National Aeronautics and
Space Administration

Commercial Lunar Payload Services Initiative

Astrobotic's Peregrine Mission One

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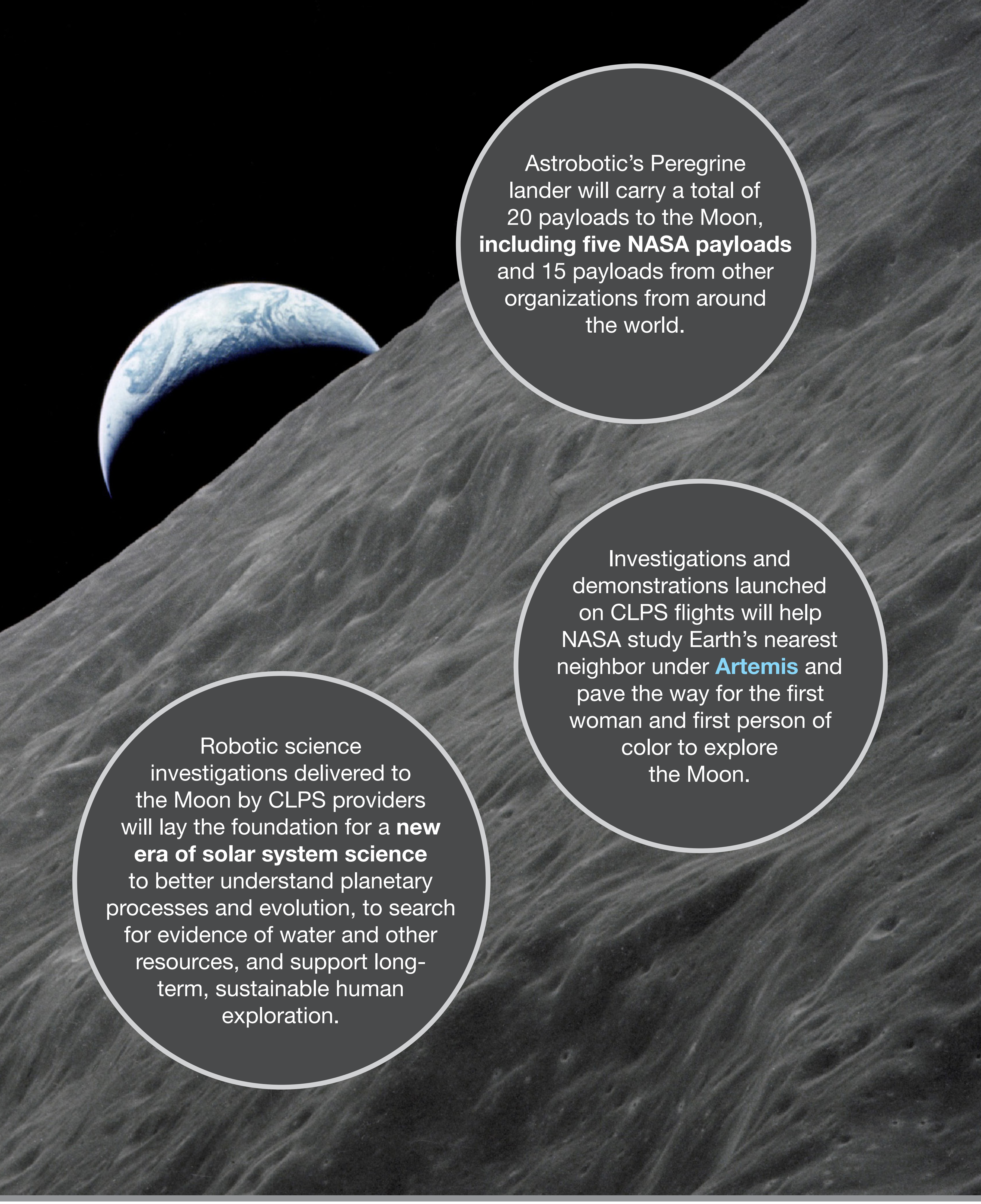
CLPS: Astrobotic's Peregrine Mission One

CLPS QUICK FACTS

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

NASA currently has 14 providers on contract under CLPS that are eligible to bid on 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 2025.

Astrobotic's Peregrine Mission One is scheduled to be **one of the first U.S. lunar landings since the final mission of the Apollo program**, over 50 years ago. This will be the first flight for United Launch Alliance's Vulcan rocket.



Astrobotic's Peregrine lander will carry a total of 20 payloads to the Moon, **including five NASA payloads** and 15 payloads from other organizations from around the world.

Investigations and demonstrations launched on CLPS flights will help NASA study Earth's nearest neighbor under **Artemis** and pave the way for the first woman and first person of color to explore the Moon.

Robotic science investigations delivered to the Moon by CLPS providers will lay the foundation for a **new era of solar system science** 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 Astrobotic and Peregrine Mission One

Astrobotic's first flight will use the company's Peregrine lunar lander and is scheduled to land in Feb. 2024 at a lunar feature named Sinus Viscositatis, adjacent to the **Gruithuisen Domes**, the largest dark spot on the near side of the Moon.

