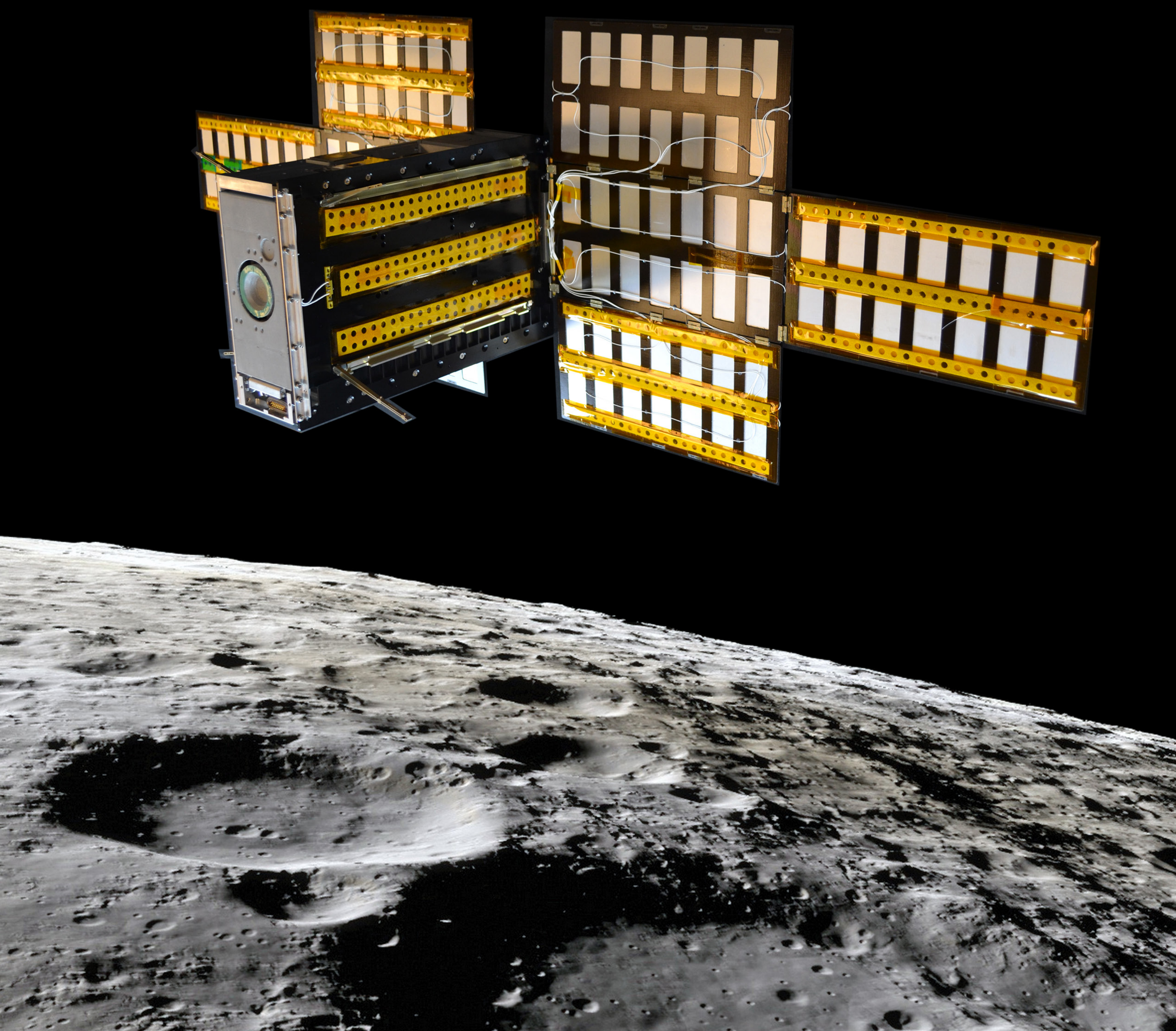
Lunar Polar Hydrogen Mapper LunaH-Map

Press Kit *August 2022*



LunaH-Map is a new type of NASA planetary science mission. LunaH-Map is a miniaturized, fully functional interplanetary spacecraft the size of a shoebox that will map hydrogen enrichments (indicators of water-ice) within permanently shadowed regions of the lunar South Pole. By flying over the South Pole at a very low altitude, LunaH-Map will be able to resolve ice enrichments that previous spacecraft missions could not. The spacecraft will use a miniaturized propulsion system, attitude control, power and communications systems to maneuver into orbit around the Moon.

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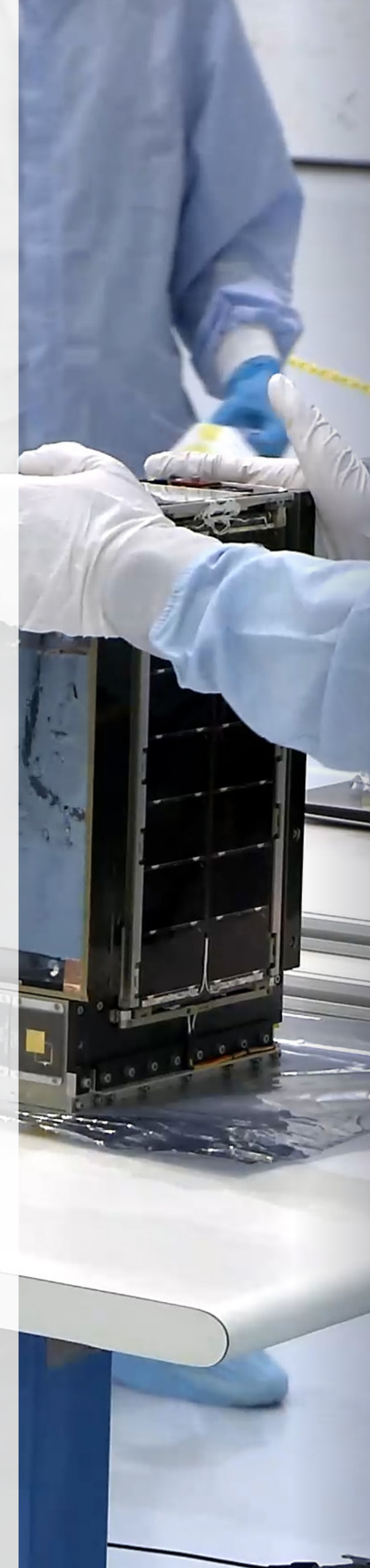
News Releases, Features and Status Reports

