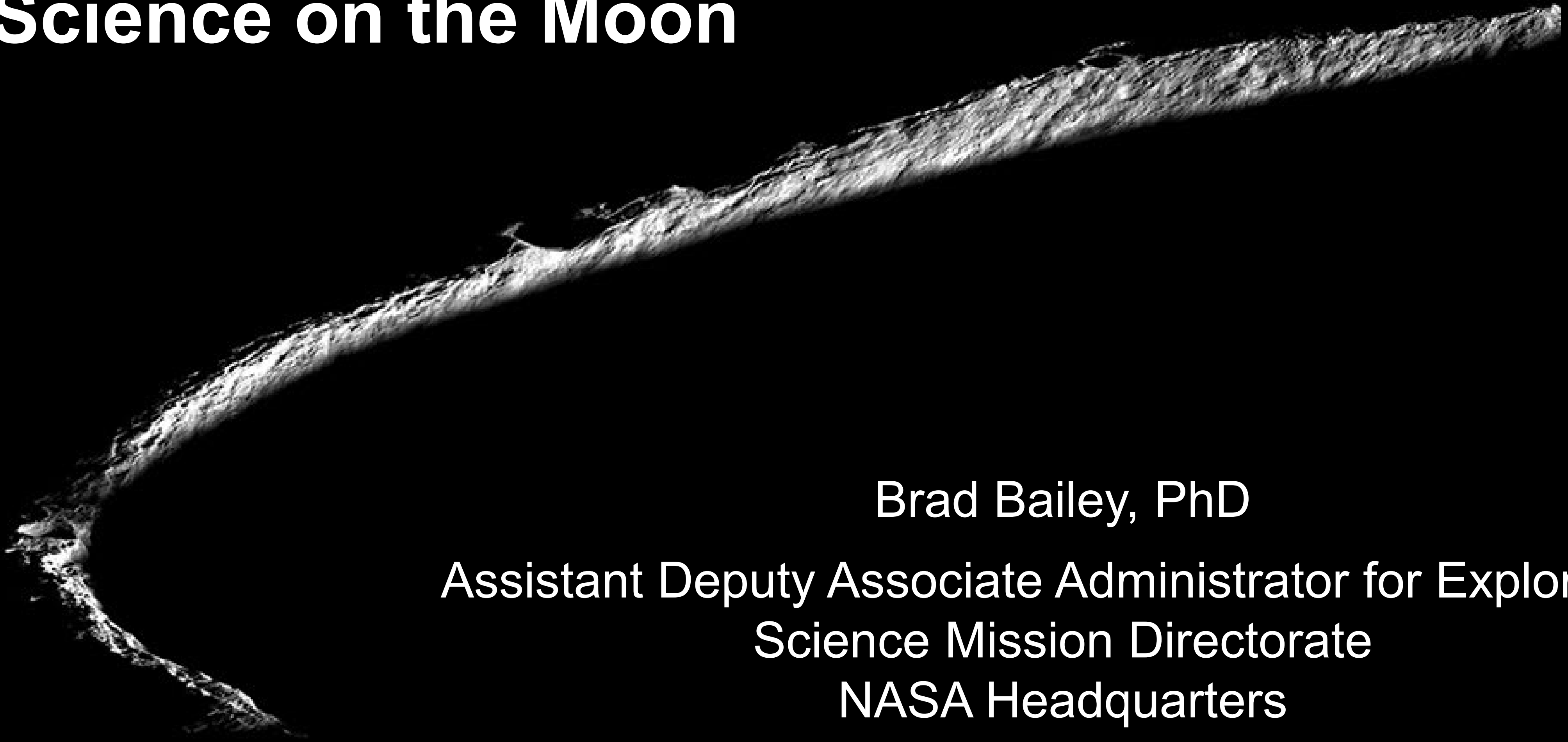
Science on the Moon



Brad Bailey, PhD

Assistant Deputy Associate Administrator for Exploration
Science Mission Directorate
NASA Headquarters

Image Credit: NASA/ASU

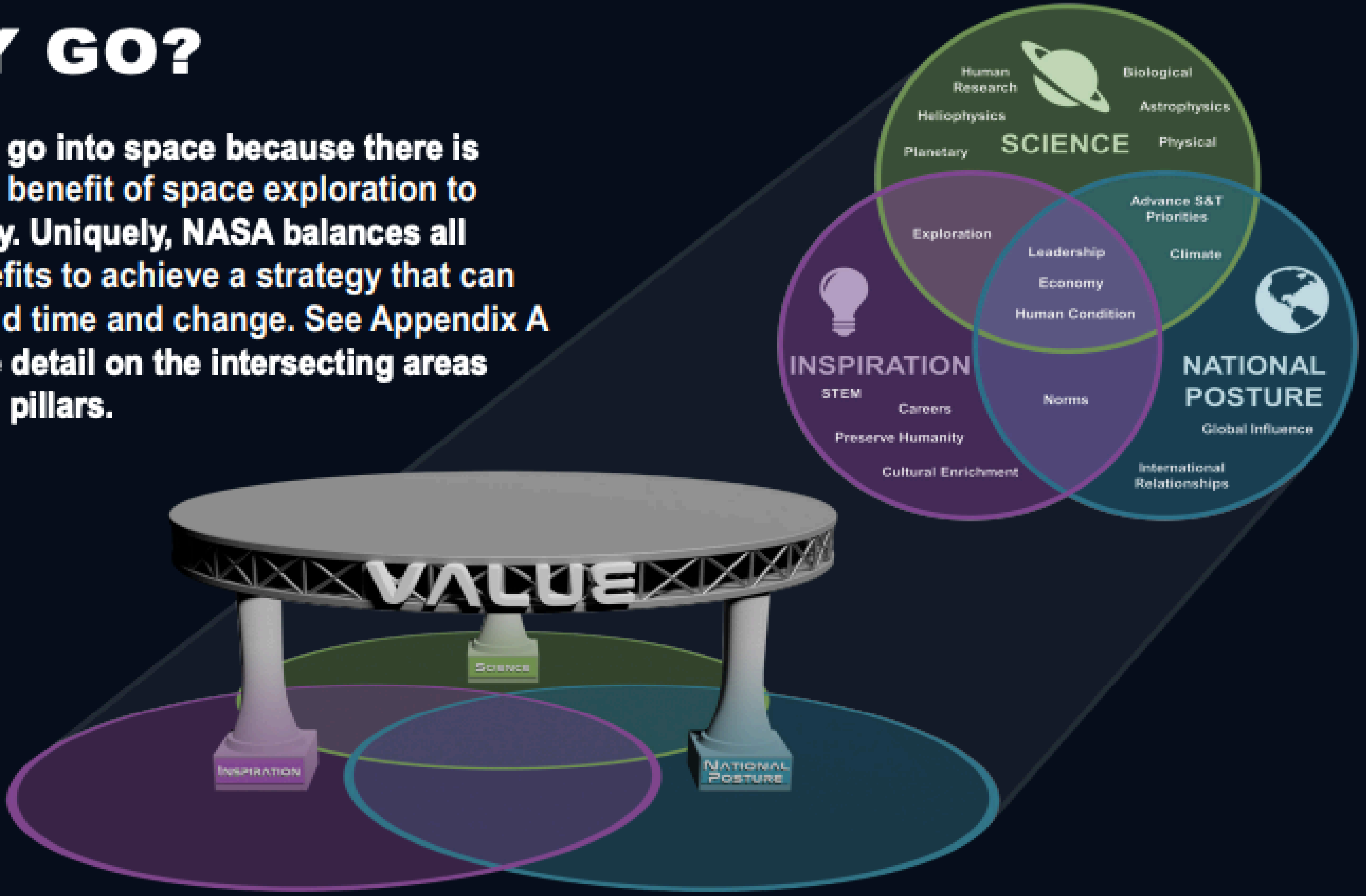
National Aeronautics and
Space Administration