Peregrine's Landing Site

Peregrine Mission One will land at Sinus Viscositatis, a region of mare (basaltic lava flow) – outside of the Gruithuisen Domes, a set of large, non-basaltic domes on the near side of the Moon. This landing site is a geologic enigma along the mare/highlands boundary on the northeast border of Oceanus

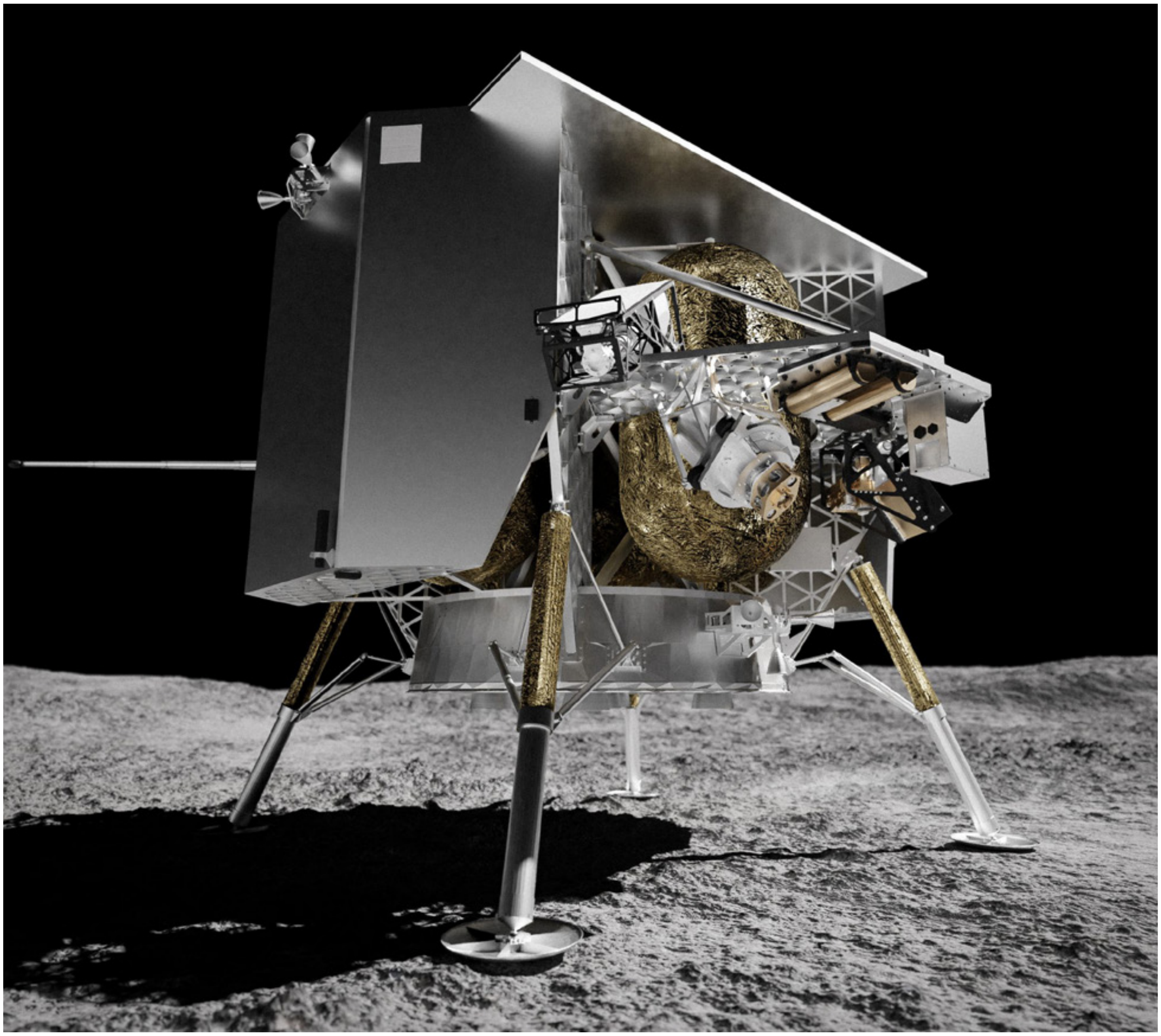


Illustration of Astrobotic's Peregrine lunar lander. *Credit: Astrobotic*

Procellarum, also known as the "Ocean of Storms." The Domes are suspected to have been formed by a sticky magma rich in silica, similar in composition to granite. On Earth, formations like these need significant water content and plate tectonics to form, but without these key ingredients on the Moon, lunar scientists have been left to wonder how these domes formed and evolved over time.

About NASA'S CLPS Initiative

NASA's **CLPS** 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 orbit. The CLPS model aims to enable new avenues of completing high-value and high-priority scientific investigations, technology

Image of Sinus Viscositatis near the Gruithuisen Domes. Astrobotic's Peregrine lander will land in this large flat region that was once a giant lava flow. LROC (Lunar Reconnaissance Orbiter Camera) WAC (Wide Angle Camera) mosaic. *Credit: NASA/GSFC/ Arizona State University*