News, updates and feature stories about the LunaH-Map mission are available at **https://lunahmap.asu.edu**

Video and Images

A collection of videos, animation, images and infographics can be found on the mission website's gallery:
https://lunahmap.asu.edu

The NASA image use policy is available at
https://www.nasa.gov/multimedia/guidelines/index.html



Media Events

The most up-to-date information about LunaH-Map mission media events and where to watch them is available at:
http://www.nasa.gov/multimedia/nasatv/schedule.html

Click **NASA TV** (top navigation) for more information

How to Watch

News briefings and launch commentary will be streamed on **NASA TV, NASA.gov/live,** and **YouTube.com/NASA**

On-demand recordings will also be available on YouTube after the live events have finished.

For more information about NASA TV's programming schedule, visit **http://www.nasa.gov/ntv**

Additional Resources on the Web

Additional information about the LunaH-Map mission, including a digital version of this press kit, can be found on the mission's website:
https://lunahmap.asu.edu

NASA's LunaH-Map fact sheet is available at:
https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=LUNAH-MAP

Social Media

Join the conversation and follow these accounts and hashtags for the latest mission updates:

Twitter: @NASA, @NASASolarSystem, @NASAMoon, @lunahmap

Facebook: /NASA, /NASASolarSystem, /NASAMoon, /lunahmap

Instagram: @nasa, @nasasolarsystem

Hashtags: #theHissilent #LunaHMap

QUICK FACTS: FIVE KEY TAKEAWAYS FROM THE LUNAH-MAP MISSION

1

The Lunar Polar Hydrogen Mapper (LunaH-Map) mission is one of the tiniest NASA planetary science missions but has big science goals. Previous missions and studies have identified the presence of water-ice at the Moon's poles. However, there are still unanswered questions about how much water-ice is contained within permanently shadowed regions.

It is also unknown how much water-ice might be retained at depth throughout illuminated regions of the lunar South Pole. LunaH-Map will answer those questions by entering orbit around the Moon and producing a neutron map that will reveal where and how much water-ice is hidden across the lunar South Pole.

LunaH-Map will help us understand the origins of water on the Moon and how it has been redistributed since the Moon's formation. The maps will also be used to plan future missions and landing sites for robotic and human water-ice prospecting.

2

LunaH-Map is led by Principal Investigator Craig Hardgrove, a professor in Arizona State University's School of Earth and Space Exploration. The spacecraft was designed, assembled, integrated and tested at ASU, in collaboration with multiple space industry partners, including Blue Canyon Technologies, Busek, NASA's Jet Propulsion Laboratory, MMA Design, Radiation Monitoring Devices, KinetX, Qwaltec and AZ Space Technologies.

3

The "H" in LunaH-Map is silent – hidden like the H (hydrogen) on the Moon.

4

In addition to the development of technologies that enable its scientific mission, like propulsion and a new neutron spectrometer science instrument, LunaH-Map will also demonstrate auto navigation software and new deep space communications capabilities that will enhance future interplanetary small spacecraft

5

In 2015, NASA announced a rideshare opportunity for about a dozen 6U CubeSats on the Space Launch System (SLS) rocket's first uncrewed flight test – the Artemis I mission. During the mission, the CubeSats will be deployed at different locations after the Orion spacecraft separates from the rocket. The CubeSats will then head out on a variety of missions such as to an asteroid, the Moon, other deep space locations or in Earth's orbit. The secondary payloads are not the primary Artemis I mission, but they provide a unique opportunity for the CubeSats to travel to space for the first time.

QUICK MISSION FACTS:

Launch Period Opens: August 2022

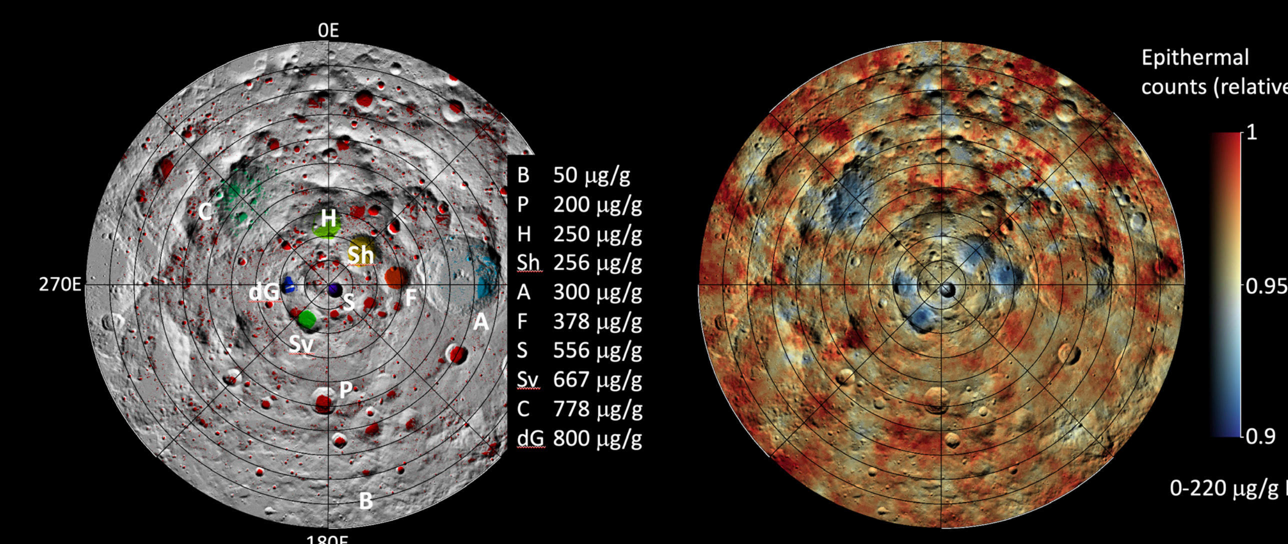
Launch Site: Cape Canaveral, United States

Launch Vehicle: Space Launch System (SLS) Artemis I

Science Phase: Two months

LunaH-Map: Water-Ice Mapping Capabilities

2 month mission (282 orbits)



Estimated distribution of water-ice at the Moon's South Pole where the water-ice is contained only within permanently shadowed regions

Representation of what LunaH-Map would see if the Moon's South Pole has the water-ice concentrations shown in the map on the left. The boundaries between water-ice enrichments are clearly defined for enrichments greater than ~15 km in diameter and >200 m/g hydrogen.