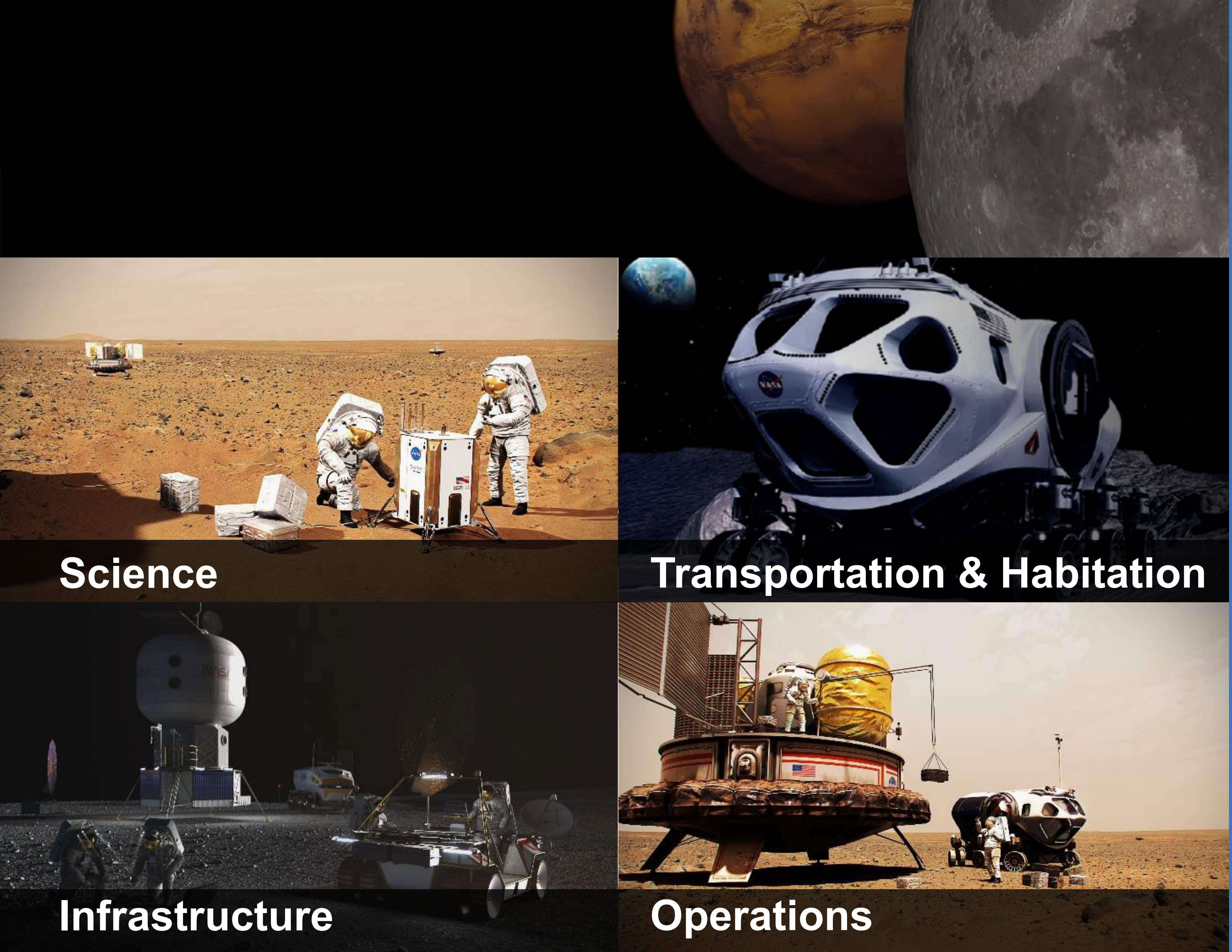
NASA's Moon to Mars Strategy and Objectives Development Public Release

@NASAArtemis

WHY GO?

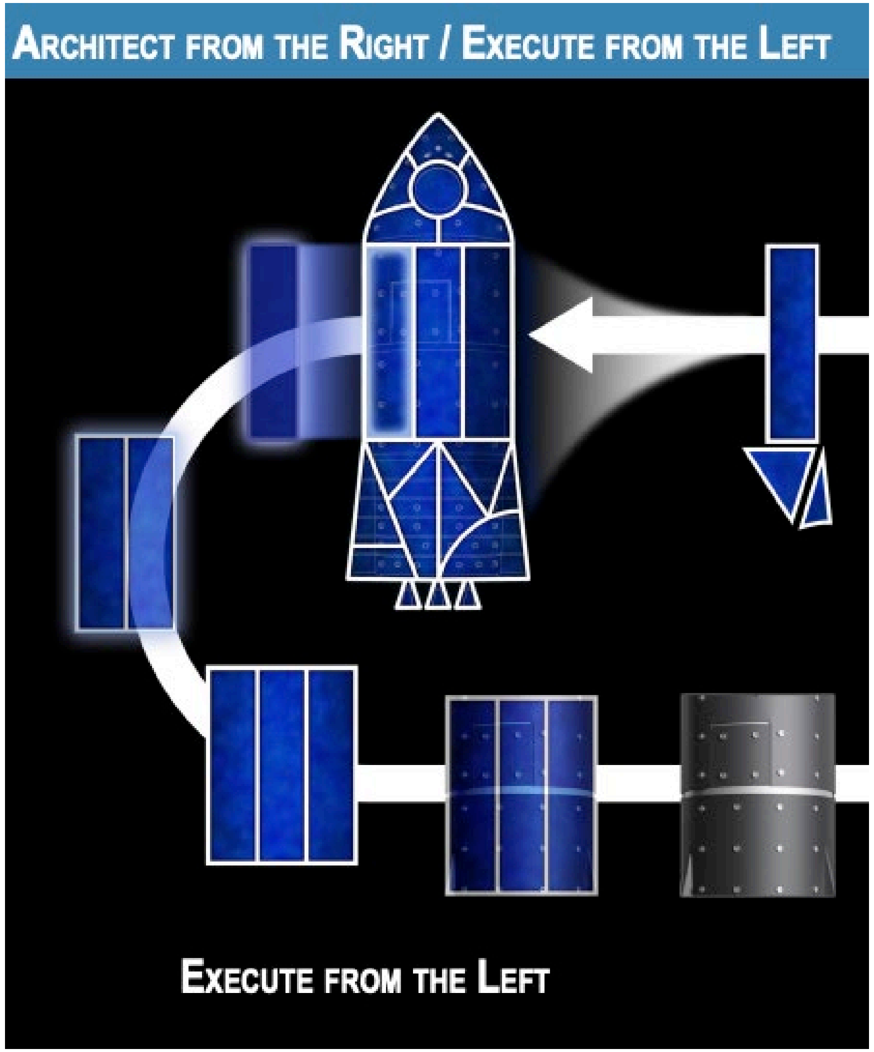
Humans go into space because there is inherent benefit of space exploration to humanity. Uniquely, NASA balances all the benefits to achieve a strategy that can withstand time and change. See Appendix A for more detail on the intersecting areas between pillars.



