National Aeronautics and
Space Administration

Commercial Lunar Payload Services

Intuitive Machines IM-1 Mission

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CLPS: Intuitive Machines IM-1 Mission

CLPS QUICK FACTS

Through NASA's CLPS (Commercial Lunar Payload Services) initiative, the agency is **buying an end-to-end commercial robotic lunar delivery service**, meaning the CLPS provider is responsible for launch services, owns its lander design and leads landing and surface operations.

NASA currently has 14 providers on contract under CLPS that are eligible to bid on delivery task orders. To date, NASA has awarded **nine task orders to five providers to deliver over 40 payloads** to the surface of the Moon between 2024 and 2026.

The Intuitive Machines IM-1 Mission is scheduled to be **one of the first U.S. lunar landings since the final mission of the Apollo program**, over 50 years ago.

Intuitive Machine's Nova-C lander will carry **12 payloads to the Moon**, including six NASA payloads and six payloads from other U.S. companies and universities.

Instruments and demonstrations launched on CLPS flights will help NASA study Earth's nearest neighbor under **Artemis** and pave the way for future crewed missions on the Moon.

Robotic science and technology investigations delivered to the Moon by CLPS providers will lay the foundation for **a new era of solar system exploration** to better understand planetary processes and evolution, to search for evidence of water and other resources, and support long-term, sustainable, human exploration.

MISSION OVERVIEW

About Intuitive Machines IM-1 Mission

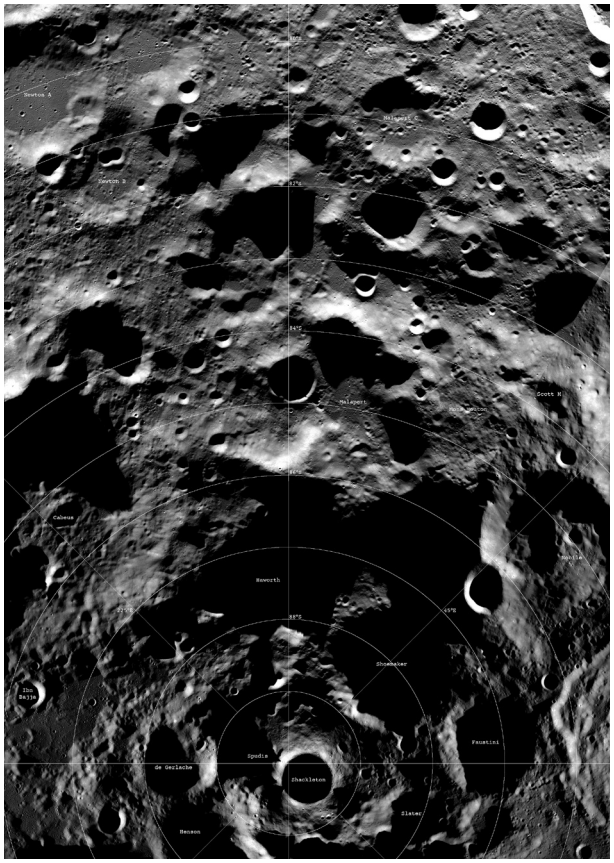
Intuitive Machines was selected as part of the CLPS vendor pool in 2018. Since then, they have been awarded three different contracts to deliver NASA science investigations and technology demonstrations to the Moon.

Intuitive Machines' first lunar delivery, IM-1 is scheduled to launch and land in mid-February 2024. The company's Nova-C lunar lander will land on the Moon's South Pole region near the lunar feature known as Malapert A. IM-1 will deliver **six NASA payloads** that will provide insights into the lunar surface environment and test technologies to better enable Artemis astronauts to land safely on the Moon.

Illustration of Intuitive Machine's Nova-C lunar lander. *Credit: Intuitive Machines/Carter Pytel*

IM-1 Landing Site

The IM-1 Nova-C lander, named Odysseus in homage to the Greek hero of The Odyssey, intends to land near the Malapert A crater in the South Pole region. This relatively flat and safe region is within the otherwise heavily cratered southern highlands on the side of the Moon visible from Earth. Landing near Malapert A will also help mission planners understand how to communicate and send data back to Earth from a location where Earth is low on the lunar horizon.