MISSION PROFILE

The Lunar Polar Hydrogen Mapper (LunaH-Map) mission is one of the smallest NASA planetary science missions but has large science goals. LunaH-Map will enter orbit around the Moon and help to reveal where and how much water-ice is hidden across the lunar South Pole, as well as hidden within regions of permanent shadow.

LunaH-Map builds upon decades of technologies demonstrated in Earth orbit, and will address lunar science questions that have so far only been tackled by bigger missions, teams and spacecraft.

The LunaH-Map spacecraft is the size of a large shoebox but has many of the major components you would find on larger spacecraft, including a solar array; an ion propulsion system; a guidance, navigation and control system; a flight computer; and a deep-space radio. LunaH-Map will only carry one science instrument, a neutron spectrometer, around which the entire spacecraft has been built.

In order to "see" into the Moon's permanently shadowed regions with the neutron spectrometer, LunaH-Map will enter an elliptical orbit around the Moon, flying very low over the lunar terrain (8–20 km or 5–12 miles over the South Pole). The scientific goal of the mission is to determine the major sources of water-ice at the lunar poles by producing a neutron map of the permanently shadowed regions. The map can also be used to help future missions that wish to use lunar water as a resource and may add to our knowledge of how water formed and evolved at the Moon's poles.

The LunaH-Map team aims to demonstrate that small, highly focused, science-driven, agile spacecraft can serve as secondary payloads on bigger NASA missions and can enhance the primary mission science, or even make unique discoveries of their own.

NASA's LunaH-Map is a secondary payload on the Space Launch System (SLS) Artemis I mission. LunaH-Map will deploy from the SLS Orion Stage Adapter after separation from the Orion spacecraft, about five and a half hours after the launch of Artemis I (after passing through the Van Allen radiation belts).

Shortly after the spacecraft makes contact with the Mission Operations Center at ASU, commissioning of the various spacecraft subsystems will continue for 24 hours after launch. One to two days after launch, the LunaH-Map propulsion system will be used to target a lunar gravity assist that will send LunaH-Map on a trajectory that allows the spacecraft to eventually return to the Moon and become captured in a high altitude circular orbit.

It will take several months for the spacecraft to be weakly captured by the Moon's gravity. Then, within about one year, LunaH-Map will achieve an elliptical orbit. At its farthest point in this orbit, the spacecraft will be 1,957 miles (3,150 kilometers) from the surface of the Moon's North Pole, while its nearest point will be 5 miles (8 kilometers) above the moon's south pole.

Once the spacecraft has entered its science orbit, the mission will begin its science phase, during which neutron measurements will be made as the spacecraft flies by the South Pole during each orbit. The orbital period is about five hours, and communication with the spacecraft is achieved using NASA's Jet Propulsion Laboratory Deep Space Network (DSN).

Radio contact and maneuver planning will occur every three to five days, with science data downlinked back to Earth on each contact. After the science data have been transmitted back to Earth and most of the fuel reserves consumed, LunaH-Map will de-orbit into the moon.

The total mission will last about a year and the spacecraft will perform nearly 300 orbits of the Moon.

During this time, LunaH-Map will be operated from the mission operations center at Arizona State University, where the spacecraft was designed and built. The team will communicate directly with DSN to send commands that will be transmitted to the spacecraft.

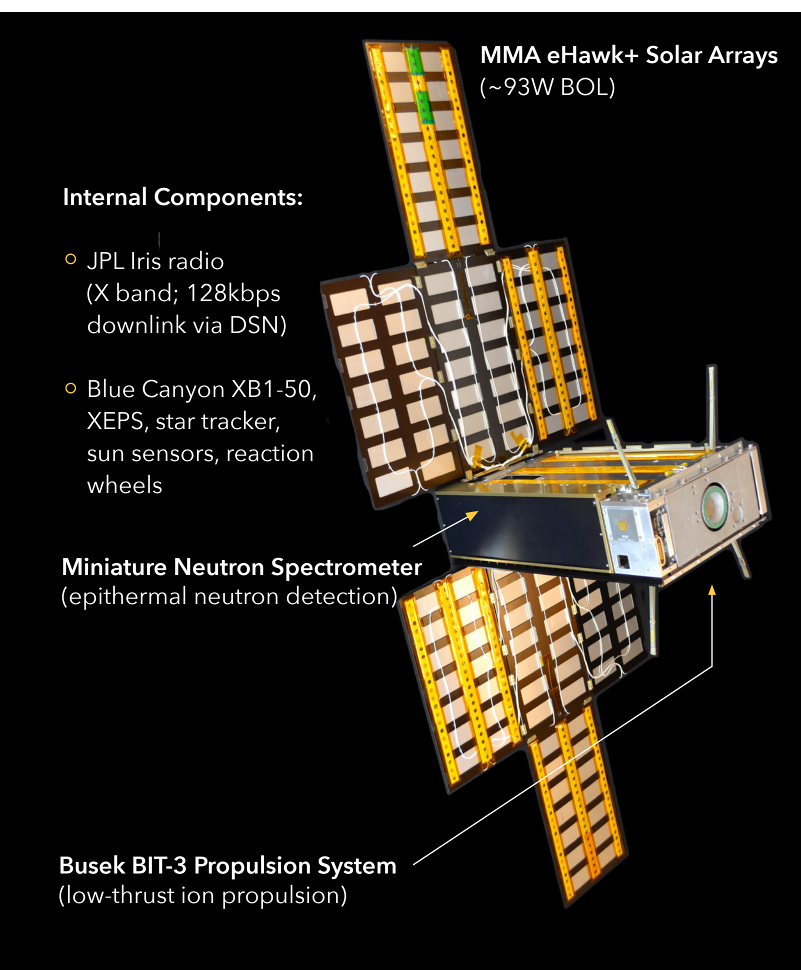
LunaH-Map team members Nathaniel Struebel (L) and Joe DuBois (R) make final adjustments to the spacecraft before shipment to NASA Kennedy Space Center.