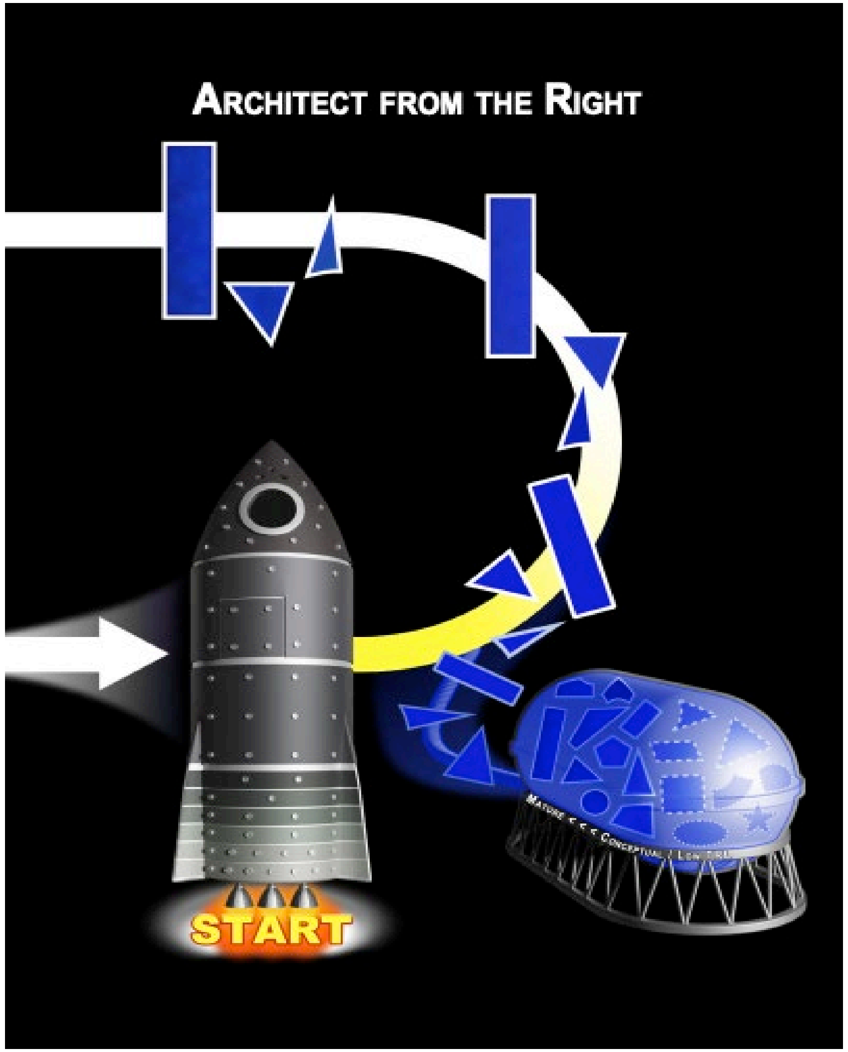


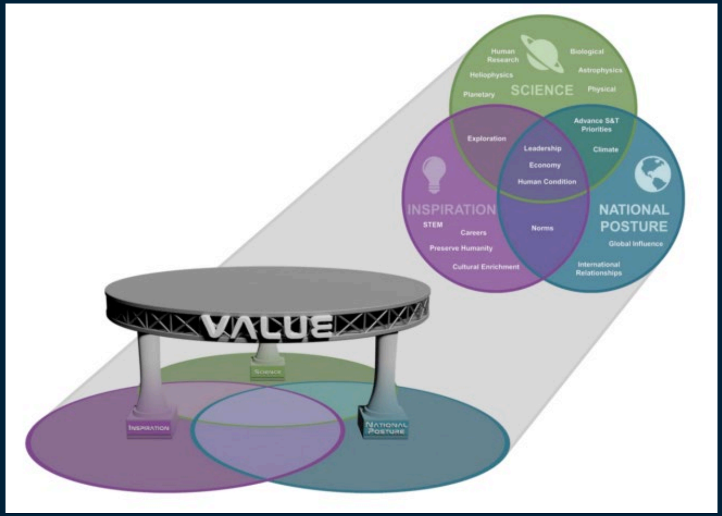
Create a blueprint for sustained human presence and exploration throughout the solar system

Architect from the Right; Execute from the Left



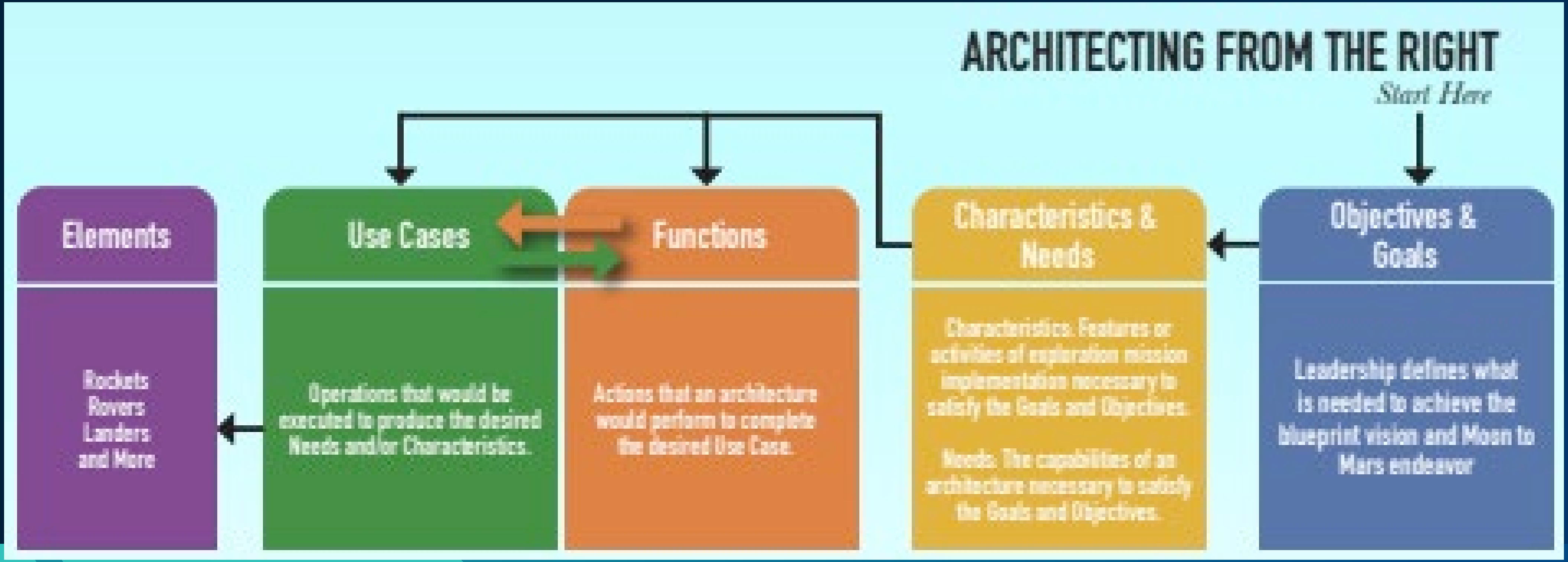
Architect from the right – work backwards from the defined goal and establish a complete set of elements that will be required for success.