The Malapert A region is seen near the top of this context map of the Moon's South Pole region. LROC (Lunar Reconnaissance Orbiter Camera) WAC (Wide Angle Camera) mosaic. *Credit: NASA/GSFC/ Arizona State University*

About NASA'S CLPS Initiative

The CLPS (Commercial Lunar Payload Services) initiative is an innovative approach connecting NASA with commercial solutions from American companies to deliver scientific, exploration, and technology payloads to the Moon's surface and into lunar orbit. The CLPS model enables new delivery avenues for important scientific investigations, technology demonstrations, and exploration. These capabilities aim to expand the lunar economy and build a marketplace on the Moon. Under this model, NASA will be one of many customers, along with commercial companies, universities and international partners, all sending payloads to the Moon. NASA's main goal for CLPS is to enable science at and about the Moon using small- to mid-size commercial landers, to advance technologies and systems on the lunar surface and develop a commercial community of service providers for Artemis.

In 2018, nine U.S. companies were selected to be part of a pool of vendors eligible to bid on contracts. A year later, five more vendors were added, bringing the total number of **CLPS contractors** to 14. As science, technology, and human exploration requirements for payloads develop, the current pool of CLPS contractors will be eligible to bid on future delivery task orders.

The **first NASA-sponsored payloads** heading to the Moon through CLPS are being launched ahead of crewed Artemis missions to help NASA better understand the lunar environment and surface characteristics, as well as how to operate in the lunar environment before landing the next generation of explorers.

CLPS contracts are indefinite delivery, indefinite quantity contracts with a combined maximum contract value of $2.6 billion through 2028.

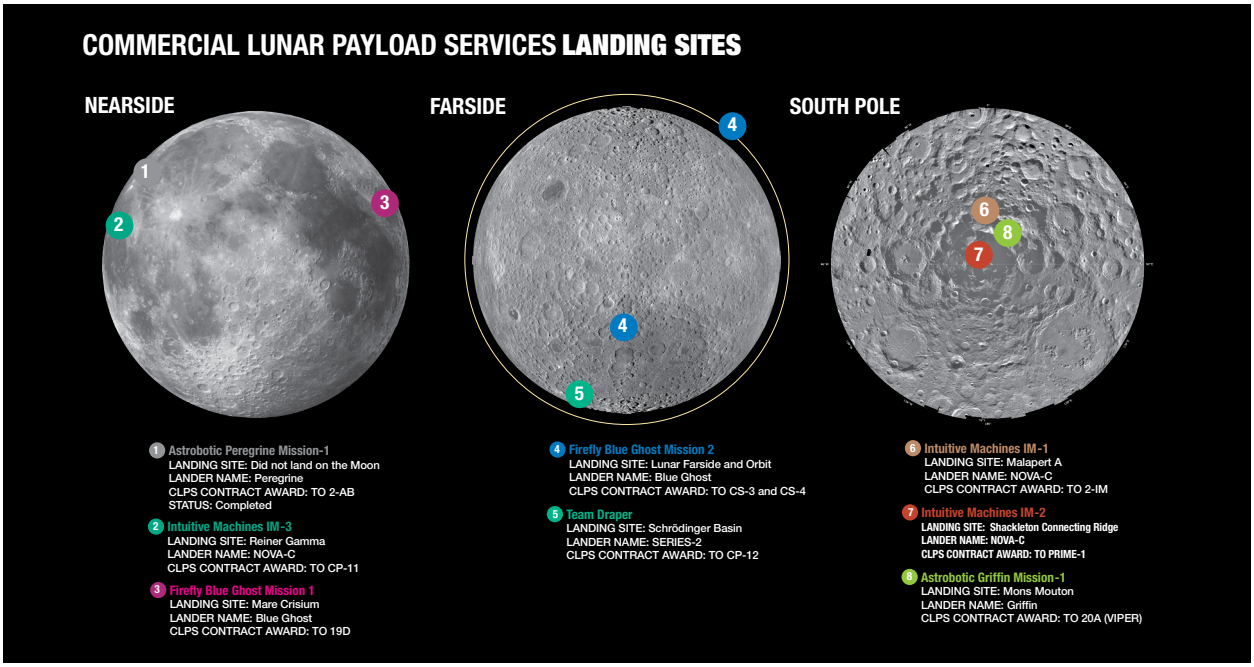


Illustration of CLPS landing sites on the nearside, farside, and South Pole of the Moon. LROC (Lunar Reconnaissance Orbiter Camera) WAC (Wide Angle Camera) basemaps.
Credit: NASA/GSFC/Arizona State University