SPACECRAFT

NASA's LunaH-Map is a fully functional interplanetary spacecraft about the size of a large shoebox and weighing about 30 pounds. It is the first interplanetary mission to be led, designed, assembled, integrated, and tested at Arizona State University. Its destination is in orbit around the Moon, from which it will map water-ice in permanently shadowed regions of the lunar South Pole.

The spacecraft, called a CubeSat, has many of the major components you would find on larger spacecraft, including a solar array; an ion propulsion system; a guidance, navigation and control system; a flight computer; and a deep-space radio.

LunaH-Map will only carry one science instrument, a neutron spectrometer, around which the entire spacecraft has been built. Within the spacecraft, there is a thumbnail sized SD card that contains the names of over 600 people from Arizona who signed up at public events to be included on the card. There is also a nameplate with signatures from the LunaH-Map team.

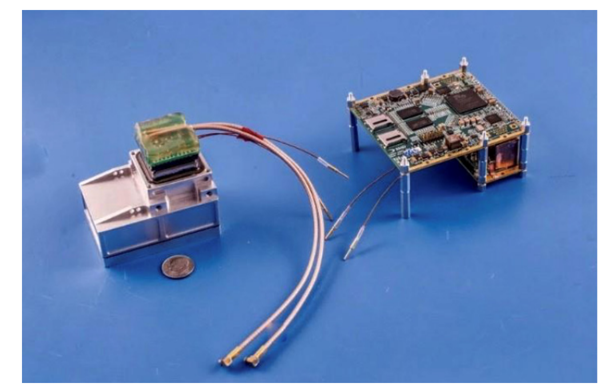


LUNAH-MAP FLIGHT SYSTEM DETAILS

Dimensions	10 x 20 x 30 cm
Mass	14 kg
Power	MMA eHawk+ 90W BOL Solar Array, Blue Canyon Technologies XEPS with 56W-hr Li-ion battery
Propulsion	Busek BIT-3 ion thruster, iodine propellant
Communication	JPL Iris V2 CubeSat Deep Space Transponder
Command and Data Handling / Guidance, Navigation and Control:	Blue Canyon Technologies XB-1 50

MINI-NS: MINIATURE NEUTRON SPECTROMETER FOR SMALL SPACECRAFT

The primary science instrument on the LunaH-Map spacecraft is the Mini-NS, which is a neutron spectrometer using an array of scintillator crystals (an elpasolite composed of Cs_2LiYCl_6, called CLYC). Mini-NS has 200 cm^2 of detecting area covered in gadolinium foil, making it sensitive primarily to epithermal (>0.3eV) neutrons. The Mini-NS consists of two detectors, each comprised of 4 sensor heads, and is independently operated with data and time synchronized to the spacecraft.



MINI-NS SPECIFICATIONS

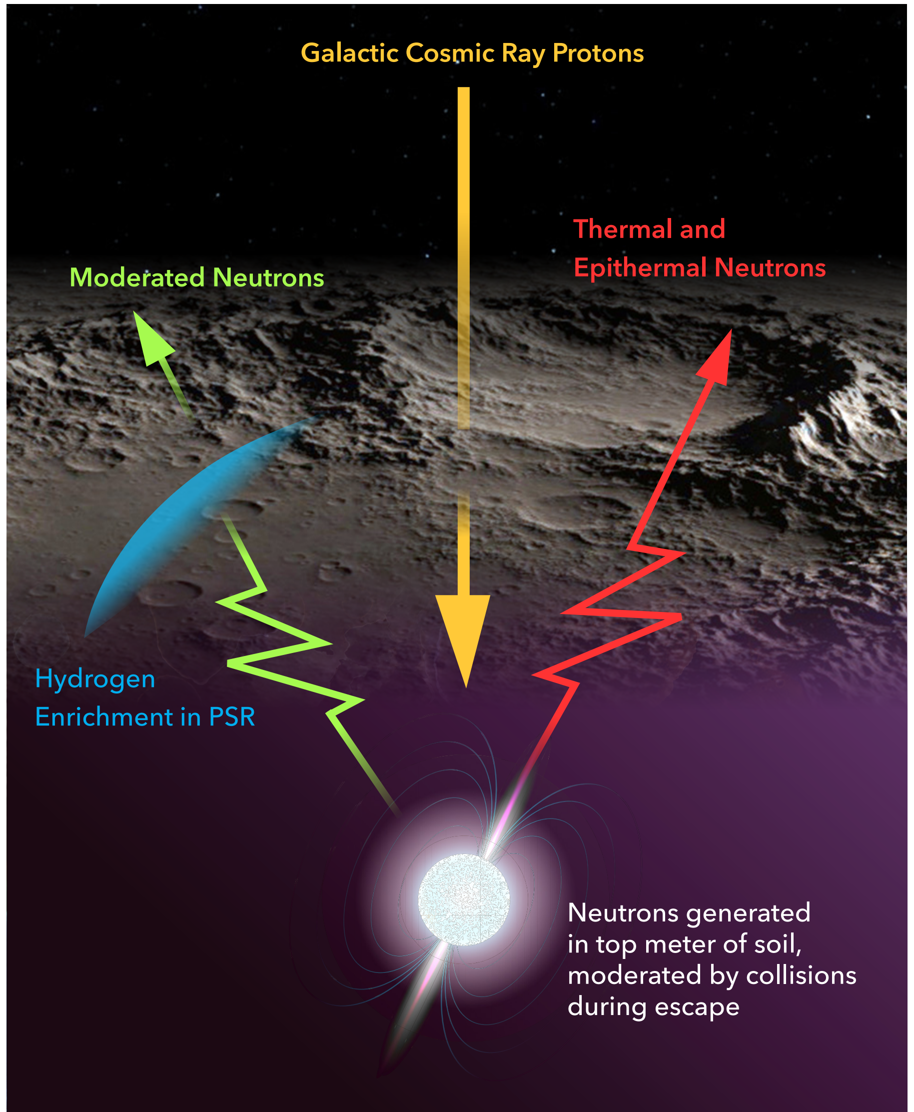
Detector (2 per instrument)	2x2 Array of 4cm x 6.3cm x 2.0cm CLYC Crystal Modules
Sensitivities	Epithermal (E > 0.3 eV) neutrons
Dimensions	25cm x 10cm x 8cm
Mass	3.4 kg
Power	3.6W (standby), 9.6W (data acquisition)
Data Acquisition Times	Counts binned every 1 second
Data Rate	14 Bytes/Sec (50 kBytes/Sec stored locally)