M2M Objectives and Architecting from the Right

https://www.nasa.gov/MoonToMarsArchitecture



Mapping of Architecture Functions to M2M Objectives

https://www.nasa.gov/MoonToMarsArchitecture

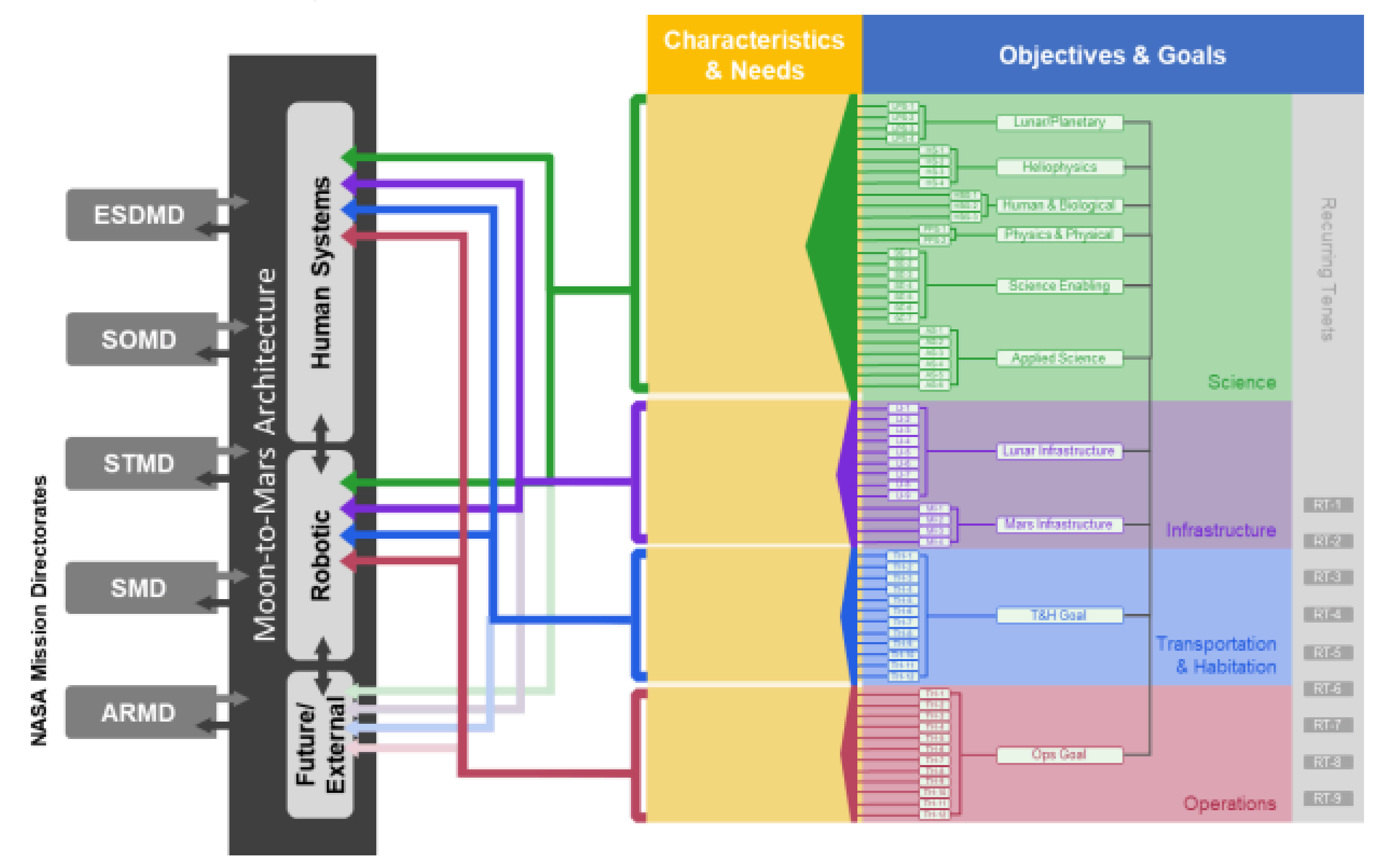


Figure 1-1. Human Exploration Moon-to-Mars Architecture Scope

NASA/TP-20230002706

Exploration Systems Development Mission Directorate

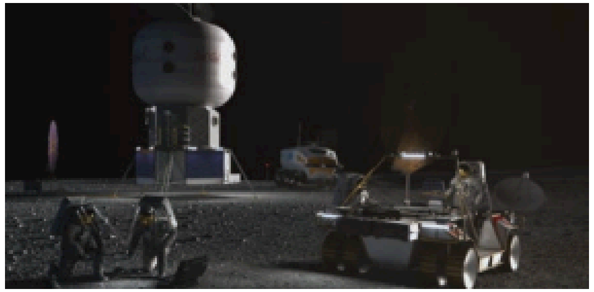
Moon-to-Mars Architecture Definition Document (ESDMD-001)

ARCHITECTURE SEGMENTS

HUMAN LUNAR RETURN

Initial capabilities, systems, and operations necessary to re-establish human presence and initial utilization (e.g., science) on and around the Moon.

Orion, SLS, EGS, Gateway, HLS, Deep Space Logistics, xEVAS, CPNT



FOUNDATIONAL EXPLORATION

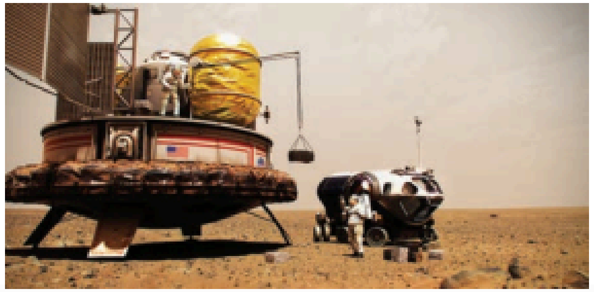
Expansion of lunar capabilities, systems, and operations supporting complex orbital and surface missions to conduct utilization (e.g., science) and Mars-forward precursor missions.

