Lunar Discovery and Exploration Program Update

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Planetary Science Advisory Committee
March 5, 2024

- Plans/Strategies
  - Implementation plan for Integrated Lunar Science Strategy (NASA) – issued for community comment
  - Community Science Definition Team: objectives for Endurance-A Mission (South Pole-Aitken Basin sample return)
  - NASA Moon2Mars Architecture Concept Review 23 – Nov 2024
  - NASA Architecture Definition Document (ADD) – Feb 2024
- Competitive Solicitations
  - Artemis III Deployed Instruments call (A3DI)
    - selections spring 2024
  - PRISM4 (Stand Alone Site Agnostic (SALSA) instruments call)
    - Draft call for community comment spring 2024
  - Planning: A4DI
  - Planning: LTV instruments
  - Planning: A4 Hand-Held Instruments
- LROC: imaged CH-3, SLIM, IM-1 landing sites
- LOLA: lased CH-3 Vikram LRA
- KPLO/Danuri/ShadowCam
  - LDEP now funding ShadowCam/DSN Ops
- Artemis II
  - Artemis II Lunar Observation Campaign (ALOC) [Lead: Young/NASA GSFC] (Artemis II)

- PRISM1 instrument suites in development:
  - Lunar Vertex - Exploring the Intersection of Geoscience and Space Plasma Physics (Lunar Vertex) [Blewett/APL] (CP-11)
  - Farside Seismic Suite (FSS) [Panning/JPL] (CP-12)
  - Lunar Interior Temperature and Materials Suite (LITMS) [Grimm/SwRI] (CP-12)
- PRISM2 instrument suites in development:
  - Lunar Vulkan Imaging and Spectroscopy Explorer (LunarVISE) [Donaldson-Hanna/UCF] (CP-21)
  - Lunar Explorer Instrument for Space Biology Applications (LEIA) [Settles/NASA ARC] (CP-22)
- PRISM3 instrument suite in development:
  - Dating an Irregular Mare Patch with a Lunar Explorer (DIMPLE) [Anderson/SwRI] (CP-32)
- Artemis III Geology Team selected (A3GT)
  - Earth-based Artemis III Geologists for Lunar Exploration (EAGLE) [Denevi/APL] (Artemis III)
- CLPS delivery competitions
  - Next: CP-22 (LEIA + others) to South Pole
    - CLPS company proposals in evaluation
  - Then: CP-21 (LunarVISE + others) to Gruithuisen Domes

- VIPER Assembly; GM-1 response to PM-1
- Lunar Trailblazer env testing -> storage; rideshare on IM-2 (Nov 2024) [Ehlmann/CalTech]