SCIENCE

Decades of lunar exploration have proven that there are water-ice enrichments in certain regions around the poles of our Moon. Some of these regions, called permanently shadowed regions at the lunar South Pole, may contain enough water to change our view of the formation and evolution of Moon. Permanently shadowed regions are areas near the North and South Poles of the Moon that never receive direct sunlight and thus are extremely cold. Even though they are exposed to the vacuum of space, water-ice can accumulate in them because they are so cold and dark. They may even contain enough water to support future human and robotic exploration of the solar system.

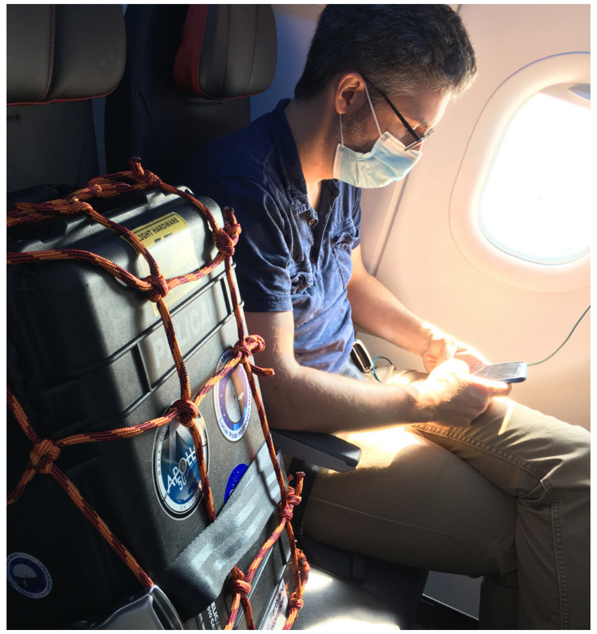
Despite knowing these enrichments exist, we don't yet know exactly how much water-ice lies within permanently shadowed regions. The LunaH-Map Miniature Neutron Spectrometer (Mini-NS) will use neutron spectroscopy to measure the energy distribution of neutrons that reach the detector and identify the hydrogen content on the Moon's surface.

Neutron spectroscopy is a powerful tool used by many NASA missions for identifying hydrated materials on planetary surfaces. If you've ever seen global maps of water on planetary bodies (the Moon, Mars, Mercury, Vesta, Ceres) they were made using a neutron spectrometer.

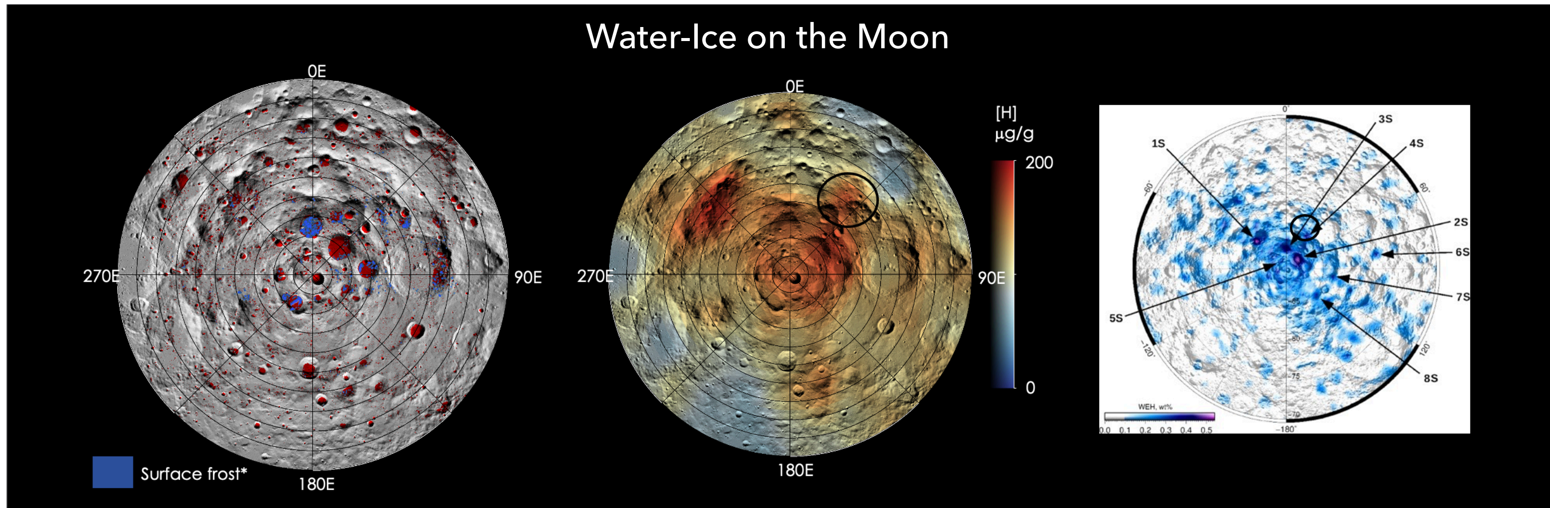


Lunar Prospector was the first planetary mission to carry a neutron spectrometer, but many have followed, including Mars Odyssey; the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission; Lunar Reconnaissance Orbiter; the Dawn mission to Vesta and Ceres; and the Dynamic Albedo of Neutrons instrument on the Mars Curiosity Rover.