LTV, PR, MPH, Large Cargo

SUSTAINED LUNAR EVOLUTION

Enabling capabilities, systems, and operations to support regional and global utilization (e.g., science), economic opportunity, and a steady cadence of human presence on and around the Moon.

Power, ISRU, Expanded mobility/habitation,



HUMANS TO MARS

Initial capabilities, systems, and operations necessary to establish human presence and initial utilization (e.g., science) on Mars and continued exploration.

Transportation, EDL, Ascent, Science Ops, Return needs

M2M Objectives – 26 Science Objectives

Lunar/Planetary Science (LPS)

Goal: Address high priority planetary science questions that are best accomplished by on-site human explorers on and around the Moon and Mars, a

LPS-1^{LM}:	Uncover the record of formed and differentia Moon and Mars, and recorded on the Moon
LPS-2^{LM}:	Advance understandi structures, characteri exospheres, and inve
LPS-3^{LM}:	Reveal inner solar sys abundance, composit
LPS-4^{M}:	Advance understandi habitable environmen habitable conditions h solar system beyond

Human and Biological Science (HBS)

Goal: Advance understanding of how biology responds to the environments of the Moon, Mars, and deep space to advance fundamental knowledge, to support safe, productive human space missions, and to reduce risks for future exploration.

HBS-1^{LM}:	Understand the space on biolo and plants.
HBS-2^{LM}:	Evaluate and v with mission du
HBS-3^{LM}:	Characterize a human health,

Science-Enabling (SE)

Goal: Develop integrated human and robotic me questions to be addressed around and on the M

SE-1^{LM}:	Provide in-depth, mission-specific transformational science on the su
SE-2^{LM}:	Enable Earth-based scientists to advanced techniques and tools.
SE-3^{LM}:	Develop the capability to retrieve on the Moon and volatile-bearing facilities on Earth.
SE-4^{LM}:	Return representative samples fr sample mass commensurate with
SE-5^{LM}:	Use robotic techniques to survey in advance of and concurrent wit surface and maximize science ret
SE-6^{LM}:	Enable long-term, planet-wide rese and surface locations at the Moon
SE-7^{LM}:	Preserve and protect representat regions and the radio quiet far sid science investigations.

Heliophysics Science (HS)

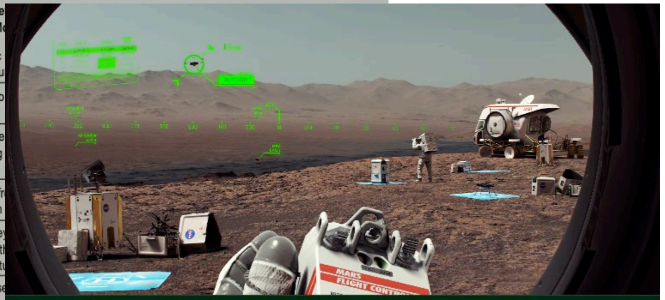
Goal: Address high-priority heliophysics science and space weather questions that are best accomplished using a combination of human explorers and robotic systems at the Moon, at Mars, and in deep space.

HS-1^{LM}:	Improve understanding of space weather phenomena to enable enhanced observation and prediction of the dynamic environment from space to the surface at the Moon and Mars.
HS-2^{LM}:	Determine the history of the Sun and solar system as recorded in the lunar and Martian regolith.
HS-3^{LM}:	Investigate and characterize fundamental plasma processes, including dust-plasma interactions, using the cislunar, near-Mars, and surface environments as laboratories.
HS-4^{LM}:	Improve understanding of magnetotail and pristine solar wind dynamics in the vicinity of the Moon and around Mars.

Physics and Physical Science (PPS)

Goal: Address high-priority physics and physical science questions that are best accomplished by using unique attributes of the lunar environment.

PPS-1^{L}:	Conduct astrophysics and fundamental physics investigations of space and time from the radio quiet environment of the lunar far side.
PPS-2^{LM}:	Advance understanding of physical systems and fundamental physics by utilizing the unique environments of the Moon, Mars, and deep space.



Applied Science (AS)

Goal: Conduct science on the Moon, in cislunar space, and around and on Mars using integrated human and robotic methods and advanced techniques, to inform design and development of exploration systems and enable safe operations.

AS-1^{LM}:	Characterize and monitor the contemporary environments of the lunar and Martian surfaces and orbits, including investigations of micrometeorite flux, atmospheric weather, space weather, space weathering, and dust, to plan, support, and monitor safety of crewed operations in these locations.
AS-2^{LM}:	Coordinate on-going and future science measurements from orbital and surface platforms to optimize human-led science campaigns on the Moon and Mars.
AS-3^{LM}:	Characterize accessible lunar and Martian resources, gather scientific research data, and analyze potential reserves to satisfy science and technology objectives and enable In-Situ Resource Utilization (ISRU) on successive missions.
AS-4^{LM}:	Conduct applied scientific investigations essential for the development of bioregenerative-based, ecological life support systems.
AS-5^{LM}:	Define crop plant species, including methods for their productive growth, capable of providing sustainable and nutritious food sources for lunar, Deep Space transit, and Mars habitation.
AS-6^{LM}:	Advance understanding of how physical systems and fundamental physical phenomena are affected by partial gravity, microgravity, and general environment of the Moon, Mars, and deep space transit.

Strategic Research and Priorities from NASEM Decadal Surveys

NASA and Community reports

Upcoming Academy / SDT Studies That Will Inform Architecture

- High Priority Science Campaigns for Human Explorers on the Surface of Mars
- Key Destinations Across the Moon to Address Decadal-level Science Objectives with Human Explorers
- SPA Sample Return Science Definition Team Report
- Science Accomplished during Human Mars Transit (planned)
- Science Addressed from a Sustained Lunar Basecamp (planned)

1:1 Trace of Lunar Themes from Planetary Decadal to M2M Objectives (M2M LPS Objectives in BLUE)

BOX 22.2 Science Themes for Lunar Exploration [Planetary Decadal]

Science Theme 1: Uncover the lunar record of solar system origin and early history. The Moon's composition, structure, and ancient surface preserve a record of early events: from the giant impact that produced the Earth−Moon system to ongoing bombardment as life on Earth emerged and evolved.

[LPS-1: Uncover the record of solar system origin and early history, by determining how and when planetary bodies formed and differentiated, characterizing the impact chronology of the inner solar system as recorded on the Moon and Mars, and characterize how impact rates in the inner solar system have changed over time as recorded on the Moon and Mars.]

Science Theme 2: Understand the geologic processes that shaped the early Earth that are best preserved on the Moon. The Moon retains a record of processes that set the evolutionary paths of rocky worlds, including volcanism, magnetism, tectonism, and impacts.

[LPS-2: Advance understanding of the geologic processes that affect planetary bodies by determining the interior structures, characterizing the magmatic histories, characterizing ancient, modern, and evolution of atmospheres/exospheres, and investigating how active processes modify the surfaces of the Moon and Mars.]