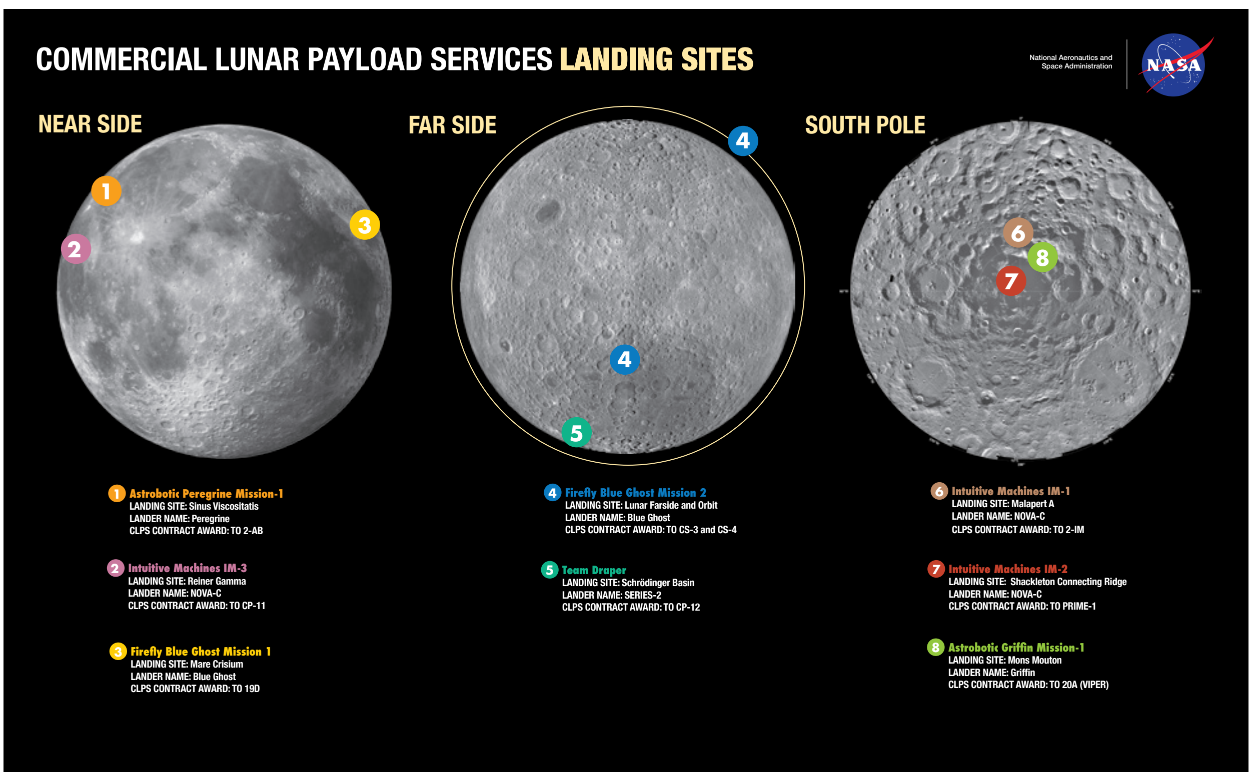


Illustration of CLPS landing sites on the near side, far side, and South Pole of the Moon. LROC (Lunar Reconnaissance Orbiter Camera) WAC (Wide Angle Camera) base maps. *Credit: NASA/GSFC/Arizona State University* demonstrations, and exploration while expanding the lunar economy and building a marketplace on the Moon. Under this model, NASA aims to be one of many customers, along with industry, universities, and international partners, all sending payloads to the Moon. NASA's goals for CLPS are to enable science at and about the Moon using small- to mid-size commercial landers; enabling NASA to advance technologies and systems on the lunar surface. CLPS aims to develop a commercial community of service providers that will enable more exploration of the Moon than ever before under the agency's Artemis program.

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 pool of CLPS contractors will be eligible to bid for lunar task orders.

The **first payloads** heading to the Moon through CLPS are being launched ahead of crewed Artemis missions to help NASA better understand 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 November 2028.

Current Timeline of all CLPS Deliveries

2024

- **Intuitive Machines** will deliver six NASA payloads near **Malapert A** crater in the lunar South Pole region, on their first mission.
- **Astrobotic** will deliver five NASA payloads to Sinus Viscotitatis, a **mare unit** (basaltic lava flow) outside of **Gruithuisen Domes**, a set of large, non-basaltic domes on the near side of the Moon.
- **Intuitive Machines** will deliver the agency's **PRIME-1** (Polar Resources Ice Mining Experiment-1) drill and mass spectrometer to the Shackleton-De Gerlache 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.