Current Timeline of all CLPS Deliveries

2024

- **Intuitive Machines** will deliver six NASA payloads near **Malapert A** crater in the South Pole region.
- **Intuitive Machines** will deliver the agency's **PRIME-1** (Polar Resources Ice Mining Experiment-1) drill and mass spectrometer to the Shackleton Connecting Ridge near the lunar South Pole region.
- **Astrobotic** will deliver the agency's **VIPER** (Volatiles Investigating Polar Exploration Rover) to Mons Mouton near Nobile Crater in the near side South Pole region.
- **Firefly Aerospace** will deliver 10 NASA science and technology demonstration payloads to volcanic terrain in Mare Crisium in the equatorial area on the near side of the Moon.
- **Intuitive Machines** will deliver NASA PRISM (Payloads and Research Investigations on the Surface of the Moon) payloads, including science investigations and a technology demonstration to Oceanus Procellarum, landing in volcanic terrain in the equatorial area on the near side of the Moon.

2025

- **Draper** will deliver PRISM science investigations to Schrödinger Basin, landing in volcanic terrain in the far side South Pole region.

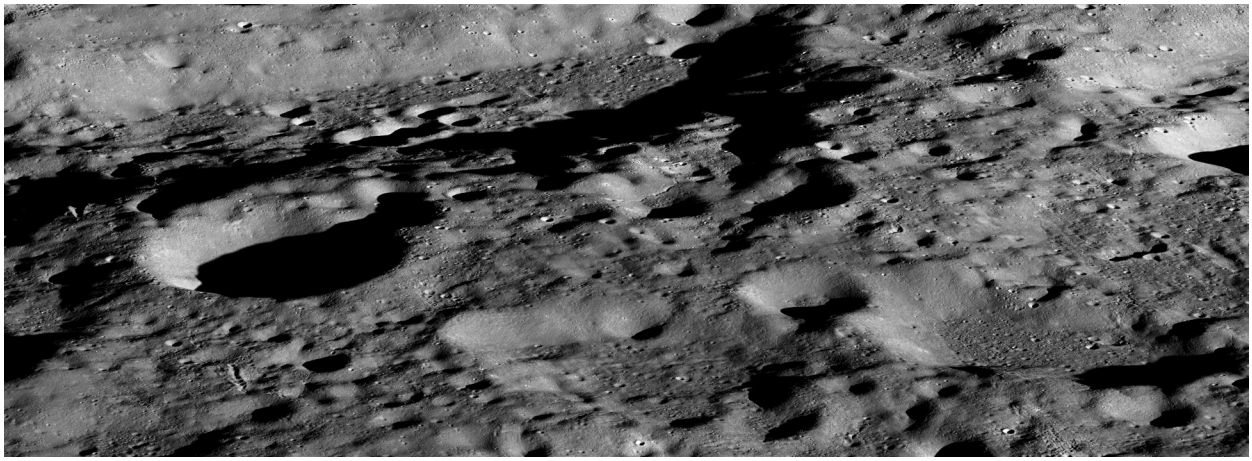
2026

- **Firefly** will deliver two NASA payloads to highlands on the far side of the Moon and deliver a communications and data relay satellite into lunar orbit, which is an ESA (European Space Agency) collaboration with NASA.
- **Firefly** will deliver a radio frequency calibration service to LuSEE-night (Lunar Surface Electromagnetics Experiment – Night) from lunar orbit.

MISSION OBJECTIVES

The primary objectives of the CLPS initiative are to enable community-driven lunar science, gain scientific insight into the regions where Artemis crews will land, and advance capabilities for science, exploration, and commercial development of the Moon.

The success of CLPS could help further establish American leadership in the commercial space industries, and the data gathered will help NASA as it prepares for crewed **Artemis** missions. The CLPS initiative is a new and innovative model for the future of space exploration to advance both science and industry with a lower-cost, higher-risk philosophy for a suite of uncrewed commercial missions. With CLPS, NASA is embracing risk in this new model to advance technologies and science in preparation for sending astronauts to the Moon, while ensuring that the risk is managed in the most valuable and constructive way.