TO2-AB

PM-1

Did Not Land

Peregrine Lander

ASTROBOTIC

TO2-IM

IM-1

Landed 2/22

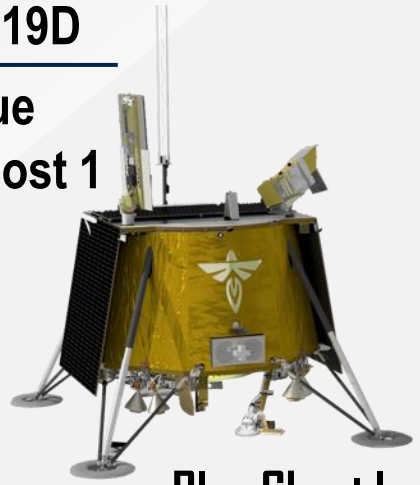
No Power 2/29

Nova-C Lander

INTUITIVE MACHINES

TO19D

Blue Ghost 1



Blue Ghost lander

FIREFLY AEROSPACE

TO20A – VIPER

GM-1

PM-1 FRB Results

NASA Evaluation

Griffin Lander

ASTROBOTIC

PRIME-1

IM-2

Nova-C Lander

INTUITIVE MACHINES

CP-11

IM-3

Nova-C Lander

INTUITIVE MACHINES

CP-12

TBA

Series-2 Lander

DRAPER

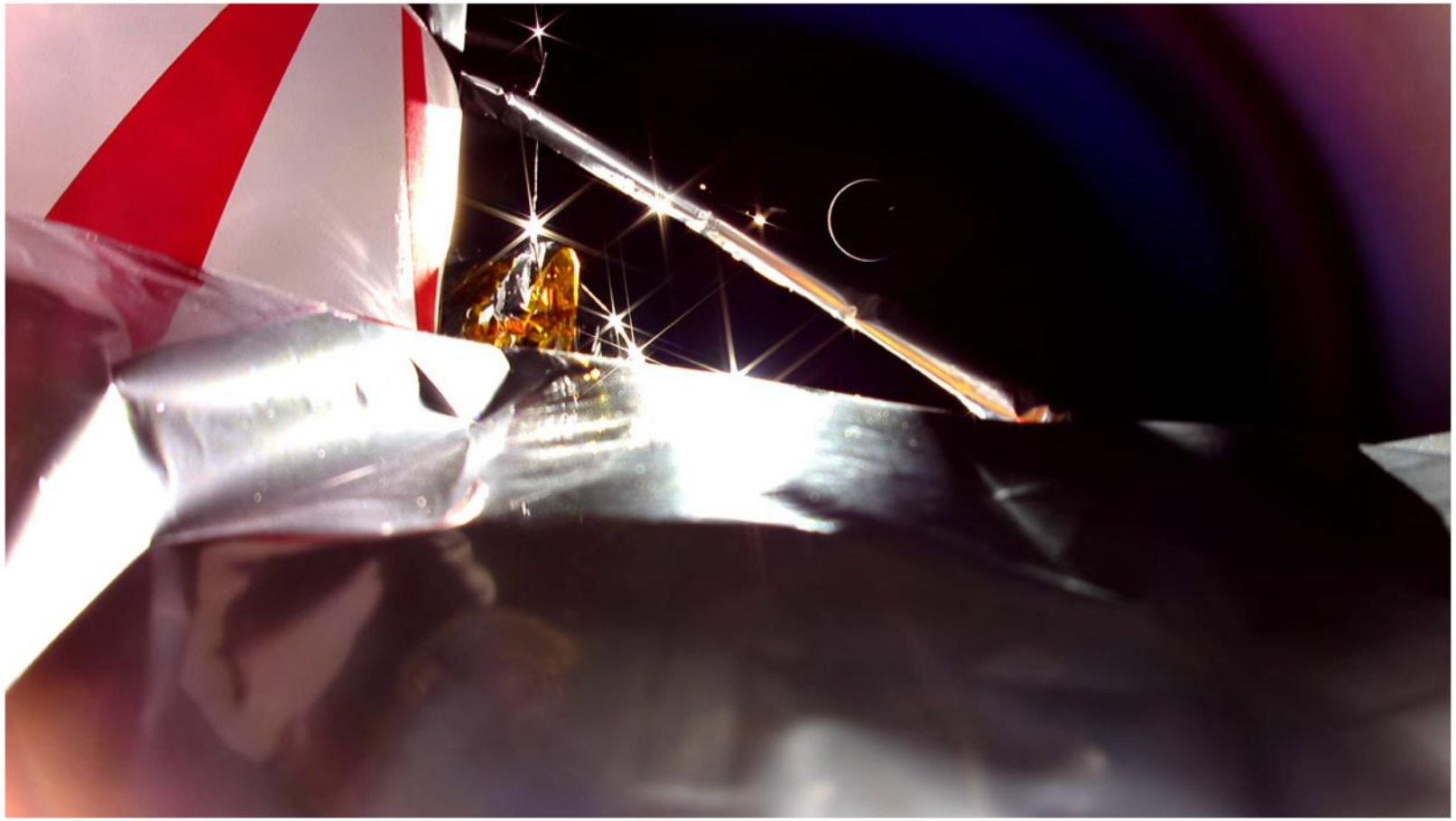
CS-3 & CS-4

Blue Ghost 2

Blue Ghost Lander

FIREFLY AEROSPACE

PM-1



By blocking the Sun with one of Peregrine's struts, Astrobotic engineers were able to capture this striking view of the crescent Earth. The company's CEO, John Thornton, identified this photo as his favorite surprise of the mission. Credit: Astrobotic.

NASA Science on PM-1

Peregrine Ion-Trap Mass Spectrometer (PITMS):
gather data about the **presence and variability of the OH, H2O, noble gases, nitrogen, and sodium** compounds that are released from the Moon's regolith and travel through the exosphere over the course of the long lunar day.