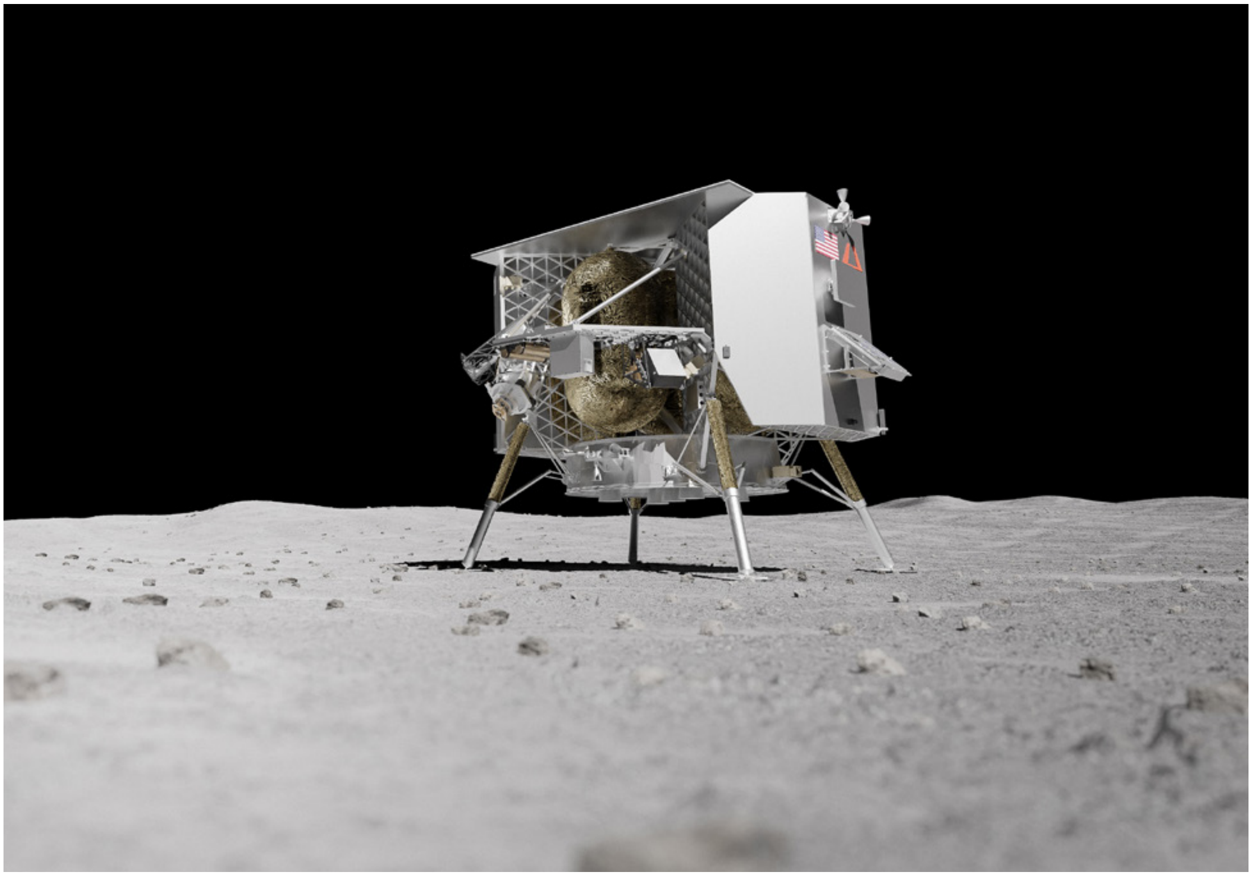
2025

- **Draper** will deliver PRISM science investigations to Schrödinger Basin, landing in volcanic terrain in the far side South Pole region.
- **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 other lunar regions, and advance capabilities for science, exploration, and commercial development of the Moon.

The success of CLPS flights will 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 accepted in the most valuable and constructive way.



Concept image of Astrobotic's Peregrine lander, which will launch on a United Launch Alliance Vulcan rocket and deliver five NASA payloads to the Moon. *Credit: Astrobotic*

WHAT'S ON BOARD

NASA Payloads and NASA Technology

This CLPS flight will deliver **five NASA payloads** making important contributions to lunar science exploration. This suite of payloads will aim to collect data on possible water molecules in the subsurface, on the surface, and in the lunar exosphere around the lander. The instruments will also measure radiation and other gases around the lander, improving our understanding of how solar radiation interacts with the lunar surface and help us plan for future human exploration. In addition, the payloads will provide complementary data to NASA's Lunar-VISE (Lunar Vulkan Imaging and Spectroscopy Explorer) instrument suite, which will land on the nearby Gruithuisen Domes in 2026.

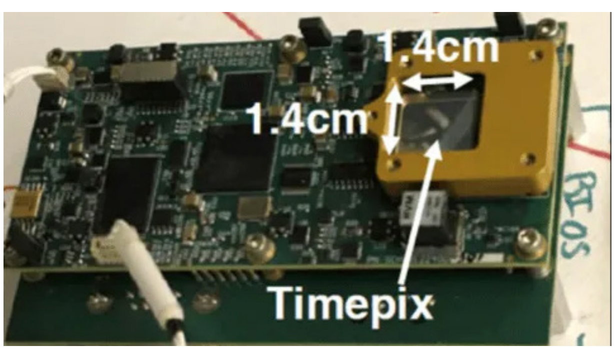
Each NASA CLPS payload is described in more detail here:

LETS (Linear Energy Transfer Spectrometer)

Lead organization: NASA Johnson Space Center

The LETS (Linear Energy Transfer Spectrometer) is a radiation monitor that is derived from heritage hardware flown on Orion EFT-1 (Exploration Flight Test-1). LETS units were flown aboard the International Space Station and BioSentinel payloads aboard Artemis I . LETS uses the same core technology as the HERA (Hybrid Electronic Radiation Assessor) system serving as the primary radiation monitor on Artemis missions and will enable acquisition of knowledge of the lunar radiation environment and demonstrate the capabilities of these radiation monitors on the lunar surface.

Payload PI: Dr. Edward Semones



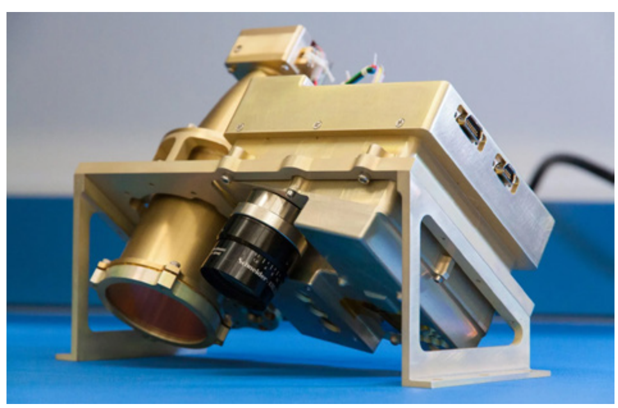
A small circuit board used within LETS' instruments that spans approximately 12 centimeters, based on the arrows used here for scale. The Timepix technology is specifically indicated to the right. *Credit: NASA*

NIRVSS (Near-Infrared Volatile Spectrometer System)

Lead organization: NASA Ames Research Center

This payload includes a spectrometer context imager and a longwave calibration sensor. It measures surface and subsurface hydration (H2O and OH) and CO2 and methane (CH4) while simultaneously mapping surface morphology and surface temperature.