Oblique view of the Nova-C landing area near Malapert A in the South Pole region of the Moon. North is to the right. LROC (Lunar Reconnaissance Orbiter Camera) NAC (Narrow Angle Camera) image M1435077792LR. *Credit: NASA/GSFC/Arizona State University*

WHAT'S ON BOARD

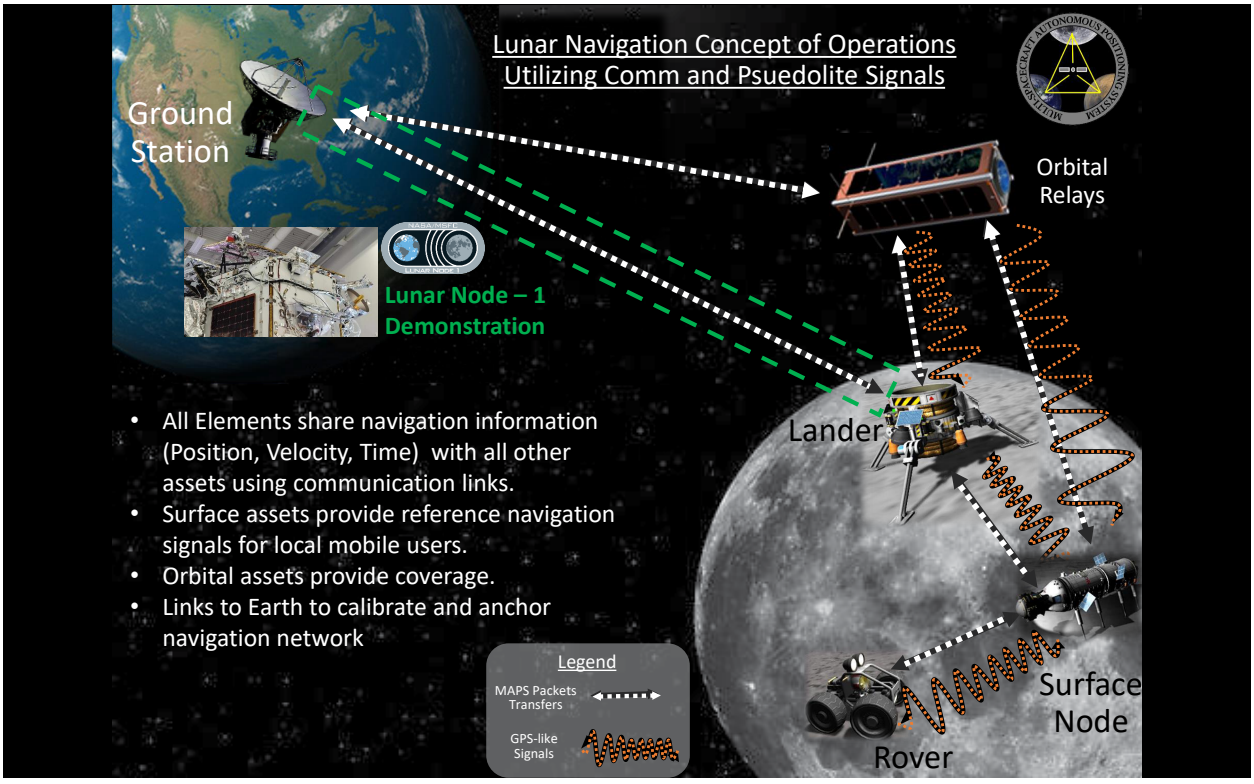
NASA Payloads on Board

The IM-1 mission will deliver **six NASA payloads** that will provide vital insights into exploration technologies and science instruments that investigate the lunar environment and mitigate risks for future missions to the Moon. This suite of payloads will focus on collecting data on plume-surface interactions, investigating space weathering/ lunar surface interactions and radio astronomy, testing precision landing technologies, and measuring the quantity of liquid engine fuel as it is used. The Nova-C lander will also carry retroreflectors contributing to a network of location markers on the Moon to be used for communication and navigation for future autonomous navigation technologies.