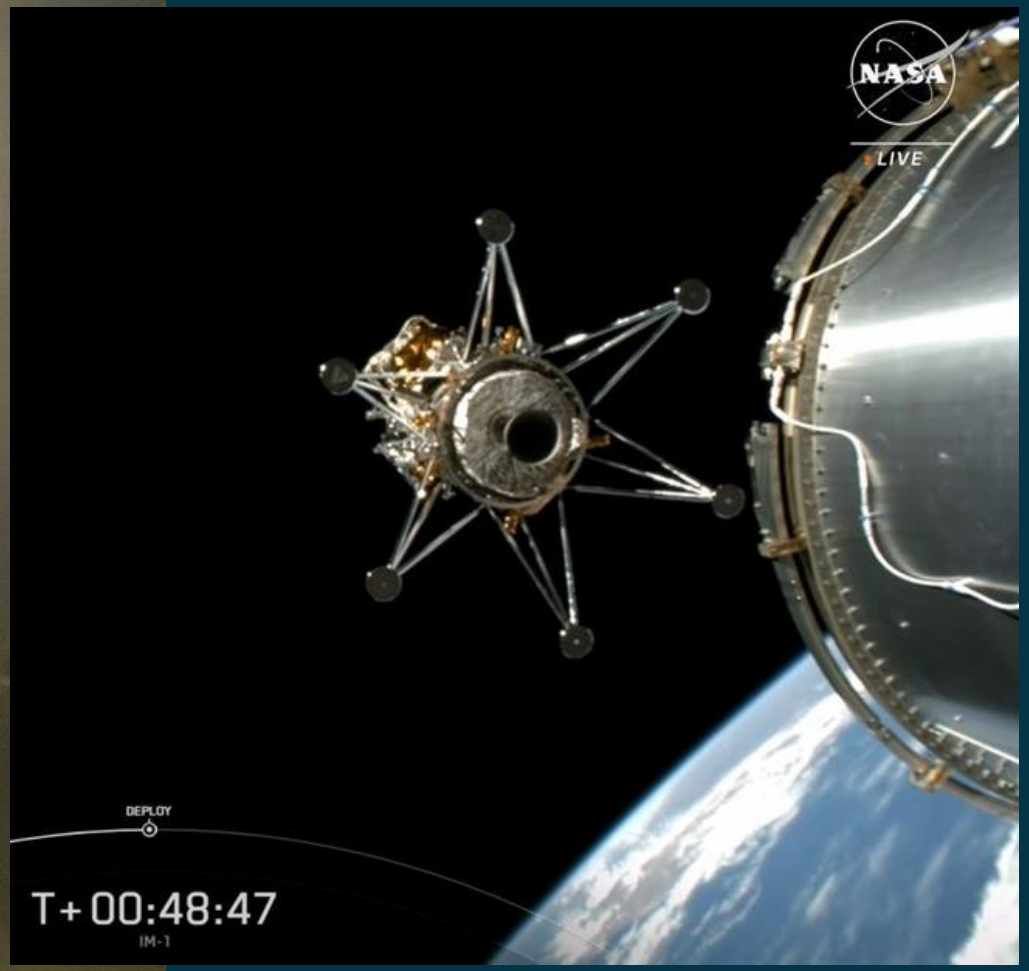
Neutron Spectrometer System (NSS):
determine the **abundance of hydrogen-bearing** materials and the bulk regolith **composition** at the landing site **up to a depth of three feet below the surface** and measure any variations during the diurnal cycle.

Lunar Retroreflector Array (LRA):
function as a permanent **location marker on the Moon** for decades to come.

Near Infrared Volatile Spectrometer System (NIRVSS):
measure **surface and subsurface hydration** (H_2O and OH) as well as CO2 and methane, while simultaneously mapping **surface morphology and surface temperatures.**

Linear Energy Transfer Spectrometer (LETS):
quantify **radiation** at the lunar surface **from Galactic Cosmic Rays**—high-energy particles that zip into our solar system from distant points in the galaxy—and from space weather caused by the Sun.

IM-1



NASA Science & Tech on IM-1

Stereo Cameras for Lunar Plume-Surface Studies (SCALPSS):
record effects of engine plume interactions with the lunar surface to **understand how the landing event changes the lunar surface topography**