Payload PI: Dr. Anthony Colaprete

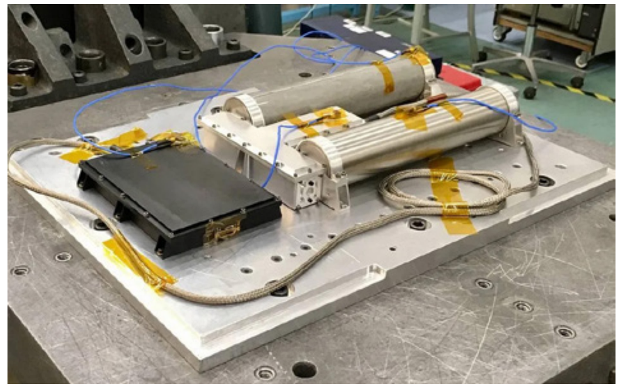

NIRVSS will measure surface and subsurface hydration on the Moon. These measurements can be taken while the instrument is moving. *Credit: NASA*

NSS (Neutron Spectrometer System)

Lead Organization: NASA Ames Research Center

The NSS instrument will determine the abundance of hydrogen-bearing materials and the bulk regolith composition at the landing site and measure any time variations in hydrogenous volatile abundance during the diurnal cycle.

Payload PI: Dr. Richard Elphic



The NSS will determine the composition of the majority of the regolith at the landing site as well as measure the abundance of hydrogen-bearing materials. *Credit: NASA*

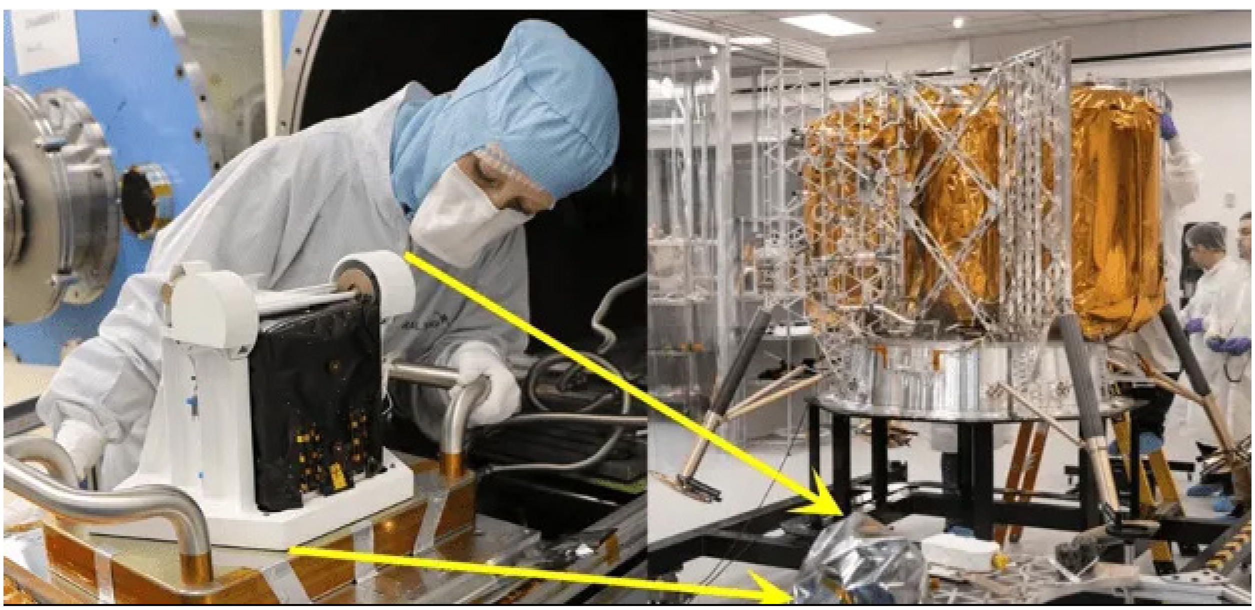
PITMS (Peregrine Ion-Trap Mass Spectrometer)

Lead organization: NASA Goddard Space Flight Center

PITMS will characterize the lunar exosphere after descent and landing, and throughout the lunar day, to understand the release and movement of lunar surface volatiles.

PITMS is a partnership between NASA, The Open University, and the European Space Agency.

Payload PI: Dr. Barbara Cohen



PITMS (Peregrine Ion-Trap Mass Spectrometer) is shown to the left in the lab being examined by a staff scientist; to the right, it's shown with a model of Astrobotic's Peregrine One lander for scale. PITMS will collect data to analyze volatiles in the Moon's exosphere after descent, landing, and throughout the day. *Credit: NASA*

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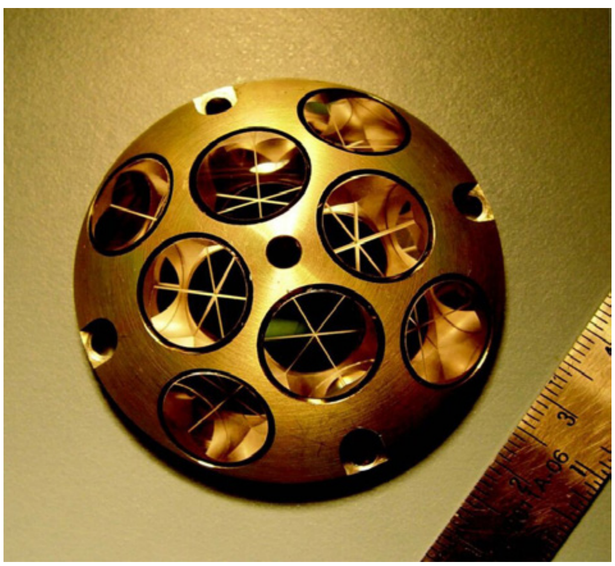
LRA (Laser Retroreflector Array)

Lead organization: NASA Goddard Space Flight Center

The 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 LRA on the lander.

