide power and propulsion; a crew module in the middle that will accommodate four astronauts; and a launch abort system on top that will protect the crew in the event of failure by the Orion's launch rocket —

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The Orion spacecraft's first test launch came aboard a Delta IV Heavy rocket, the most powerful rocket in operation now. Future missions will use the Space Launch System, which will be the most powerful rocket ever built. KIM SHIFLETT, NASA

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known as the Space Launch System, or SLS, the largest and most powerful NASA has ever built.

Before using it for space exploration, NASA will test the system during four principal demonstrations. The first was completed in December 2014, when NASA successfully tested many of Orion's critical systems in medium Earth orbit, including its heat shield, avionics, parachutes, computers and separation mechanisms. The second will test the launch abort system in early 2019. The third will follow in late 2019, when NASA will integrate SLS and Orion for the first time, sending the latter on a 25-day journey around the moon to test its capabilities in deep space. The fourth test is scheduled for 2022 and will travel the same path as the third, but this time with the program's first crew on board.

Once Orion has proven it's up to the task of deep space exploration, it will enter a new phase in what NASA calls "the proving ground." This is a region of space more than 40,000 miles past the moon. It's only three to five days' travel from Earth — but it's deeper in space than any human has previously traveled.

"The proving ground will be an orbit in the vicinity of the moon," Kirasich says. "It's where we're going to demonstrate — to prove, if you will — the technologies that we will need to go to Mars."

Earth-independent

In deep space, communication with Earth will be slow; routine deliveries of supplies will be impractical; and crews won't have the option of a quick return to Earth in an emergency. In the proving ground, therefore, NASA will test systems and technologies that allow astronauts to be more self-sufficient — or, as NASA calls it, "Earth-independent."

"Low Earth orbit, where the (International) Space Station is, is about 200 miles above the Earth's surface. The moon is over a thousand times that — 240,000 miles. And Mars, on average, is 35 million miles," says Mike Hawes, vice president and general manager of the Orion program at Lockheed Martin, which is building the crew module for NASA. "So we're trying to develop systems that have the fundamental capability to survive time and distance in a way that has not been done before."

Ultimately, NASA will leverage the Earth-independence gained during Orion's missions to build the Deep Space Gateway, a piece of moon-orbiting infrastructure that will serve simultaneously

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Orion

In June, engineers kicked off a series of tests of critical safety systems on Orion's crew module, service module and launch abort system. Engineers in Colorado are also preparing a series of load, acoustic, vibration, shock and lightning tests. The work will help ensure the spacecraft and its systems are sound and can withstand the stresses of launch and flight.

SOURCE: NASA

The Orion spacecraft is topped with a launch abort system, made up of a small rocket connected to the crew module. In the event of a failure of the craft's launch rocket, the system fires and carries the crew module clear.
JIM GROSSMAN, NASA

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as a lunar research station and a transportation node on the way to Mars.

"What we plan to do is launch crews of four into orbit around the moon, where Orion could dock with a habitation module where we'll do the kind of research in deep space that we do today in low Earth orbit" at the International Space Station, says Greg Williams, deputy associate administrator for policy and plans in NASA's Human Exploration and Operations Mission Directorate.

"We could use that infrastructure as a staging area to assemble and test a larger vehicle that would essentially be a transit vehicle to take humans to Mars or similar places in the solar system."

'The Next New World'

NASA already is designing that deep-space bus station and could build it as soon as 2026. First and foremost, though, it's focused on finishing the bus.

"Right now we are in the heart of our testing campaign," says Jim Geffre, deputy manager of Orion's vehicle integration office. To ensure that Orion's components can withstand the rigors of deep space, he says, NASA and its partners are testing them ad nauseam in labs on the ground. "There are a number of different stressing environments that the Orion spacecraft will have to deal with. Those include things like the vacuum of space, a wide range of temperature conditions from extreme cold to extreme heat, and high structural loading. ... Until you actually fly the spacecraft, there's no way to test all those things at once. So we test them individually, then through analysis and other means put them all together to make sure the vehicle can withstand them simultaneously."