Neutron detectors measure the energy distribution of neutrons that reach the detector, which is highly dependent upon the hydrogen content of the top meter of a planetary surface. The Mini-NS is the first planetary science neutron detector to use CLYC, an elpasolite class of inorganic scintillator for neutron detection. The large surface area of the Mini-NS, the high efficiency for epithermal neutrons of its CLYC sensors, and low spacecraft periapse at the Moon's South Pole will provide high-resolution maps of hydrogen within ~5 degrees of the pole. The map below was produced by NASA's Lunar Prospector and illustrates the hydrogen abundance at the lunar South Pole, where red indicates elevated hydrogen. LunaH-Map is designed to produce an improved neutron map where individual regions in permanent shadow can be resolved from one another.



LunaH-Map PI Craig Hardgrove with spacecraft flying to NASA's Kennedy Space Center. Image/ASU



*Lunar Reconnaissance Orbiter LAMP UV spectral features consistent with surface frost shown in blue. Frosts are not observed over all PSRS (in red) and regions with frost do not positively correlate with hydration enrichments from neutron maps**

*Lunar Prospector Neutron Spectrometer (LPNS): Lunar South Pole H map derived neutron counts show broad H enrichments centered on Faustini and north of Nobile**

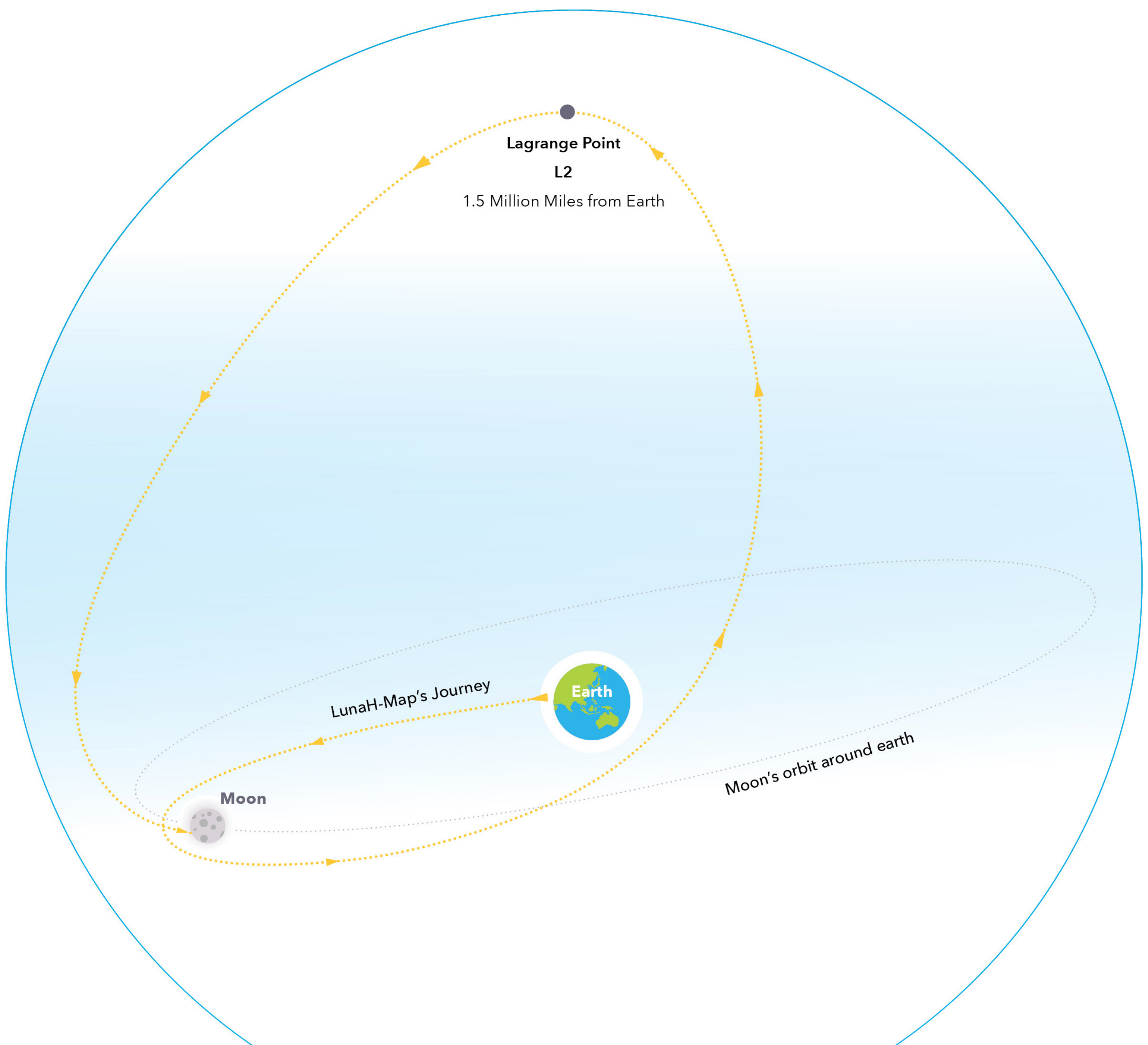
*Lunar Reconnaissance Orbiter Lunar Epithermal Neutron Detector (LEND): Analysis of LEND data reveals H enrichments in Shoemaker, Haworth and Cabeus. No enrichments in Faustini or north of Nobile**

** Hayne, P. O. et al. (2015) Icarus ; cf. LOLA-reflectance/Diviner analyses by Fisher et al. (2017) Icarus & M3/LOLA/Diviner/LAMP analyses by Li et al. (2018) PNAS*

LUNAH-MAP TRAJECTORY AND ORBIT

Upon deployment from SLS, LunaH-Map will use its low-thrust iodine ion propulsion system to position itself into a highly elliptical orbit with the closest point to the Moon over the South Pole, at a height of between 8 and 20 kilometers.