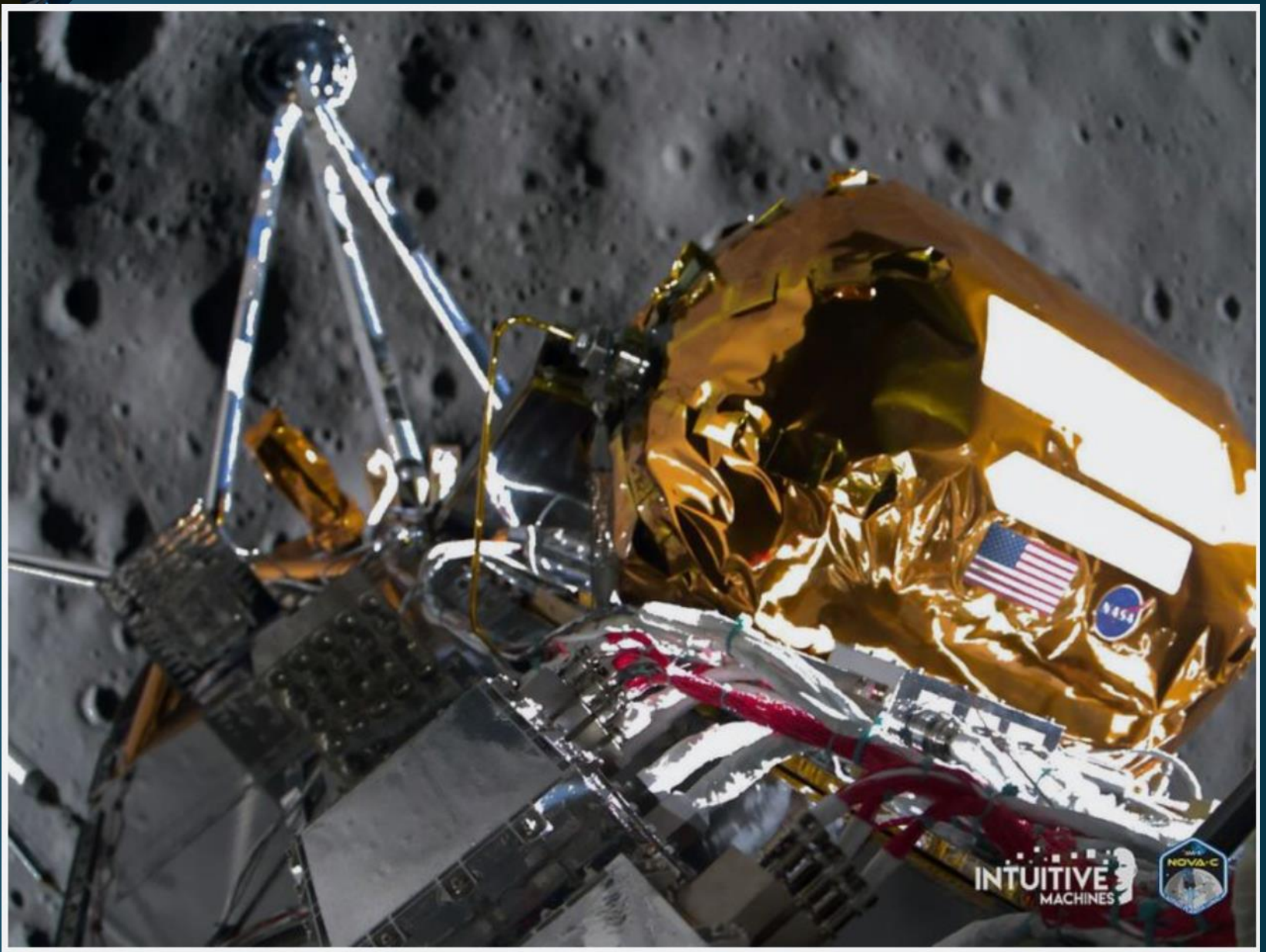
Radio Wave Observations at the Lunar Surface photoElectron Sheath (ROLSES):
measure the **density of the electrons** ejected from lunar dust by photons of sunlight and detect **radio emissions from the Sun, Jupiter, and Earth's aurora** to characterize the south polar environment of the Moon

Navigation Doppler Lidar (NDL):
laser-based sensor that helps the spacecraft determine **how far above the surface it is and how fast it is moving**, to help the spacecraft land precisely

Lunar Retroreflector Array (LRA):
a permanent **location marker on the Moon** for decades to come.

Lunar Node-1 (LN-1):
transmit navigation and communication radio signals to **guide incoming/outgoing vehicles with precision** to reduce the amount of fuel required for future safe landings

Radio Frequency Mass Gauge (RFMG):
space-age gauge to **measure the amount of cryogenic propellant in spacecraft in zero gravity,** to monitor propellant reserves and save fuel during transit and landing



Enlarge / Intuitive Machines' *Odysseus* lander is shown shortly before touching down on the Moon.