LN-1 (Lunar Node 1 Navigation Demonstrator)

LN-1 is a small CubeSat-sized flight hardware experiment that integrates navigation and communication functionality for autonomous navigation to support future surface and orbital operations.

Payload Principal Investigator: Dr. Evan Anzalone, NASA Marshall Space Flight Center



This is a lunar navigation concept of operations with MAPS (Multi-spacecraft Autonomous Positioning System) implementation. It demonstrates a network of communication and navigation amongst local surface and orbital operations. Transfers of MAPS-compatible packets are represented by dotted arrows, while GPS-like signals are indicated by black and red. LN-1 will test multiple navigation links from the surface of the moon back to Earth to characterize both types of signals. *Credit: NASA*

SCALPSS (Stereo Cameras for Lunar Plume-Surface Studies)

SCALPSS will use a suite of four cameras to capture stereo and still image data of the dust plume created by the lander's engine as it begins its descent to the lunar surface until after the engine shuts off.

Payload Principal Investigator: Michelle Munk, NASA Langley Research Center

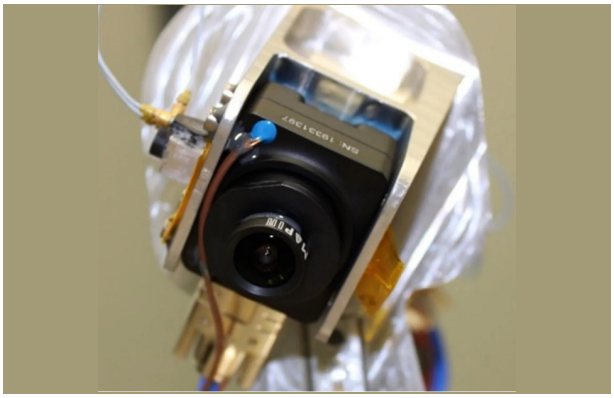
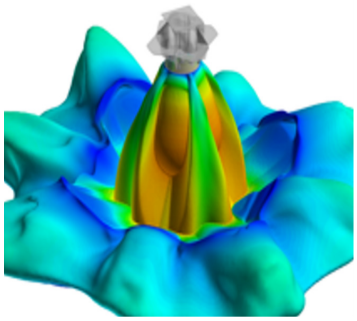


Image of one of the four cameras that will capture information about the lander's descent and assess how it affects the lunar surface. The stereo cameras will capture images and data of the plume (column of exhaust gases) and surface area below the lander resulting in a dust cloud (see image below). *Credit: NASA*

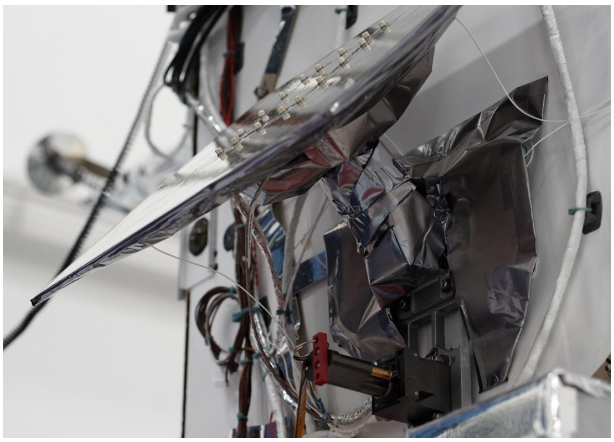


This computer-generated model represents the behavior of the dust and exhaust ejected from plume-surface interactions. The orange, yellow, and green column is plume (column of exhaust gases) from the engines during landing/descent. The turquoise and blue represent displaced dust from the lunar surface. *Credit: NASA*

ROLSES (Radio-wave Observations at the Lunar Surface of the Photoelectron Sheath)

ROLSES will employ four antennas and a low-frequency radio receiver system to determine the density and scale height of the Moon's photoelectron sheath, a very thin layer of electrons above the surface of the Moon, and will also detect solar radio bursts, radio emissions from Jupiter, dust impacting the surface of the moon, and how radio noisy Earth is.