Science Theme 3: Reveal inner solar system volatile origin and delivery processes. The Moon hosts water and other volatiles in its interior, across its surface, and in ice deposits at its poles, providing a record that may help constrain the origins of Earth's oceans and the building blocks for life, as well as ongoing volatile delivery processes.

[LPS-3: Reveal inner solar system volatile origin and delivery processes by determining the age, origin, distribution, abundance, composition, transport, and sequestration of lunar and Martian volatiles.]

Science makes Heavy Use of Architecture



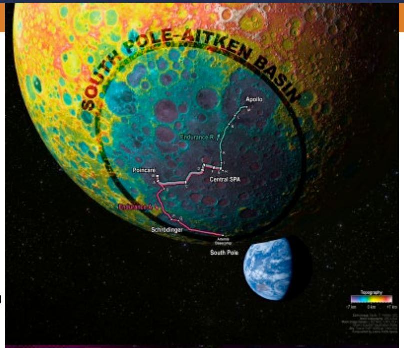






Science is enabled by Architecture

Image credit: Keane et al



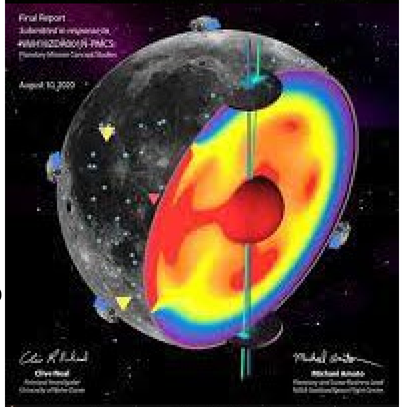
LPS-1







Image credit: LGN



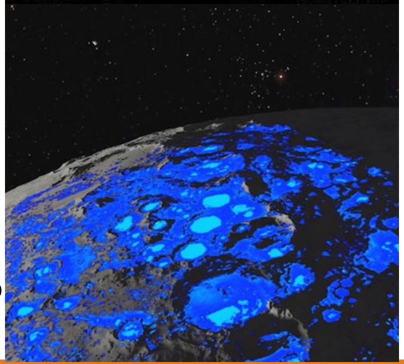
LPS-2







Image credit: ESA



LPS-3







Science is enabled by Architecture

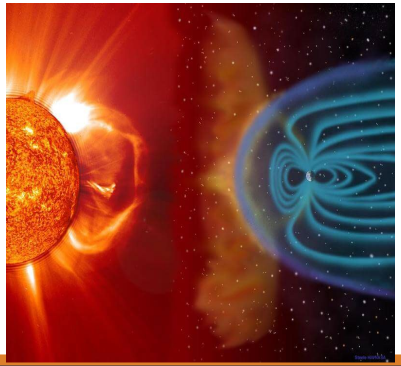
Image credit: Pexels

HBS

Image credit: NASA

HBS

Image credit: ESA

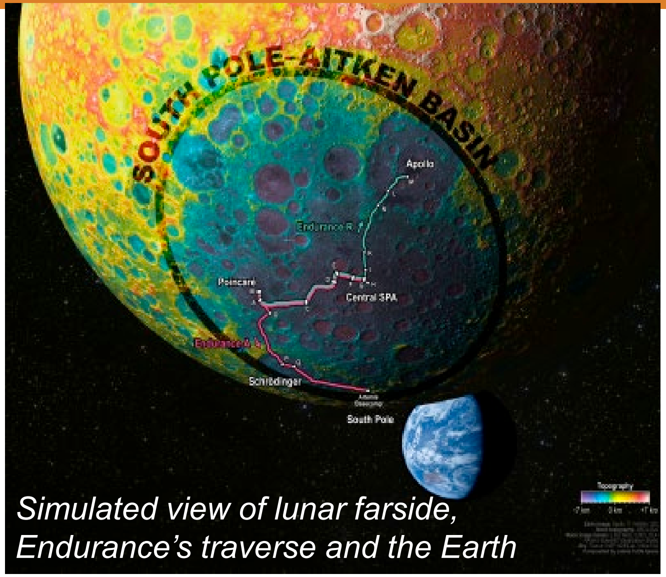


HS

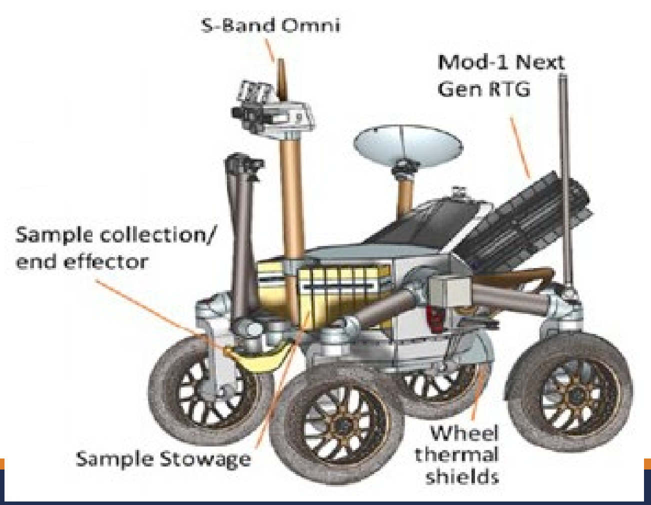
An Example of Human/Robotic Synergy:
Endurance A: South Pole-Aitken Sampling Campaign

- Top lunar priority of the Planetary Decadal Survey: “Endurance A”
  - long-duration rover
  - traverses ~2000km
  - Brings ~100kg of samples, taken at strategic sites throughout the South Pole-Aitken basin, to South Pole for HLS to Earth
- Addresses five lunar science objectives, including:
  - Solar System Chronology: Anchors the earliest impact history of the Solar System, tests the giant planet instability, impact cataclysm, and late heavy bombardment hypotheses, and anchors the “middle ages” of solar system chronology
  - Planetary Evolution: Tests the lunar magma ocean hypothesis, characterizes the thermochemical evolution of terrestrial planets, and explores the geologic diversity of a giant impact basin from floor to rim

***Recommendation*: Endurance-A should be implemented as a *strategic medium-class mission* as the *highest priority* of the Lunar Discovery and Exploration Program. Endurance-A would utilize CLPS to deliver the rover to the Moon, a long-range traverse to collect a substantial mass of high-value samples, and astronauts to return them to Earth.** *– Origins, Worlds, and Life (Planetary Decadal), 22-17*



Simulated view of lunar farside, Endurance’s traverse and the Earth



The full Endurance Report is available at https://tinyurl.com/2p88fx4f

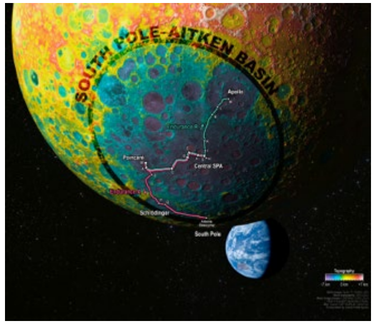
FY 2025 President's Budget Request Moon to Mars Manifest