IM-1

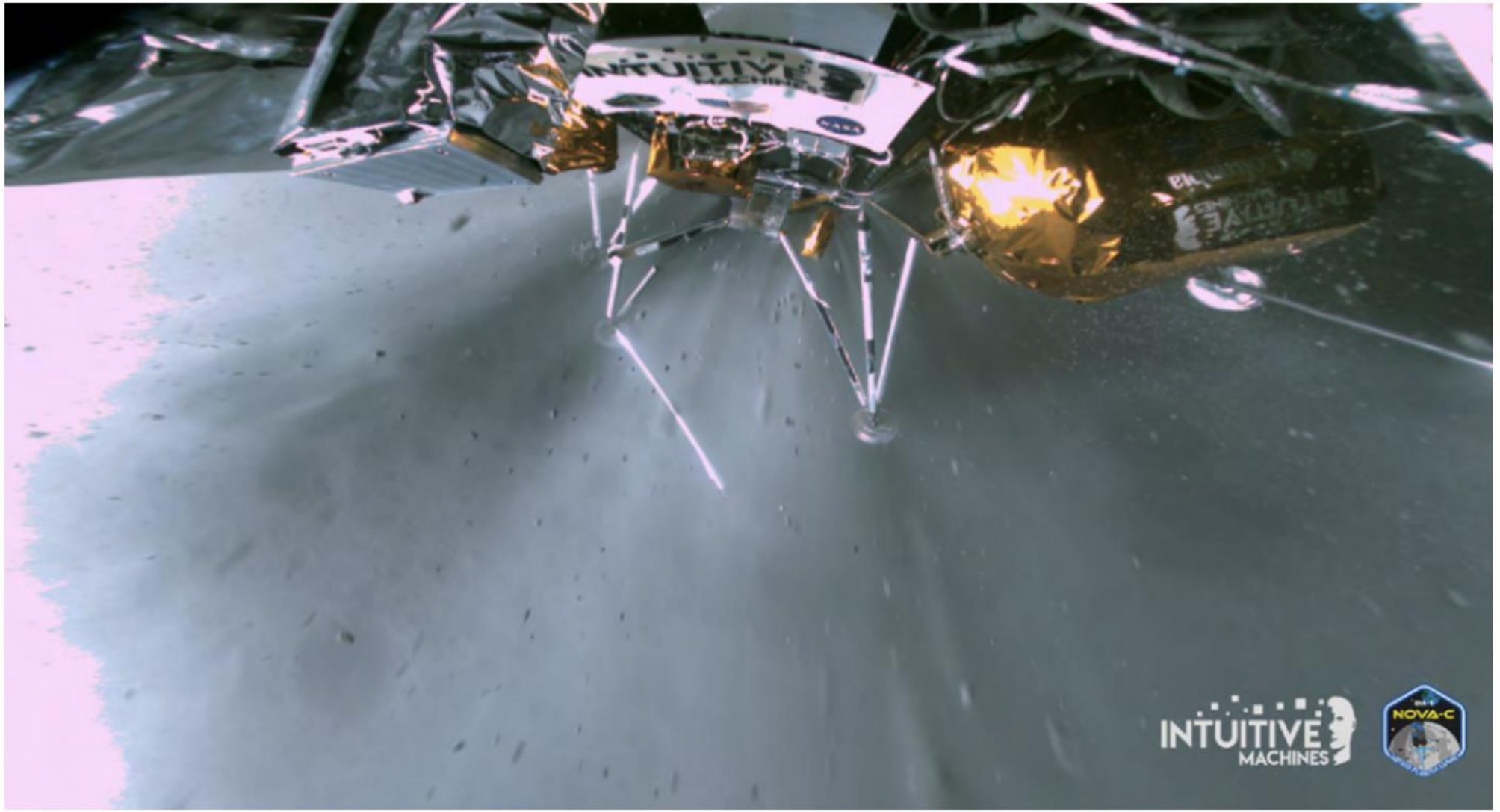
