News in focus

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The Artemis I launch paves the way for a future human mission to the Moon.

LIFT OFF! ARTEMIS ROCKET LAUNCH KICKS OFF NEW ERA OF HUMAN MOON EXPLORATION

NASA's Artemis I mission is testing a rocket and capsule that could return astronauts to the Moon after 50 years.

By Alexandra Witze

NASA's huge new rocket blasted off from Kennedy Space Center in Florida at 1.47 a.m. Eastern time on 16 November, achieving a major milestone in the agency's plans to send astronauts back to the Moon.

"We rise together, back to the Moon and beyond," said NASA launch commentator Derrol Nail as the mighty rocket thundered into the night skies above Cape Canaveral.

The launch put an uncrewed astronaut capsule, called Orion, into Earth orbit and towards a planned course to fly past the Moon and back over 26 days. The flight, known as Artemis I, will test whether the rocket and capsule will be able to transport humans safely, while carrying a number of scientific experiments.

This is the first time in half a century that NASA has flown a rocket powerful enough to send humans beyond low Earth orbit.

The flight was delayed after two attempts, in late August and early September, were cut short owing to hardware problems including leaks of liquid hydrogen fuel. NASA then passed on a launch opportunity in late September because of an approaching hurricane, before putting the rocket back on the launch pad, where it experienced high winds and rain from a different storm just before launch. NASA managers say that the storm caused only minor damage to the rocket, including peeling off a strip of caulk.

The delays meant that several of the

small solar-powered satellites that Artemis I deployed into space after launch to conduct research have not had their batteries charged in more than a year. As *Nature* went to press, mission controllers had made contact with eight of the ten satellites, with two of those eight experiencing communications or control problems.

A symbolic start

For many researchers, Artemis I represents the symbolic start of a new era of US lunar exploration. NASA named this and subsequent planned flights Artemis in homage to the Apollo programme that sent 12 astronauts to the lunar surface between 1969 and 1972. In Greek mythology, Artemis is the goddess of the Moon and twin sister to the Sun god Apollo.

With the Artemis programme, NASA aims to establish a long-term presence on the Moon. That will begin with a series of robotic landers starting early next year, followed by astronauts landing at the lunar south pole no earlier than 2025, and the establishment of a lunar space station and base after that. If NASA is successful, part of the historical significance of Artemis will be that sustained presence, says Teasel Muir-Harmony, a historian at the Smithsonian Institution's National Air and Space Museum in Washington DC.

Science will also benefit. Astronauts landing on the Moon will be studying ice hidden in the shadowed craters at the never-yet-explored lunar south pole. That means collecting Moon rocks, which the United States has not done since the last Apollo mission, in 1972. Analysis of lunar rocks at the south pole could reveal secrets of the early Solar System that scientists have long been hoping to crack. "We're dying to get down to the surface and bring those rocks back," says Brett Denevi, a lunar researcher at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "We're on the precipice of something really exciting."

But there's a lot of uncertainty. Several US presidents previously tried to set NASA on a path to return to the Moon or send humans to Mars, but because of budget cuts and shifting priorities, the agency has not managed to take those steps until now. "There's the scepticism and cynicism of, is this really going to happen?" Denevi says.

Back to the Moon

After the Apollo programme ended, NASA focused on building and flying the space shuttle, which operated between 1981 and 2011, and constructing and working aboard the International Space Station, which has been permanently occupied since 2000.

Space experts have been waiting for another big lunar launch for a long time. "As a child of Apollo, I never believed I'd see this," says David Parker, director of human and robotic exploration at the European Space Agency in Noordwijk, the Netherlands.

"It's making it real, that we're going back to the Moon," adds Chiara Ferrari-Wong, a lunar scientist at the University of Hawaii at Manoa. "It's all feeling very real now."

Artemis I is meant to be a basic check of engineering systems. "If history is any indicator, it doesn't have to be a flawless flight," Muir-Harmony says. The equivalent flights in the Apollo programme revealed problems that needed to be fixed: for instance, Apollo 6, an uncrewed flight of the Saturn V rocket in 1968, experienced oscillations soon after launch.