FY	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Exploration Systems Development Mission Directorate			**Artemis II** (Sep. 2025) Crewed Flight SLS Block 1/ Orion/ML1	**Artemis III** (Sep. 2026) Crewed Flight SLS Block 1/ Orion/ML1 HLS Crewed Lunar Demo xEVA Surface Suits *HLS Uncrewed Lunar Demo* *Gateway PPE/HALO Launch*	*Gateway PPE/HALO Arrival in NRHO*	**Artemis IV** (Sep. 2028) Crewed Flight SLS Block 1B/ Orion/ML2 I-Hab to Gateway Gateway Logistics Services Sustaining HLS Crewed Lunar Demo xEVA Surface Suits *Sustaining HLS Uncrewed Lunar Demo*		**Artemis V** (Mar. 2030) Crewed Flight SLS Block 1B/ Orion/ML2 ESPRIT to Gateway Sustaining HLS Crewed Lunar Demo xEVA Surface Suits LTV	**Artemis VI** (Mar. 2031) Crewed Flight SLS Block 1B/ Orion/ML2 Airlock to Gateway Gateway Logistics Services Gateway External Robotics System TBD Sustaining HLS Services xEVA Surface Suits	**Artemis VII** (Mar. 2032) Crewed Flight SLS Block 1B/ Orion/ML2 Gateway Operations TBD Sustaining HLS Services xEVA Surface Suits Pressurized Rover
Space Operations Mission Directorate	DSN Upgrades (DLEU) Completed DSS-36 [Canberra]	Completed DSS-24 [Goldstone]	DSS-34 [Canberra] DSS-56 [Madrid]		Lunar Communications Relay and Navigation Services (LCRNS)–Increment Increment Alpha	Lunar Exploration Ground Sites 1-3 DSS-54 [Madrid] Increment Bravo	Increment Charlie	Ongoing Science, Human Research Program, and Technology Development in LEO (ISS transition to CLD)		
Science Mission Directorate CLPS Flights Outlined	LRO Mars 2020:	ESCAPADE Attempted: TO 2-AB Completed: TO 2-IM TO 19D	TO 20A: VIPER HERMES ready for integration ESA Lunar Pathfinder delivered for launch AVATAR (Artemis II) TO PRIME-1 Lunar Trailblazer TO CP-11	Artemis III Surface Science Instruments MMX (MEGANE/ P-Sampler) TO CS-3&4 TO CP-12	LRO continued ops TO CS-06 TO CP-21 TO CP-22	Artemis IV Surface Science Instruments TO CS-6 TO CP-31	Rosalind Franklin Mission (RFM) Launch, Landing TO CP-41 TO CP-42 TO CP-51 TO CP-52 TO CP-61 TO CP-62	Artemis V Surface Science Instruments Artemis LTV Science Instruments	Artemis VI Surface Science Instruments	Artemis VII Surface Science Instruments
Space Technology Mission Directorate	MOXIE; MEDA DSOC	CFM SpaceX TP Flight Demo	Surface Robotic Scouts (CADRE) TO PRIME-1: Drill; Nokia LTE/4G Comm; IM Deployable Hopper CFM ULA TP Flight Demo PPE SEP qual. environ. complete CFM Eta Space TP Flight Demo	CFM Lockheed Martin TP Flight Demo NEP Concept Design	DRACO Demonstration	TO LIFT-1: Lunar Surface Power Demo (i.e., RFC, VSAT, Wireless Charging); Lunar Surface Scaled Construction Demo 1; ISRU Pilot Excavator; ISRU Subscale Demo	SEP qual. complete			Fission Surface Power demo delivered for launch TO LIFT-2: Lunar Surface Scaled Construction Demo 2; Autonomous Robotics Demo; Deployable Hopper 2; ISRU Subscale Demo 2

Icons are representative only, and may not reflect final configurations, not to scale | Icons represent the fiscal year in which an event occurs | Based on FY 2025 President's budget request

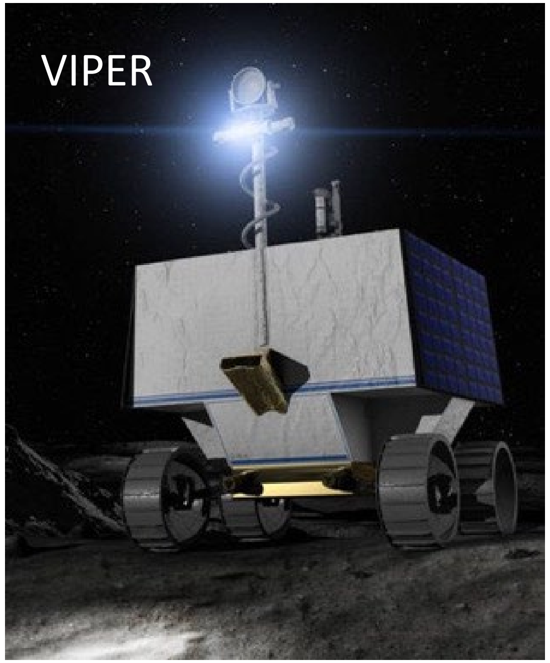
Science Activities Planned for Artemis

Science Team and Science Evaluation Room

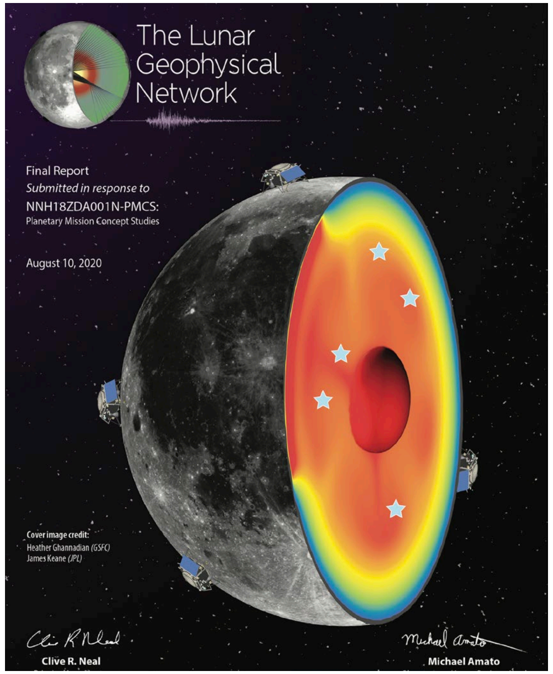


South Pole-Aitken Basin Sample Return

LTV and Pressurized Rover Instruments



LRO/LExSO

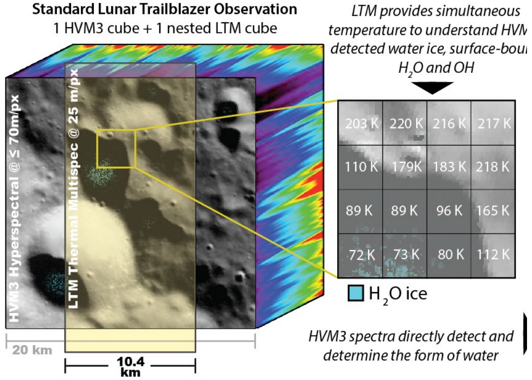


Lunar Geophysical Network

Artemis Deployed Instruments

Handheld tools/instruments

Sample Return and Curation



Lunar Trailblazer

Artemis III Science Team

Artemis Lunar Science Lead: Sarah Noble
Deputies: Debra Needham, Amanda Nahm

Artemis III Project Scientist (Dr. Noah Petro)