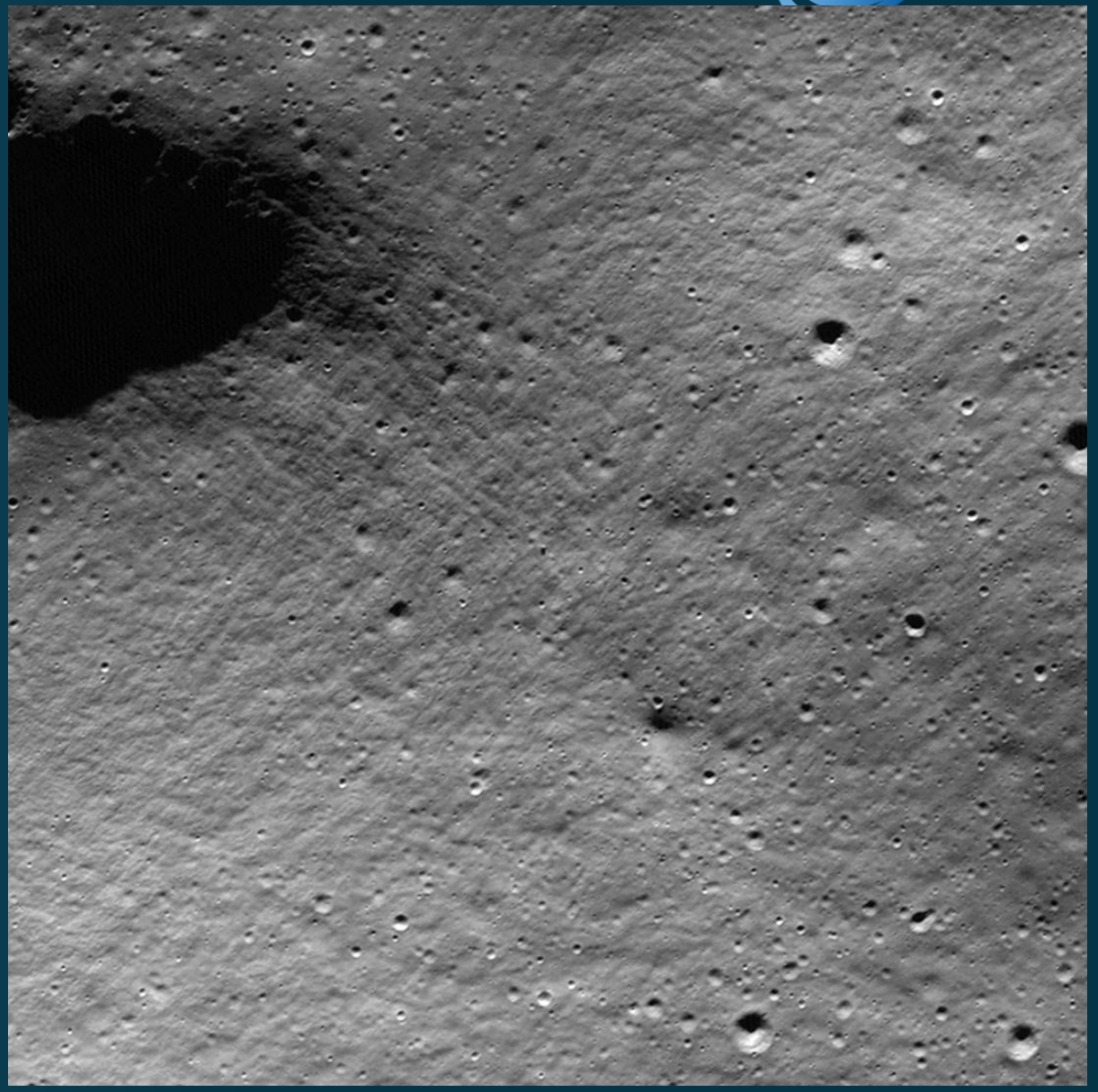