Payload Principal Investigator: Dr. Nat Gopalswamy, NASA Goddard Space Flight Center



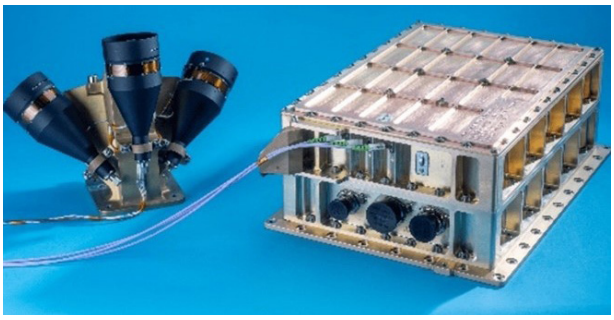
ROLSES will measure the density of the photoelectron sheath of the Moon using a low-frequency radio receiver system and four antennas. It will also have the capability to detect radio emissions from Jupiter, solar radio bursts, and radio emissions from Earth and its aurora. *Credit: NASA*

NDL (Navigation Doppler Lidar for Precise Velocity and Range Sensing)

NDL is a LIDAR-based (Light Detection and Ranging) descent and landing sensor. This instrument operates on the same principles of radar but uses pulses of light from a laser emitted through three optical

telescopes instead of radio waves. NDL measures vehicle velocity (speed and direction) and altitude (distance to ground) with high precision during descent to touchdown.

Payload Principal Investigator: Dr. Farzin Amzajerdian, NASA Langley Research Center



NDL consists of a chassis containing electronics and photonics, right, and an optical head with three small telescopes, left, for transmitting laser beams and collecting the returns from the ground. *Credit: NASA*

RFMG (Radio Frequency Mass Gauge)

RFMG is a fuel gauge used to measure the amount of propellant in spacecraft tanks in a low-gravity space environment. Using sensor technology, RFMG will measure the amount, or mass of cryogenic propellant in Nova-C's fuel and oxidizer tanks, providing data that can help predict fuel usage on future missions.

Radio Frequency Mass Gauge propellant sensor electronics installed on the Intuitive Machines Nova-C lander. *Credit: NASA Glenn Research Center/Intuitive Machines*

Payload Principal Investigator: Dr. Greg Zimmerli, NASA Glenn Research Center

LRA (Laser Retroreflector Array)

LRA is a collection of eight retroreflectors that enable precision laser ranging, which is a measurement of the distance between the orbiting or landing spacecraft to the reflector on the lander. LRA is a passive optical instrument and will function as a permanent location marker on the Moon for decades to come.

Payload Principal Investigator: Dr. Xiaoli Sun, NASA Goddard Space Flight Center

LRA is mounted on Intuitive Machine's Nova-C lander top deck solar array and will help provide precision measurements of distances between orbiting or landing spacecraft. *Credit: Intuitive Machines/Nick Rios*

Non-NASA Commercial Payloads

Nova-C will also carry six payloads from other customers, unrelated to NASA, including scientific instruments and technologies from six different American companies, dozens of science teams, and thousands of individuals. Click **here** to learn more about Intuitive Machine's IM-1 Mission commercial payloads.