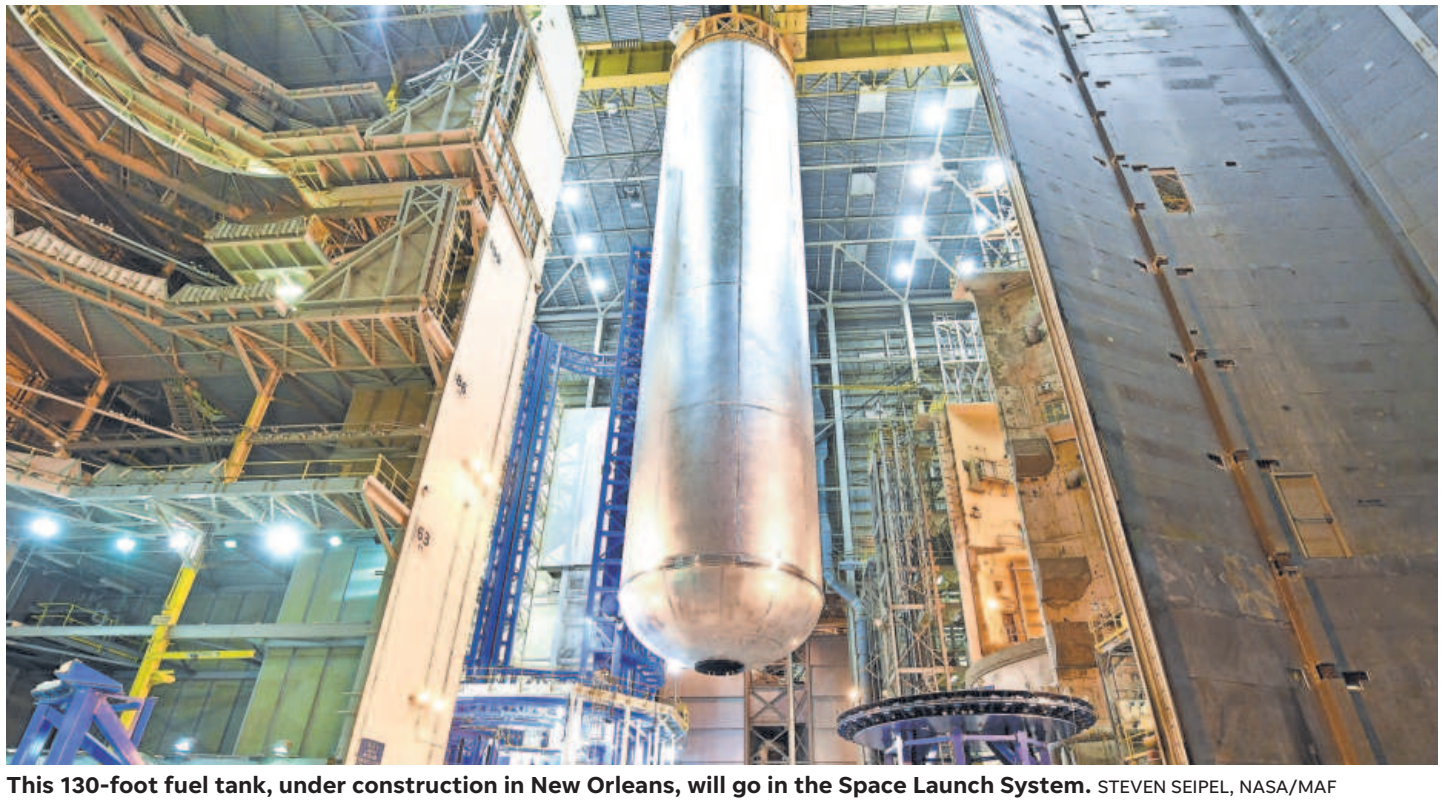
Although Orion's first crewed mission is still years away, tests also are underway to ensure the crew is as effective as the spacecraft. That work includes "human-systems integration" — optimizing the design of everything from spacesuits and seats to knobs and levers — as well as research to make sure astronauts are prepared physically, psychologically, intellectually and socially for Earth-independent space travel.

"Whether it's getting along with each other, having the right training or just having the appropriate hardware onboard the spacecraft, knowing whether humans are going to be able to perform and do the actions required to make the mission successful is key," says Orion spacecraft systems engineer Jessica Vos.

Between its human and technical requirements, Orion's scope of work is staggering. And although it has so far passed all tests with flying colors, there's no guarantee it will work in the end. Which of course leads to a question: Is it worth all the time, expense and risk?

Kirasich says absolutely.

"When we explore, we learn and we discover," he says. When humans finally walk on Mars, he says, they will make better and faster observations than robots and rovers ever could. The result will be new insights, tools and technologies that enhance the quality of life on Earth, and new capabilities with which to seek and sow life beyond it. "When European explorers came to North America, they called it the New World. This is about finding the next New World. I really believe that."



This 130-foot fuel tank, under construction in New Orleans, will go in the Space Launch System. STEVEN SEIPEL, NASA/MAF

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Jessica Vos
Orion spacecraft systems engineer

The Vehicle Assembly Building at Kennedy Space Center has new platforms to provide access to the SLS and Orion. DIMITRI GERONDIDAKIS

Space Launch System

The first structural test item for the SLS — an engine section for the bottom of the rocket's core stage — was moved by barge from New Orleans, where it was built, to NASA's Marshall Space Flight Center in Huntsville, Ala. There, hydraulic cylinders will push, pull, twist and bend the piece to validate the design and ensure it can withstand the pressures expected during launch and ascent. Two RS-25 engines with flight controllers were to be tested this year, and flight hardware for SLS is also coming together. That includes assembly of the intertank, which NASA is now preparing for application of a thermal protection system.

Ground Systems

Engineers at Kennedy Space Center in Florida are getting ready for SLS and Orion. Earlier this year, NASA completed platform installation work inside the Vehicle Assembly Building for processing the rocket and spacecraft for launch, and upgraded the turn basin where parts are offloaded from a barge for processing. Teams also installed the first umbilical on the mobile launcher to connect the spacecraft and tower and are working on adding more umbilicals. Finally, work to fill the liquid oxygen and hydrogen tanks is getting underway at Kennedy.

SOURCE: NASA