Image of Odysseus landing on the Moon with one landing leg broken. The darker area is lunar regolith being disturbed by the engines, which are still firing. Credit: Intuitive Machines

IM-1

The Odysseus lander on the surface of the Moon. The dark oval area to the left of the gold-covered helium tank is a crater. The near rim is only about 500 meters away. Credit: Intuitive Machines




NASA
EXPLORE MOON to MARS
MOON LIGHTS THE WAY

Lunar Updates

National Aeronautics and Space Administration

Sarah Noble
Artemis Lunar Science Lead
Science Mission Directorate

Update on the “Implementation Plan for a NASA Integrated Lunar Science Strategy in the Artemis Era”

Draft released for public comment on November 14th

- Received 21 individual responses through the Google Form (plus 1 additional individual response through email), plus a compiled group response from GSFC and a compiled response from LEAG
- We appreciate the feedback and are working on edits with a final version expected to be released later this Spring

Next Steps – activities we are committing to undertake over the next two years

- Funding a short study to further define the rover requirements and potential payloads of the Endurance-A concept. This effort includes gathering community input, to better define the science objectives (section 4.1).
- Conducting a pre-phase A study on “LExSO” (Lunar Exploration Science Orbiter) using the LEAG Continuous Lunar Orbital Capabilities Specific Action Team (CLOC-SAT) report as a guide (section 3.2)
- Requesting a joint LEAG/ExMag study on Artemis Samples, including panels on volatile as well as non-volatiles samples and sample data (sections 4.3, 5.2, 5.5).
- Continuing community engagement on the evolving Moon to Mars Definition Document (section 1).
- Continuing the Lunar Surface Science Workshop series to acquire direct feedback on topics important to the science community (section 5.7).
- Planning for a South Pole Aiken Basin Sample Return Science Definition Team (SDT) to further flesh out the science objectives and measurement requirements of such a mission (section 4.1).
- Developing a statement of task for a National Academy of Sciences study on the science value of potential non-polar human destinations (sections 4.1, 4.4).
- Working with the USGS to define a coordinated geologic mapping strategy for exploration of the south pole (section 5.5).
- Planning for a LGN payload study to explore the requirements and feasibility of a CLPS-based approach (section 4.2)
- National Academy of Sciences study has been requested on the cross-disciplinary science humans should address on the surface of Mars (section 5.8).

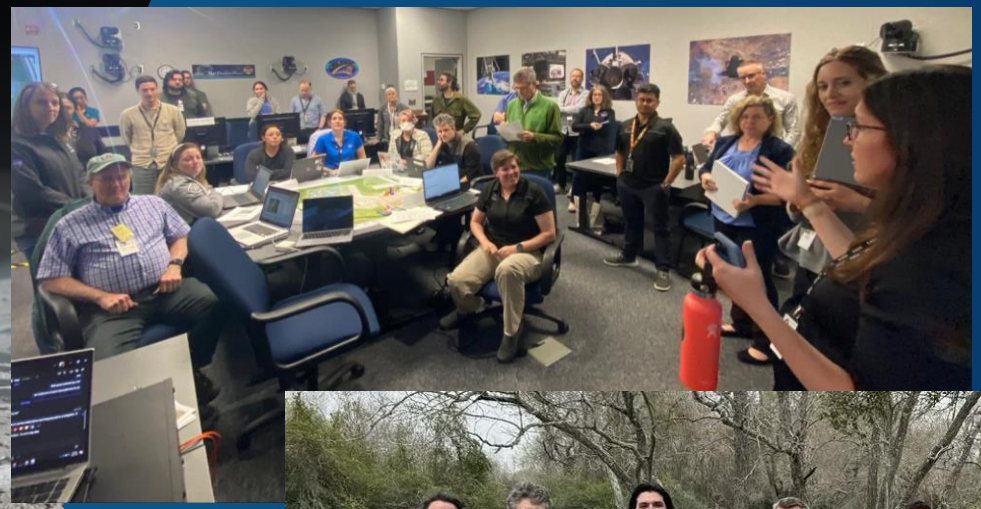
C.25 Lunar Mapping Program

“This program element is intended to enable individual researchers to participate as a member of a geologic mapping team in the planning and execution of campaign-style mapping of selected regions of the Moon.”

- Pilot program
- Call is similar to Analog Activities Program (only 3 pgs!)
- Selected participants will work together as a single team to support the construction of targeted, innovative, and content-diverse geologic maps that will aid in lunar exploration
- Proposals due 6/12/24 (no step 1s)
  - Open to advanced graduate students

1St Artemis Science Team meeting

The Artemis Internal Science Team (AIST) and the Artemis Geology Team (A3GT) held their first formal joint training activity at JSC Feb 26-Mar 1