The LRA is a passive optical instrument and will function as a permanent location marker on the Moon for decades to come.

Payload PI: Dr. Xiaoli Sun



LRA has eight retroreflectors inside. It will be mounted on Astrobotic's Peregrine lander deck and help provide precision measurements of distances between orbiting or landing spacecraft. *Credit: NASA*

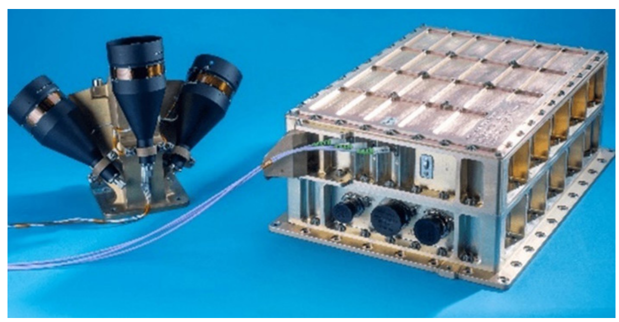
NDL (Navigation Doppler Lidar for Precise Velocity and Range Sensing)*

Lead Organization: NASA Langley Research Center

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

PI: Dr. Farzin Amzajerdian

** NDL is a flight-controlled guidance and navigation sensor but is not considered a NASA CLPS payload.*



NDL is pictured with its three telescopes (left) and the chassis that contains the electronics and photonics (right). *Credit: NASA*

Non-NASA Commercial Payloads

Peregrine will also carry 15 payloads from other customers, unrelated to NASA, including scientific instruments, technologies, and mementos from seven different countries, dozens of science teams, and thousands of individuals. Click **here** to learn more about Astrobotic's Peregrine Mission One.

MAJOR MISSION MILESTONES AND TIMELINE

Launch Information

Astrobotic's Peregrine Mission One launch will take place from Cape Canaveral, Florida on a ULA (United Launch Alliance) Vulcan rocket targeted for a multi-day launch window, which opens no earlier than Jan. 8, 2024. After Peregrine separates from the ULA rocket, Astrobotic's Mission Control Center will take control of Peregrine until the lander reaches the Moon's orbit between 17 and 19 days after launch. Peregrine will orbit the Moon for up to 39 days before beginning its descent to the landing site. Descent operations will take place completely autonomously.

Launch Site: Launch Complex-41 at Cape Canaveral Space Force Station in Florida

Launch Window: Starting Jan. 8, 2024

Mission Duration: 10 days (surface)

Landing Site: Sinus Viscositatis

NASA Payloads: **CLPS Astrobotic Peregrine Mission-1 NASA-Provided Lunar Payloads**

Lander Name: **Peregrine**

Task Order Information: TO2-AB

Launch Vehicle: United Launch Alliance Vulcan rocket

Vulcan, United Launch Alliance's next-generation American rocket, lifts off in this artist's rendering.
Credit: ULA

CLPS: Astrobotic's Peregrine Mission One

Peregrine Mission One Trajectory

The specific trajectory for Peregrine Mission One is based on the launch profile and landing site. A generic trajectory will begin with Peregrine's launch from Cape Canaveral into Earth's orbit. Shortly after launch, Peregrine will separate from the ULA Vulcan rocket and begin a 17-to-19-day cruise phase to the Moon's orbit, which includes an orbit around the Earth and several maneuvers to prepare the lander for insertion into lunar orbit. Following the cruise phase, Peregrine will orbit the Moon for up to 17 days before beginning its autonomous descent to the lunar surface. During this phase, Astrobotic will perform lunar orbit injection maneuvers and orbital payload deployments to ensure Peregrine lands safely on the surface of the Moon.

- Launch to High Elliptical Orbit Aboard the Launch Vehicle
- Separation from the Launch Vehicle
- Trajectory Correction Maneuvers
- Cruise Through Cislunar Space
- Lunar Orbit Insertion Maneuver
- Lunar Orbit Hold
- Autonomous Descent Operations
- Landing on the Lunar Surface