MAJOR MISSION MILESTONES AND TIMELINE

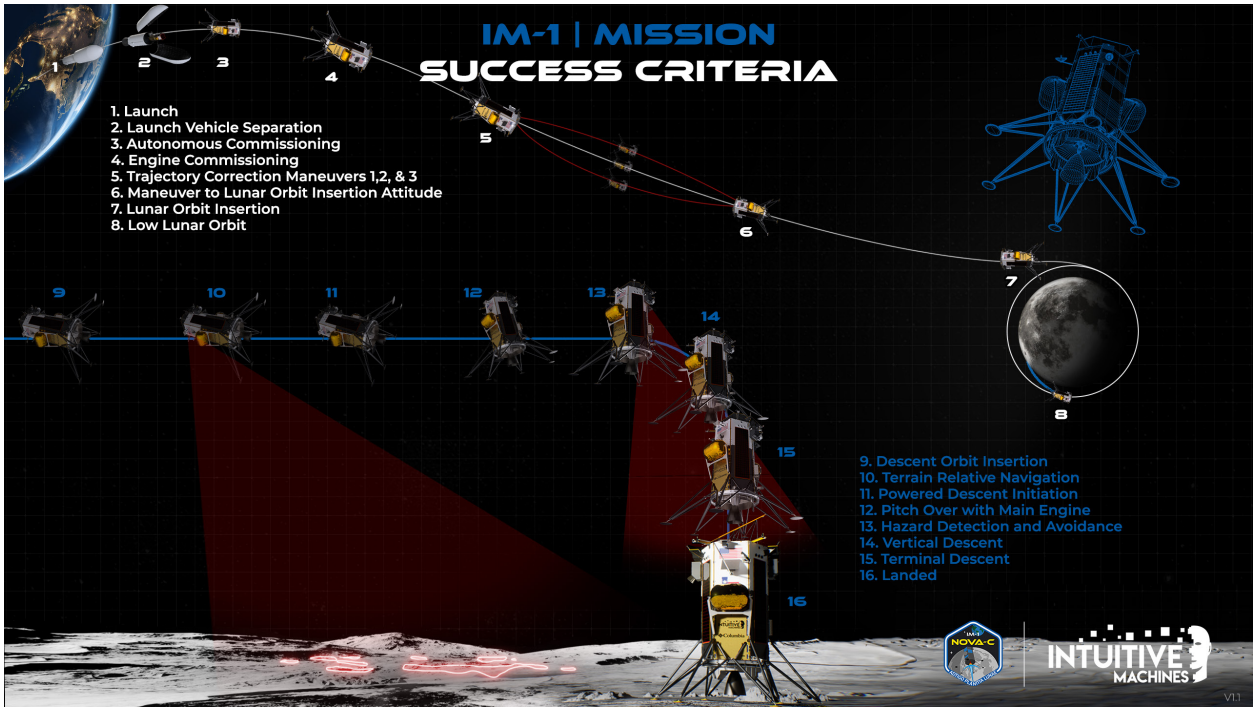
Launch Information

The IM-1 mission will launch from Complex 39A at NASA's Kennedy Space Center in Florida, targeted for a multi-day launch window, which opens no earlier than mid-February. Intuitive Machines conducts all mission operations through Nova Control (NC) based at Intuitive Machines' headquarters in Houston, Texas.

- Launch Site: **Kennedy Space Center**
- Launch Window: **Starting mid-February, 2024**
- Mission Duration: **Approx. 9 days (transit), approx. 10 days (lunar surface operations)**
- Landing Site: **Malapert A**
- Payloads: **CLPS IM-1 NASA-Provided Lunar Payloads**
- Lander Name: **Odysseus**
- Lander Class: **Nova-C**
- Task Order Information: **TO2-IM-1**
- Launch Vehicle: **SpaceX Falcon 9 Rocket**

IM-1 Trajectory

Approximately 50 minutes after launch, the Nova-C lander will separate from the rocket and begin a seven-day cruise to the Moon's orbit. The lander will orbit the Moon for approximately one day before beginning its powered descent to the landing site in the South Pole region of the Moon.



This illustration depicts Nova-C's trajectory from launch to descent to the lunar surface.
Credit: Intuitive Machines/Hunter Christian

IM-1 Descent Profile and Timeline

Approximately one hour before nominal touchdown on the lunar surface, the IM-1 Nova-C lunar lander executes Descent Orbit Insertion (DOI) on the Moon's far side. DOI is a main engine firing to slow the spacecraft so its altitude drops from 100 kilometers to about 10 kilometers above the lunar surface. After DOI, Nova-C coasts for about an hour before reaching Powered Descent Initiation (PDI). During PDI, cameras and lasers feed information to the lander's navigation algorithms, which provide Guidance, Navigation, and Control (GNC). With a safe site identified, Nova-C will begin its descent to the lunar surface. Nova-C's engine is continuously throttling down from PDI to vertical descent and terminal descent. Flight controllers expect about a 15-second delay before confirming the ultimate milestone, softly landing on the surface of the Moon.