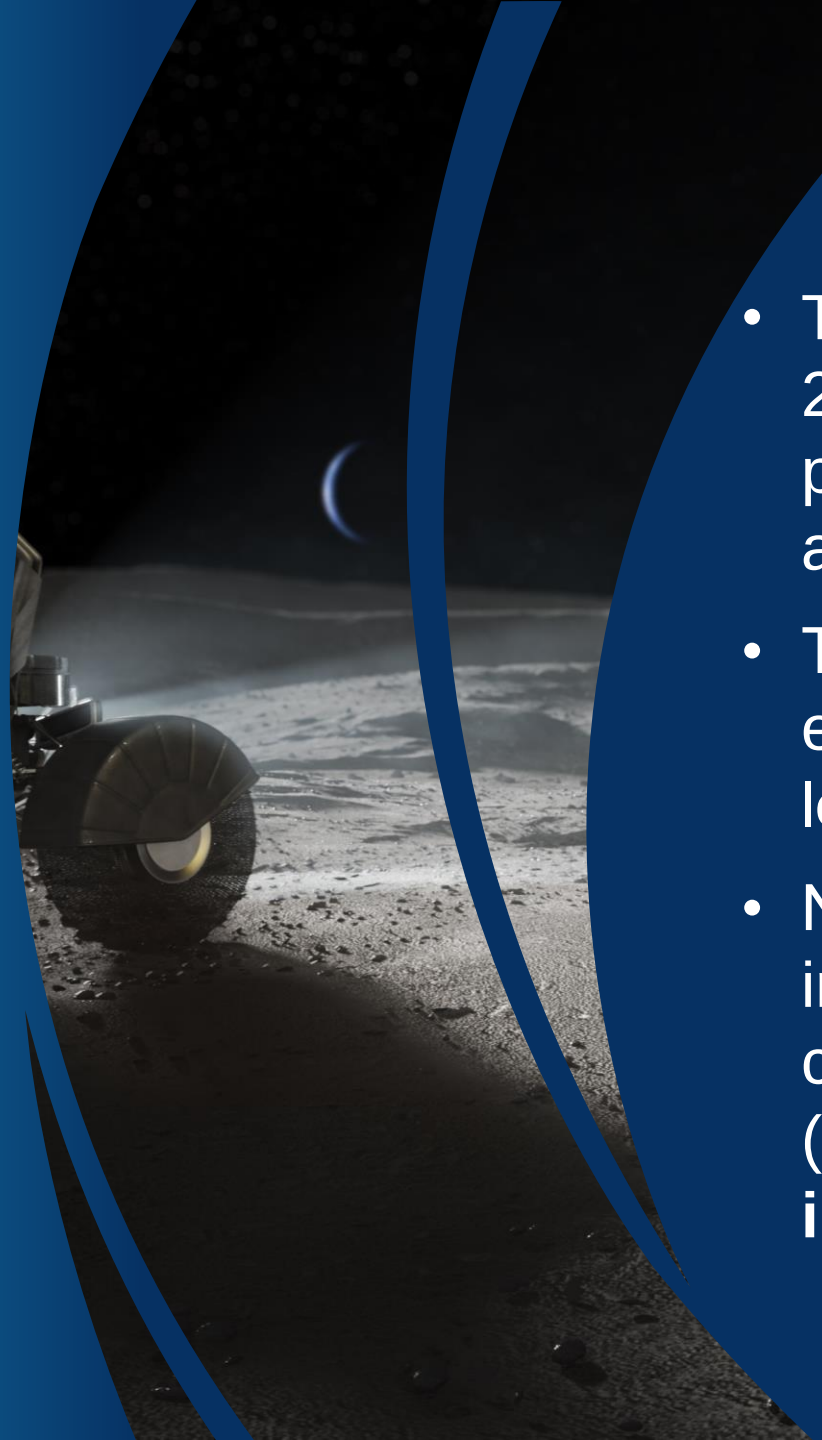
Lunar Surface Science Workshops (LSSWs)

Last year:

- Candidate Artemis III Landing Sites (Apr)
- Updates from HQ (May)
- Geologic Maps for Artemis Strategic Decisions (Aug)
- Artemis Orbital Observation Science (Dec)

This year:

- Science Enabled by the Artemis Base Camp – April 3rd
  - Abstracts due tomorrow!
- Updates from HQ – May 23rd
- Plume-Surface Interactions – July 9th-10th
- BPS Decadal Discussion – TBD Summer



International Lunar Year

- The Department of State is proposing a sustained 18-24 month program of scientific collaboration and public outreach, facilitating international lunar science and exploration starting in the 2027-2030 time frame.
- The goal of the ILY is to fashion a “vibrant multilateral effort in which countries can collaborate on forward-looking lunar science and exploration initiatives.”
- NASA’s proposed role is “to contribute to relevant interagency activities and engage with existing community groups and mission teams (LEAG/SSERVI/LRO) and **develop science initiatives**.“

Eclipse - April 8th

You can’t have an eclipse without the Moon!

https://science.nasa.gov/eclipses/future-eclipses/eclipse-2024/