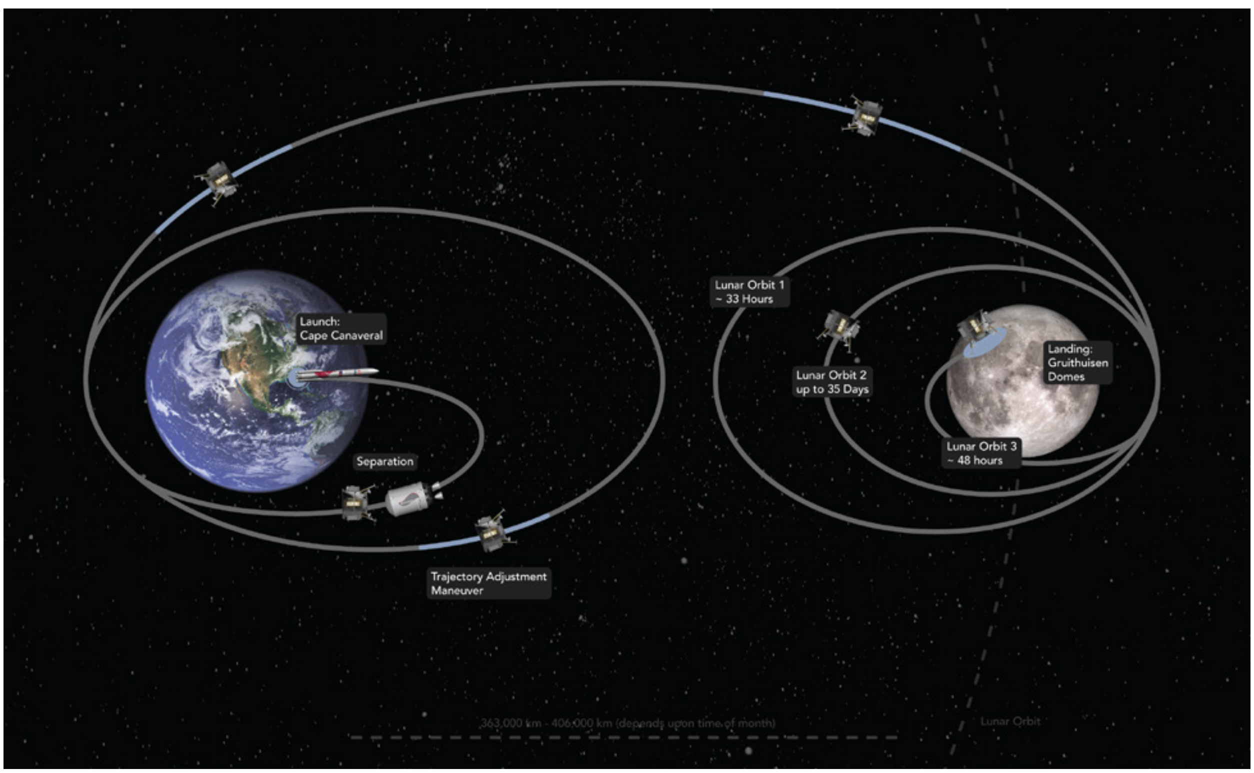


Illustration of Astrobotic's Peregrine Mission One trajectory. *Credit: Astrobotic*

Peregrine Mission One Descent Profile

As a CLPS provider, Astrobotic is responsible for end-to-end delivery of NASA CLPS payloads to the lunar surface, including descent operations. Autonomous descent operations will take Peregrine from lunar orbit safely to the landing site on the lunar surface.