Intuitive Machines - CLPS Milestones

2018

First nine CLPS vendors announced

- November: **NASA announces first nine companies to be part of the CLPS vendor pool**

2019

NASA selects first commercial and academic payloads

- February: **NASA announces first payloads for early CLPS flights**

First Intuitive Machines task order awarded

- May: **NASA selects Astrobotic, Orbit Beyond, and Intuitive Machines to deliver payloads to Moon**
- July: **NASA announces 12 new lunar investigations for CLPS flights**

Five more CLPS vendors announced

- November: **NASA adds five more vendors to CLPS pool**

2020

Second Intuitive Machines task order awarded

- October: **NASA selects Intuitive Machines to deliver PRIME-1**

2021

Third Intuitive Machines task order awarded

- November: **NASA awards Intuitive Machines to deliver four payloads**

2023

- May: **Intuitive Machines Lunar Landing Site Moves to South Pole**

2024

First CLPS flights land on the Moon

- February: Intuitive Machines IM-1 Mission expected landing date February 22, 2024

What's Coming Up

Intuitive Machines' second awarded delivery task order, the **IM-2 mission**, is scheduled to land at the lunar South Pole in 2024 using the Nova-C lunar lander. This will be the first surface, or in-situ, resource utilization demonstration on the Moon utilizing a drill and a mass spectrometer to measure the volatile content (meaning things that can be readily vaporized) of subsurface materials. IM-2 will also carry two commercial Tipping Point technology demonstrations from NASA's Space Technology Mission Directorate – a small hopper robot (Intuitive Machines) and 4G LTE communications system (Nokia). Understanding the content of water and other volatiles at the South Pole is critical for designing the Artemis base camp that will be built near the South Pole, a region of the Moon specifically chosen to ensure access to a source of water ice – a critical element for survival.

The third Intuitive Machines awarded delivery task order, the **IM-3 mission**, is scheduled to land near the equator at the Moon's Reiner Gamma swirl in 2024 using the Nova-C lunar lander. Reiner Gamma is a feature commonly referred to as a lunar swirl, located on the lunar near side in Oceanus Procellarum. Lunar swirls are associated with magnetic anomalies in the lunar crust, but more data is needed to characterize them and understand their formation.

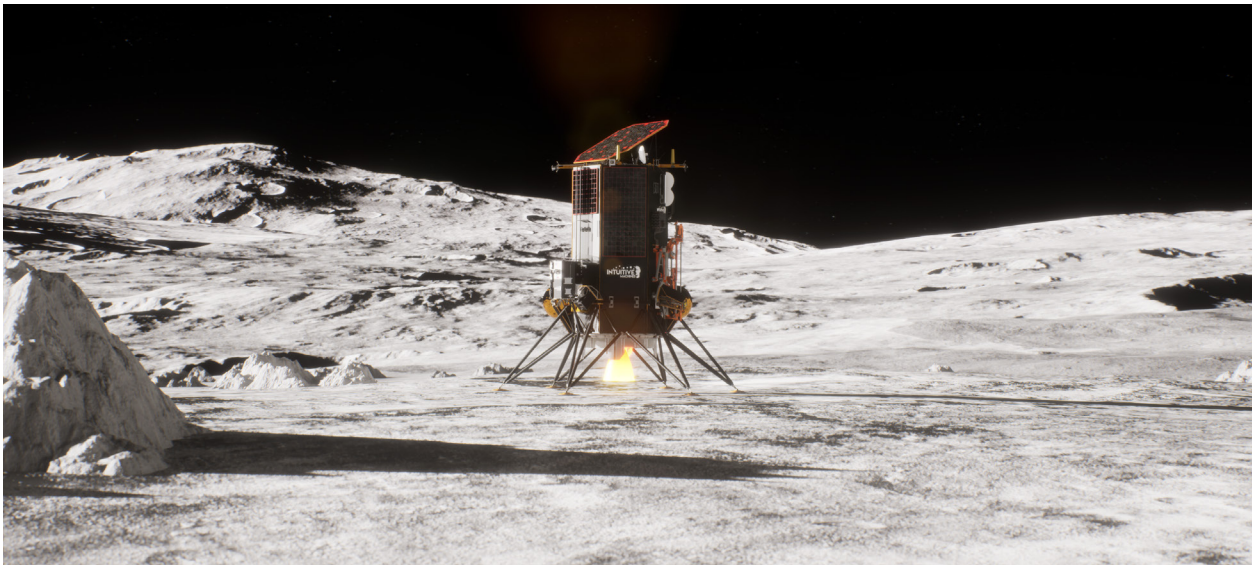


Illustration of Intuitive Machines' Nova-C lander with a depiction of NASA's the Polar Resources Ice-Mining Experiment-1 attached to the spacecraft on the surface of the Moon. *Credit: Intuitive Machines/ Carter Pytel*

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