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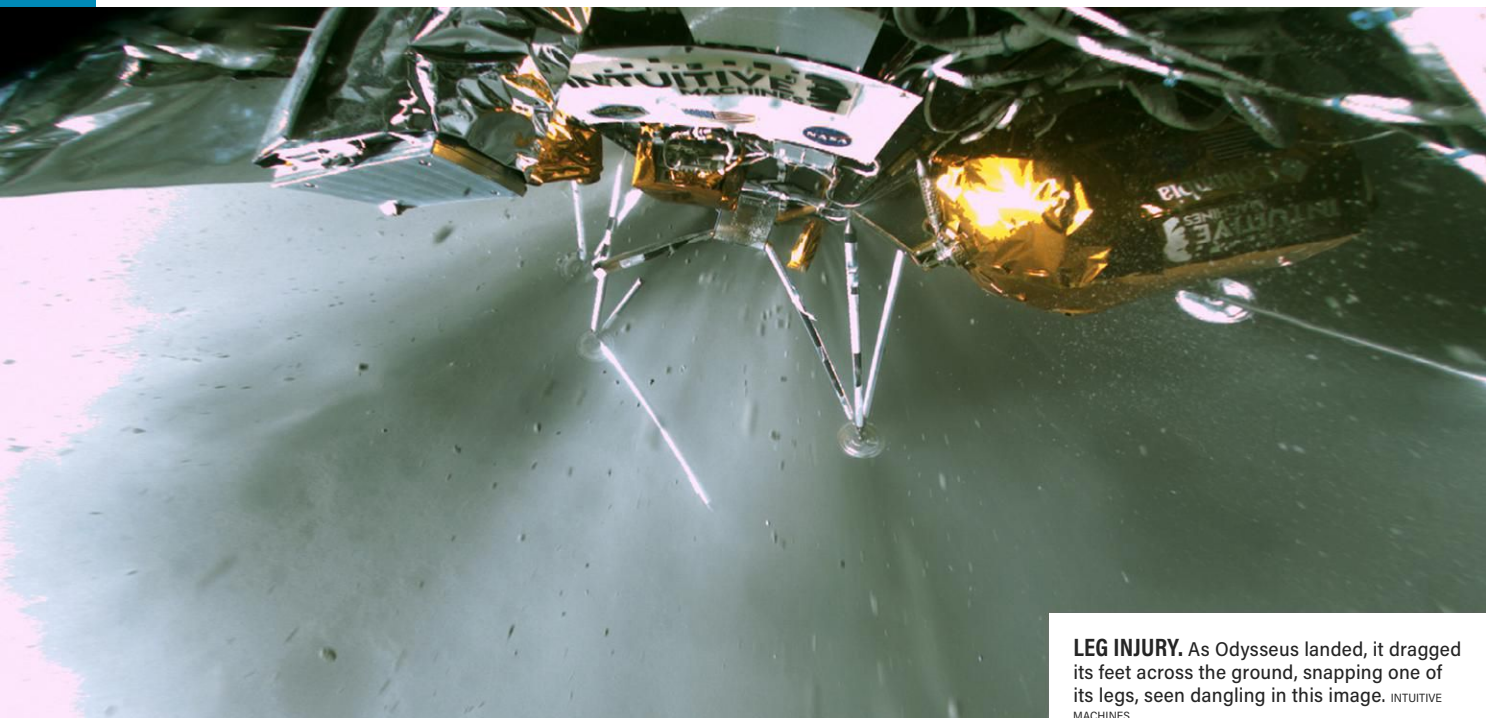
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# ODYSSEUS MAKES EPIC LUNAR JOURNEY, BREAKS LEG, PHONES HOME

The historic lander is the first commercial mission to make a soft landing on the Moon.



**LEG INJURY.** As Odysseus landed, it dragged its feet across the ground, snapping one of its legs, seen dangling in this image. INTUITIVE MACHINES

» On Feb. 22, the lunar lander Odysseus touched down softly — if somewhat awkwardly — on the Moon, becoming the first American-made craft to land there since 1972. It also became the first non-governmental craft to ever do so, after previous private attempts had failed.

It wasn't a flawless landing. As Odysseus — about 14 feet (4.3 meters) tall and weighing roughly 1,488 pounds (675 kilograms) — neared the lunar surface, instead of hovering stably before touching down, it was still drifting slowly. When its feet touched down, they skidded across the Moon's surface, snapping one of the craft's six landing gear legs. As the engine shut off, Odysseus gently toppled partially

over, coming to rest at about a 30° angle from upright.

Despite the tumble, the lander was able to generate power from its solar panels, allowing all its payloads to collect and return data. However, the awkward landing altered the mission because the craft's solar panels could not aim directly at the Sun. The lander was scheduled to collect data for as long as 10 days but instead was put into hibernation after six days as lunar night approached.

Odysseus was not designed to survive the cold night, but Intuitive Machines hoped that as the Sun rose overhead three weeks later, enough light would reach its solar panels to wake it up. Flight controllers started listening for

a signal on March 20, but after three days of radio silence, the team called time on Odysseus and declared its mission had ended.