During the Artemis I flight, the Orion capsule will head to what's called a distant retrograde orbit around the Moon. That will take it around 64,000 kilometres past the Moon, travelling in the opposite direction to the Moon's orbit of Earth. Throughout the journey, mission controllers will test how the capsule responds to flying in deep space. Orion will eventually leave that orbit and head back towards Earth, splashing down in the Pacific Ocean off San Diego, California (see 'Flight path').

If all goes well, the next launch of the rocket — a mission known as Artemis II, which that will happen no earlier than 2024 — will carry four astronauts around the Moon. The crewed landing, Artemis III, will follow. Each launch is estimated to cost at least US$4 billion.

But many steps remain before those flights become reality. Most significantly, the aerospace company SpaceX in Hawthorne, California — which NASA has contracted to supply a crewed lunar lander called Starship — will need to demonstrate that the giant ship is capable of carrying astronauts from lunar orbit to the Moon's surface. So far, Starship has been tested only on the ground, although it could attempt its first orbital flight in the coming months.

There's science to be done

NASA has pledged that at least one of the two Artemis III astronauts who will step onto the lunar surface will be a woman. The pair will probably stay on the Moon for around 6.5 days, venturing out of Starship to conduct various scientific experiments, including collecting rocks.

Their exact landing site has yet to be chosen, although in August NASA announced a shortlist of 13 regions around the lunar south pole.

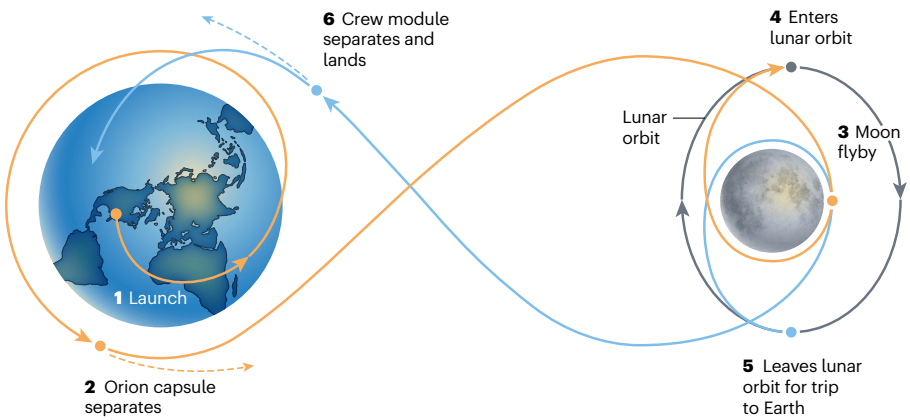
One spot researchers want to investigate is the largest crater on the Moon, the South Pole–Aitken impact basin, created by an ancient collision. Getting rock samples from the crater would allow researchers to pinpoint when the collision occurred, thus anchoring a key point in the history of the early Solar System. Some of the potential Artemis III landing sites might contain rocks tossed out by the ancient collision.

Well before astronauts arrive, however, a host of robotic Moon missions are slated to take place. A series of landers built by US commercial companies will ferry scientific instruments and other payloads to the lunar surface. The first of these missions will happen no earlier than the beginning of next year, and will head to a volcanic plain in the Moon's northern hemisphere known as Lacus Mortis, carrying experiments including several that will measure the chemistry of the lunar soil. Another, much-anticipated, delivery will be a rover that is scheduled to go to the south pole in 2024 to drill for ice.

For Ferrari-Wong, NASA's return to the Moon represents a broader cultural touchstone that resonates with both scientists and members of the public around the world who gaze up at the Moon every night. "What I love about studying the Moon, and what's so exciting about Artemis, is that it's symbolic to almost everyone," she says. "It's also the next step to the rest of the Solar System. That's just amazing."

FLIGHT PATH

In the first Artemis mission, the Orion spacecraft will travel without a crew and reach the Moon in several days. After passing about 100 km above the lunar surface, Orion will enter into lunar orbit, allowing engineers to test the spacecraft and collect data. Then, an engine burn will send it back towards Earth. The entire mission will last up to 42 days.



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