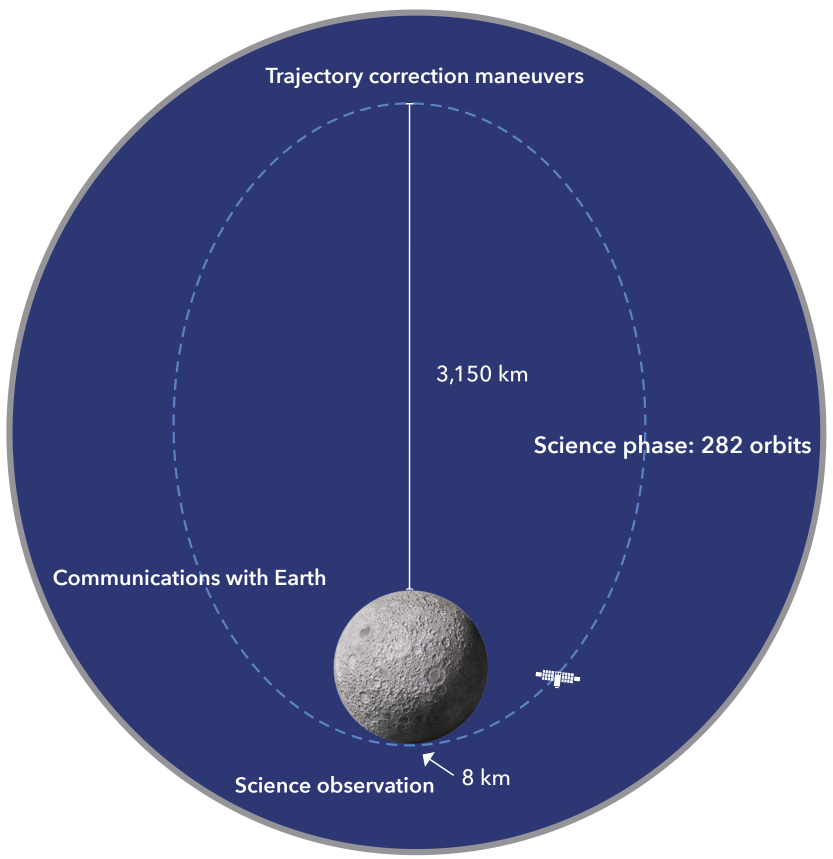
It will take up to 70 days for the spacecraft to be weakly captured by the Moon's gravity. Then, within about one year, LunaH-Map will achieve an elliptical orbit. The illustration below represents the shortest and longest possible mission durations based on the expected launch windows for SLS Artemis I. Because LunaH-Map uses a low-thrust propulsion system, the spacecraft cannot directly enter lunar orbit after deployment from the SLS, and instead needs to execute a series of long duration propulsive maneuvers that use the gravitational forces of the Moon, as well as the Earth and Sun, to eventually become weakly captured by the Moon. Due to this, the total mission duration for LunaH-Map is highly dependent upon the Earth-Moon-Sun position on the launch day of SLS Artemis I.



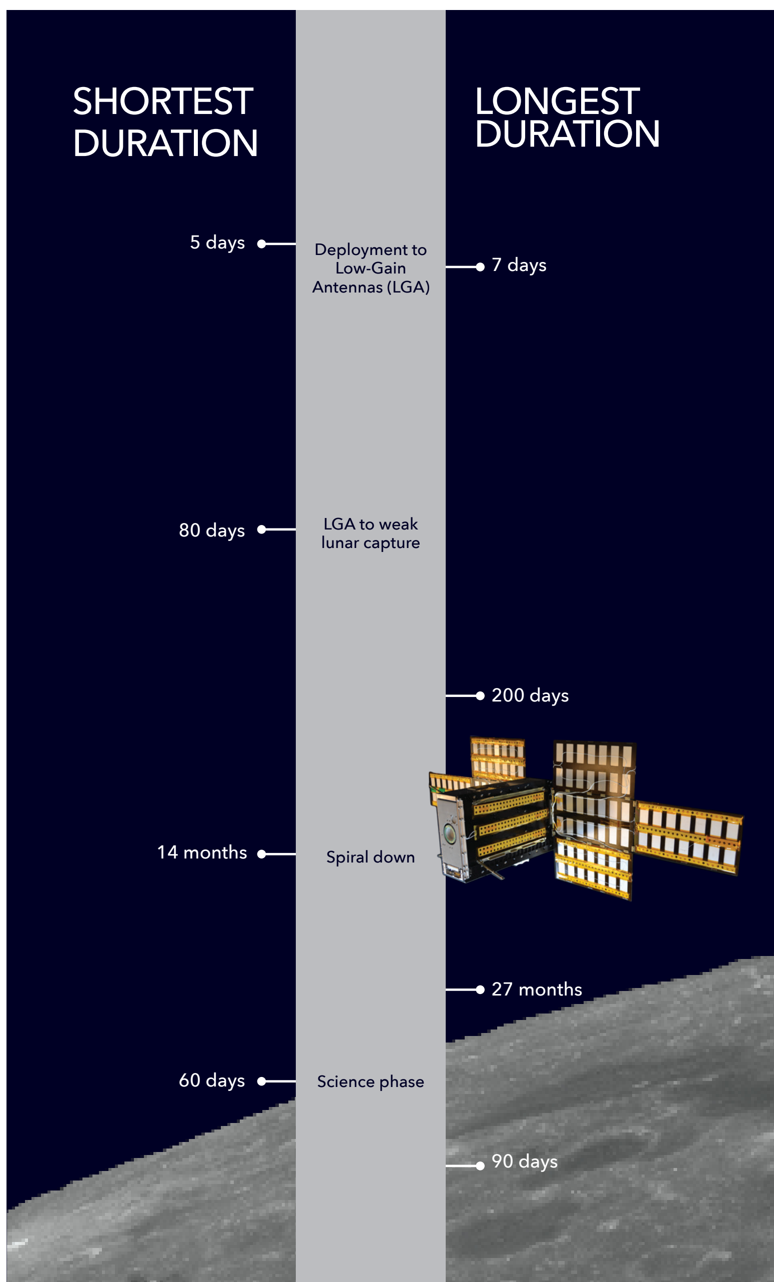
At its farthest point in this orbit, the spacecraft will be 1,957 miles (3,150 kilometers) from the lunar surface above the North Pole, while its nearest point will be 5 miles (8 kilometers) above the South Pole. Once this has been achieved, there will be a minimum two month science phase when neutron measurements will be made as the spacecraft flies by the South Pole during each orbit.