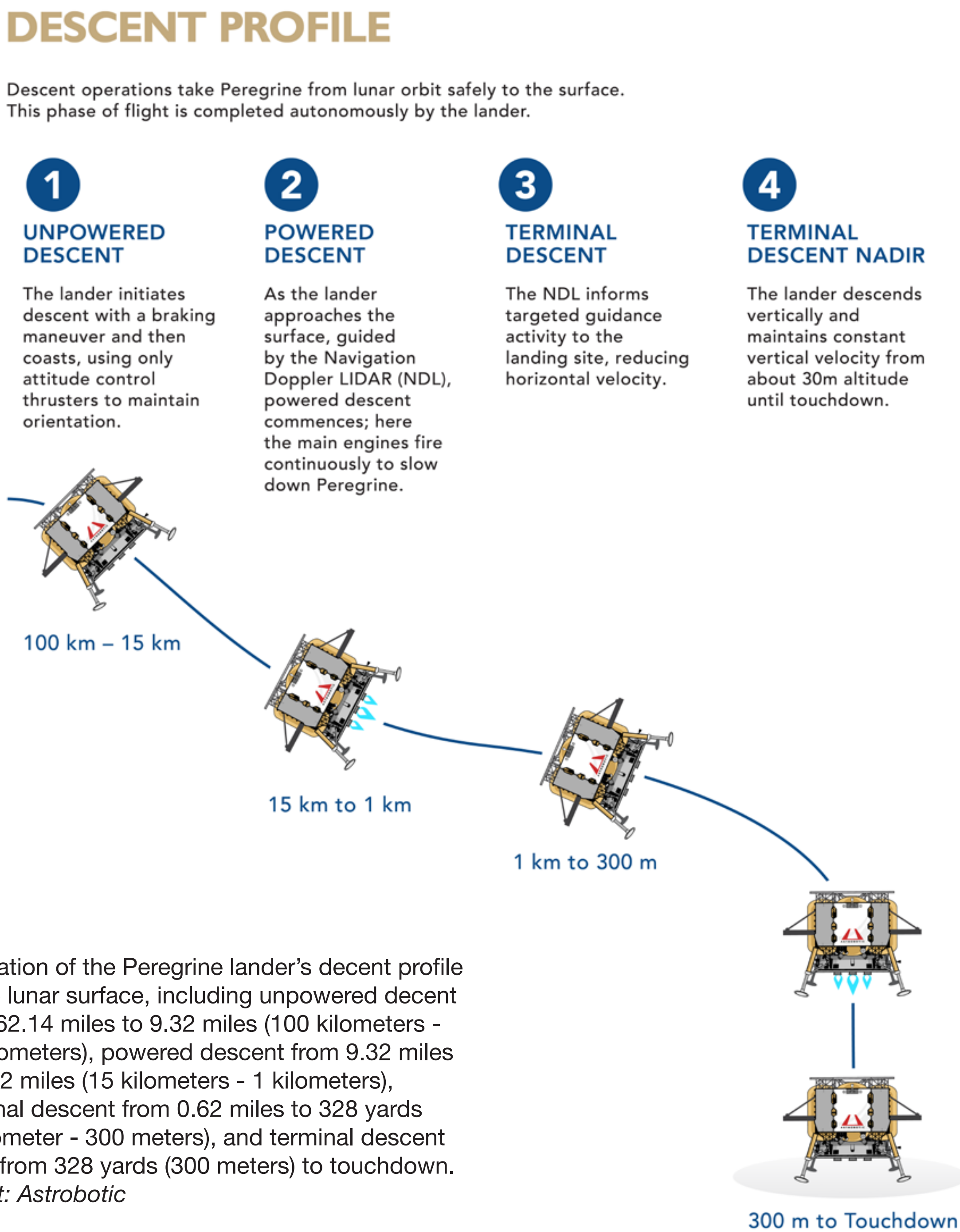


Illustration of the Peregrine lander's decent profile to the lunar surface, including unpowered decent from 62.14 miles to 9.32 miles (100 kilometers - 15 kilometers), powered descent from 9.32 miles to 0.62 miles (15 kilometers - 1 kilometers), terminal descent from 0.62 miles to 328 yards (1 kilometer - 300 meters), and terminal descent nadir from 328 yards (300 meters) to touchdown. *Credit: Astrobotic*

CLPS: Astrobotic's Peregrine Mission One

NASA 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 Astrobotic task order awarded

- May: **First Commercial Moon Delivery Assignments to Advance Artemis**
- 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 Astrobotic task order awarded

- June: **NASA names Astrobotic as CLPS provider to deliver VIPER to Moon**

2021

VIPER landing site announced

- September: **NASA announces VIPER will land near the western edge of Nobile Crater** at the Moon's South Pole

2023

- February: **New Landing Site Will Upgrade Science Returns for Astrobotic Flight**
- November: Astrobotic's Peregrine lander arrives in Florida for launch preparations

2024

First CLPS flights to the Moon

- January: Astrobotic's Peregrine Mission One launch

What's Coming Up

Astrobotic's second CLPS flight is scheduled to land near the lunar South Pole in 2024, using the company's Griffin lunar lander. The Griffin flight will deliver NASA's first robotic Moon rover, the VIPER (Volatiles Investigating Polar Exploration Rover), to the Mons Mouton region, named in honor of NASA mathematician Melba Roy Mouton. VIPER is a solar- and battery-powered rover that will characterize the distribution and physical state of lunar polar water and other volatiles in cold traps on the Moon. It will evaluate the potential for future on-site, or in-situ, resource utilization that could support sustained human exploration at the Moon's South Pole as part of NASA's Artemis missions. VIPER will also be the first to experience the environments that astronauts will later experience. VIPER will operate over multiple lunar days and traverse into permanently shadowed regions. Using its drill and three science instruments, researchers will gain a better understanding of how frozen water and other volatiles are distributed on the Moon, their cosmic origin, and what has kept them preserved in the lunar soil for billions of years.

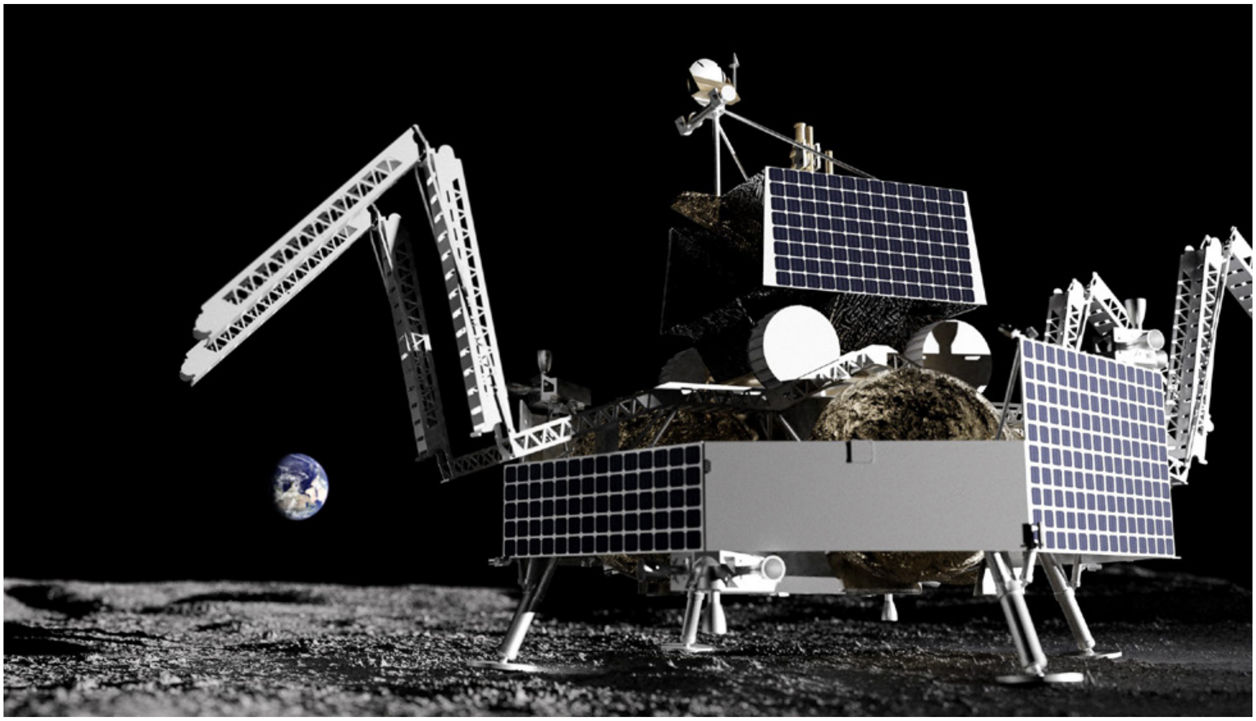


Illustration of Astrobotic's Griffin lunar lander. *Credit: Astrobotic*

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