## SOUTHERN LANDING

Odysseus carried six payloads for commercial companies and another six under contract for NASA. Several of NASA's payloads were intended to test navigation and landing technology that will be used for the agency's Artemis program, which will return astronauts to the Moon. "All of the data that can be used for Artemis will be used for Artemis," said NASA's Sue Lederer during a press conference Feb. 28.

Odysseus landed about 185 miles (300 kilometers) from the Moon's south pole,



**CANTED GET-UP.** Odysseus came to rest at an angle, leaning against a crater slope. INTUITIVE MACHINES

near a crater named Malapert A. The area is part of the rugged polar highlands, the same region Artemis landings will target.

Due to a wiring error, Odysseus was forced to fly its touchdown without its built-in laser rangefinders, a key navigation instrument. Engineers delayed the landing to put together a last-minute hack, rerouting data from the laser-ranging tools on one of the science payloads. However, Intuitive Machines revealed that the patch didn't work; in the scramble, engineers missed a flag in the code to tell the navigation algorithm the data were valid.

As a result, the lander came to rest about 0.9 mile (1.5 km) outside of its intended landing zone, at a higher elevation than expected, and on a 12° slope within a small crater. These factors contributed to its slightly clumsy touchdown.

Still, for Intuitive Machines, the fact that the craft managed to land softly using only data from its cameras and internal motion sensors is a feat in itself. "It's the first time anybody's flown this algorithm, and it exceeded expectations because we live to tell about it," said Tim Crain, the company's chief technology officer.

### TECHNOLOGY DEMONSTRATIONS

The NASA payloads included a variety of tests and demonstrations, including landing technologies (involved in the failed laser rangefinder patch), tracking the lander's fuel in zero gravity, and other navigation and communication tools.

One instrument was designed to observe how the landing engine exhaust interacts with the lunar surface and its sharp, abrasive dust. Unfortunately a hardware failure prevented it from collecting data during the descent and landing, but controllers were able to later fix this and make observations from the landing site.

In another spaceflight first, Odysseus' engine runs on a mixture of liquid methane and liquid oxygen. These propellants must be stored at very low temperatures, as even in space, heat from the Sun or spacecraft exhaust can cause them to boil off. Such cryogenic fuels are expected to play a key long-term role in the Artemis program.

The lunar lander also brought a payload to study radio emissions from objects like the Sun, Jupiter, and Earth. This is an early first step toward a long-held dream of astronomers: placing a radio telescope on the Moon's farside, shielded from interference from Earth.

The landing is the second mission of NASA's Commercial Lunar Payload Services (CLPS) initiative, which contracts commercial companies to deliver tools and technology to the Moon. The first CLPS mission, the Peregrine lander built by the U.S. company Astrobotic, failed to reach the Moon and burned up in Earth's atmosphere in January. —E.G., MARK ZASTROW

### THE TENSION IS REAL

JWST has confirmed the Hubble Space Telescope's measurement of the rate of expansion of the modern universe by observing Cepheid variable stars, whose pulsations are linked to their intrinsic brightness and can be used to gauge cosmic distances. The result differs from models and data of the early universe, deepening the so-called Hubble tension.

### TELESCOPE TROUBLE

In February, the National Science Foundation's board recommended capping U.S. funding of next-gen extremely large telescopes at \$1.6 billion. This could mean one of two planned observatories — the Giant Magellan Telescope in Chile and the Thirty Meter Telescope on the island of Hawai'i — may lose out on funds needed for construction.

### NEW MOONS

Ground-based telescopes have discovered three new moons in our solar system — one around Uranus and two around Neptune. All are between 5 and 14 miles (8 to 23 km) in diameter.

### EPOCH ROW

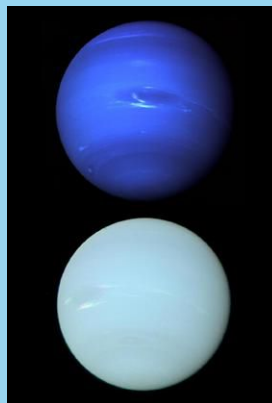
By a 12–4 vote, a committee of geologists rejected a proposal to declare 1952 the start of a new, human-dominated geological epoch, the Anthropocene. Some proposal critics argued that its sole defining geological feature — the appearance of nuclear testing fallout — does not fully capture how humans have altered Earth.

### OBERPFAFFENHOFEN, HOW DO YOU READ?

Future European astronauts exploring the Moon will communicate with a new ESA crewed lunar mission control center to be established in the German city of Oberpfaffenhofen, near Munich, according to a letter of intent signed March 13. —M.Z.

## Neptune's true hues

Ever since NASA's Voyager 2 flew past Neptune in 1989, the ice giant has often been depicted in a deep, dark ultramarine (top). But the authors of a Jan. 5 paper in *Monthly Notices of the Royal Astronomical Society*, who reprocessed the Voyager 2 data, point out that Neptune is not actually that blue (bottom). The misconception arose due to the way NASA technicians originally processed the image, scaling the intensity and contrast to retain details in bright storms in the planet's atmosphere. In fact, Neptune's natural color is much closer to the pale blue of Uranus. —M.Z.



PATRICK IRWIN/NASA/JPL-CALTECH