Mission Timeline

Launch Period Opens: August 2022
Launch → Lunar Orbit Insertion (LOI): 4.25 months
LOI → Begin Science Phase: ~14 months
Science Phase: 2 months
Decommissioning Phase: 1 month
Total Mission Duration = 21.25 months



The orbital period is between 4 and 5 hours and communication with the spacecraft is achieved using the Deep Space Network (DSN). Radio contact and maneuver planning will occur every 3 to 5 days, with science data downlinked back to Earth on each contact. Finally, after the science data have been transmitted back to Earth and most of the fuel reserves consumed, LunaH-Map will de-orbit into the lunar South Pole, perhaps within one of the permanently shadowed regions or near the pole.



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Brent Gordon, MMA Design LLC
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LAUNCH VEHICLE

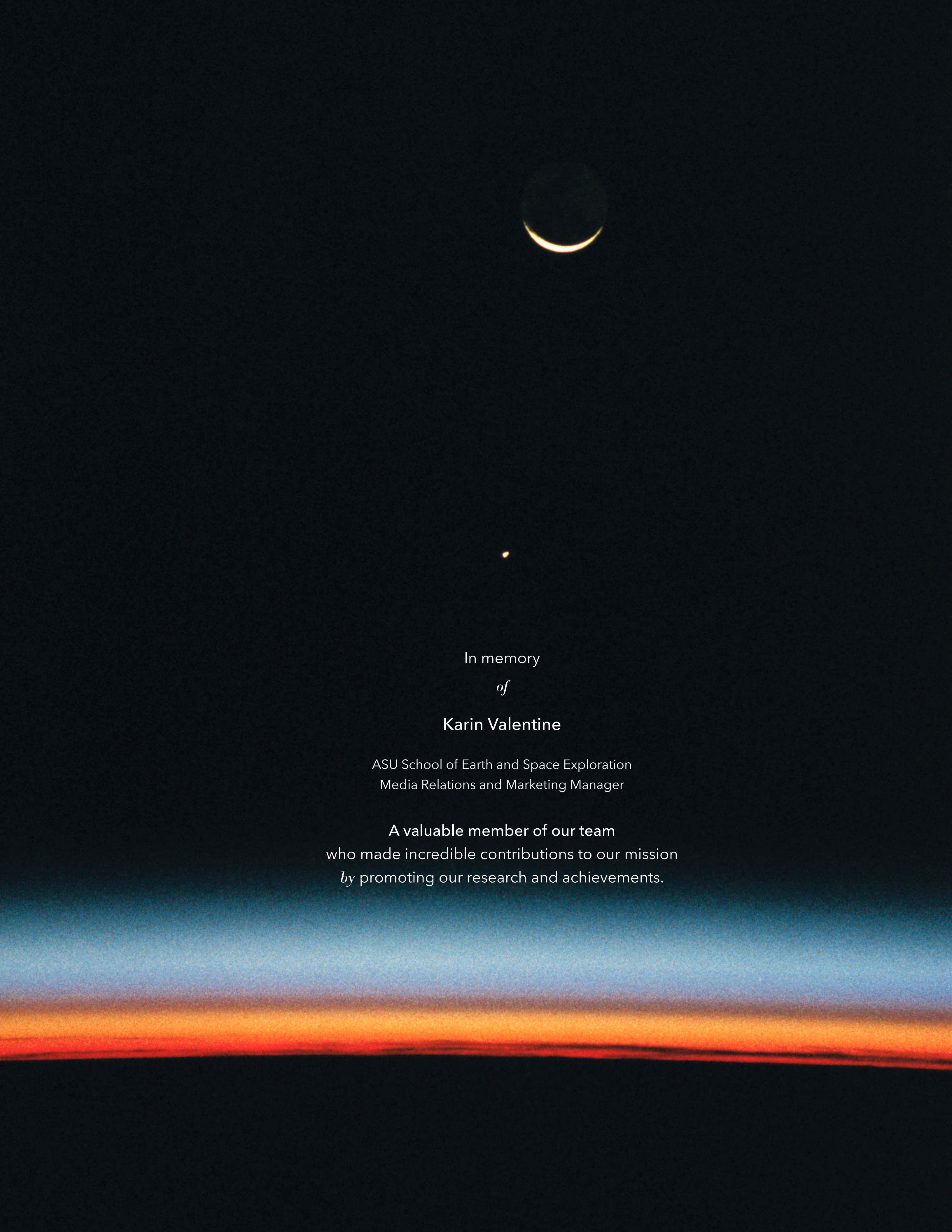
LunaH-Map is one of 10 CubeSats that will fly as secondary payloads on NASA's Space Launch System (SLS) rocket's Orion stage adapter as part of the Artemis I mission. The rocket will launch from Kennedy Space Center in Cape Canaveral, Florida.

After the Orion spacecraft separates from the SLS rocket for a precise trajectory toward the Moon, the large shoebox-sized payloads are released from the Orion stage adapter to conduct their own science and technology missions.

SLS's main goal for the Artemis I mission is to successfully send the uncrewed Orion spacecraft to lunar orbit, where it can test out critical spacecraft systems and then return to Earth, testing the spacecraft's heat shield at lunar reentry speeds. The Orion stage adapter connects the rocket to Orion and contains room inside the adapter to provide a rare opportunity to send the CubeSats to deep space using extra lift-capacity on the uncrewed mission. Each CubeSat provides its own propulsion and navigation to get to various deep space destinations.

Orion Stage Adapter Ring holding the CubeSats
Image/NASA Kennedy Space Center

For more information about the LunaH-Map Mission
https://lunahmap.asu.edu



In memory

of

Karin Valentine

ASU School of Earth and Space Exploration
Media Relations and Marketing Manager

A valuable member of our team
who made incredible contributions to our mission
by promoting our research and achievements.