Internal Artemis Science Team

- NASA scientists working within Artemis
- SMD funded
- Conflicted from competition

Competitively selected Geology Team

- ~12-member team
- Will be augmented with 8-10 additional scientists thought a Participating Scientist call

Competitively selected Payload Teams

- Artemis III payloads call proposals due soon
- 1-2 selections from call
- Investigating directed payload too

Artemis Internal Science Team

Artemis Lunar Science Lead: Sarah Noble
Deputies: Debra Needham, Amanda Nahm

Training and Ops
- Training and Strategic Integration Lead - **Cindy Evans**
- Science Flight Operations Lead - **Kelsey Young**
- EVA Hardware and Testing Integration Lead - **Trevor Graff**

Samples
- Sample Integrity Lead - **Barbara Cohen**
- Contamination Control Scientist - **Andy Needham**
- Artemis Curation Lead – **Juliane Gross**

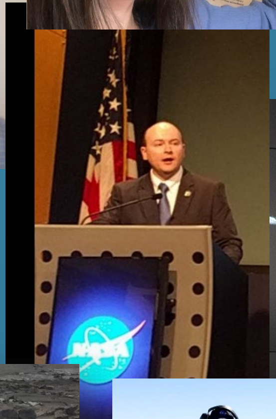
Planning and Data
- Mission Planning and Science Implementation Lead - **Sam Lawrence**
- Spatial Planning and Data Lead - **Noah Petro**
- Software Systems Lead **- Matthew Miller**

Payloads
- SMD Payload Integration Officer - **Renee Weber**










Artemis III Geology Team

Artemis Lunar Science Lead: Sarah Noble
Deputies: Debra Needham, Amanda Nahm

- Principal Investigator – **Brett Denevi**, JHUAPL
- Deputy Principal Investigator – **Lauren Edgar**, USGS
  - Co-I – **Brad Jolliff**, Washington University
  - Co-I – **Caleb Fassett**, JHUAPL
  - Co-I – **Dana Hurley**, JHUAPL
  - Co-I – **Gordon Osinski (Oz)**, Univ of Western Ontario
  - Co-I – **Jennifer Heldmann**, NASA Ames
  - Co-I – **Jose Hurtado**, Univ of Texas at El Paso
  - Co-I – **Juliane Gross***, Rutgers University
  - Co-I – **Katie Joy**, University of Manchester
  - Co-I – **Mark Robinson**, Arizona State Univ
  - Co-I – **Yang Liu**, Jet Propulsion Lab

CLPS IDIQ Contract and Portfolio

- 14 domestic companies eligible to compete for Lunar surface delivery task orders
- 8 awarded lunar surface deliveries actively in work with initial deliveries as soon as Q1 2023.
- NASA expects to continue cadence of ~2 flights per year
- CLPS contractors are encouraged to sell lunar delivery services outside of the CLPS IDIQ to non-NASA and non-USG customers.

Initial CLPS companies (Nov 2018):

- *Astrobotic*
- *Deep Space Systems*
- *Draper*
- *Firefly Aerospace*
- *Intuitive Machines*
- *Lockheed Martin Space*
- *Masten Space Systems*
- *Moon Express*
- *Orbit Beyond*

First On-Ramp (Nov 2019):

- *Blue Origin*
- *Ceres Robotics*
- *Sierra Nevada Corporation*
- *SpaceX*
- *Tyvak Nano-Satellite Systems, Inc.*

Awarded Deliveries:

TO2 2023
Astrobotic
Peregrine

TO2/20C 2023
Intuitive Machines
NOVA-C

TO PRIME-1 2023
Intuitive Machines
NOVA-C

TO19C 2023
Masten
XL-1

CP-11 2024
Intuitive Machines
NOVA-C

TO19D 2024
Firefly Aerospace
Blue Ghost

TO20A 2024
Astrobotic
Griffin

CP-12 2025
Draper
Series-2

TOCS3 2026
Firefly Aerospace
Blue Ghost

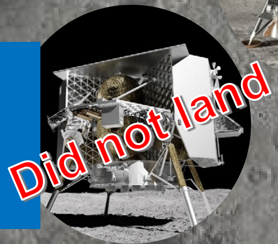
CLPS Deliveries

2024-2028

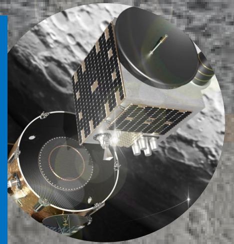
Delivery Site:
Gruithuisen Domes
Provider TBD
CP-21 | 2027

Delivery Site:
Ina IMP
Provider TBD
CP-32 | 2027

Delivery Site:
Sinus Viscositatis
Provider: Astrobotic
TO2-AB | Jan 2024



Delivery Site:
Lunar Far Side &
Orbit Insertion
Provider: Firefly
CS-3 & CS-4 | 2025

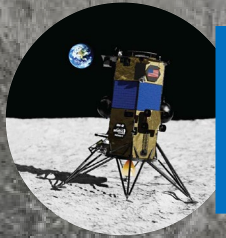


Delivery Site:
Reiner Gamma
Provider: IM
CP-11 | 2025

Delivery Site:
TBD
Provider TBD
CP-41 | 2028

Delivery Site:
South Pole
Provider TBD
CS-6 | 2027

Delivery Site:
Mare Crisium
Provider: Firefly
TO19D | Late 2024



Delivery Site:
Shackleton Connecting Ridge
Provider: IM
TO PRIME-1 | Q4 2024

Delivery Site: Malapert A
Provider: Intuitive
Machines (IM)
TO2-IM | Feb 2024

Delivery Site:
Schrödinger Basin
Provider: Draper
CP-12 | 2026

Delivery Site:
South Pole
Provider TBD
CP-22 | 2027

Delivery Site:
Mons Mouton
Provider : Astrobotic
VIPER | Nov 2024

Updated 3/7/2024

TO2-AB

PM-1

Did Not Land

Peregrine Lander

ASTROBOTIC

TO2-IM

IM-1

Landed 2/22

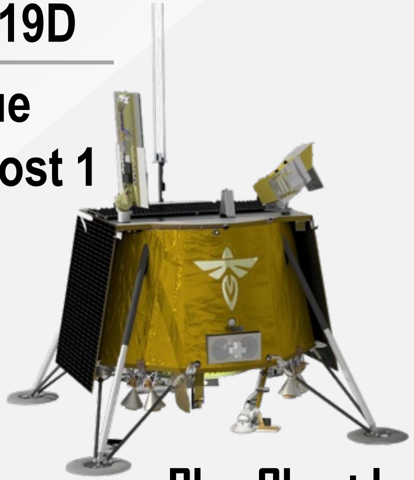
No Power 2/29

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

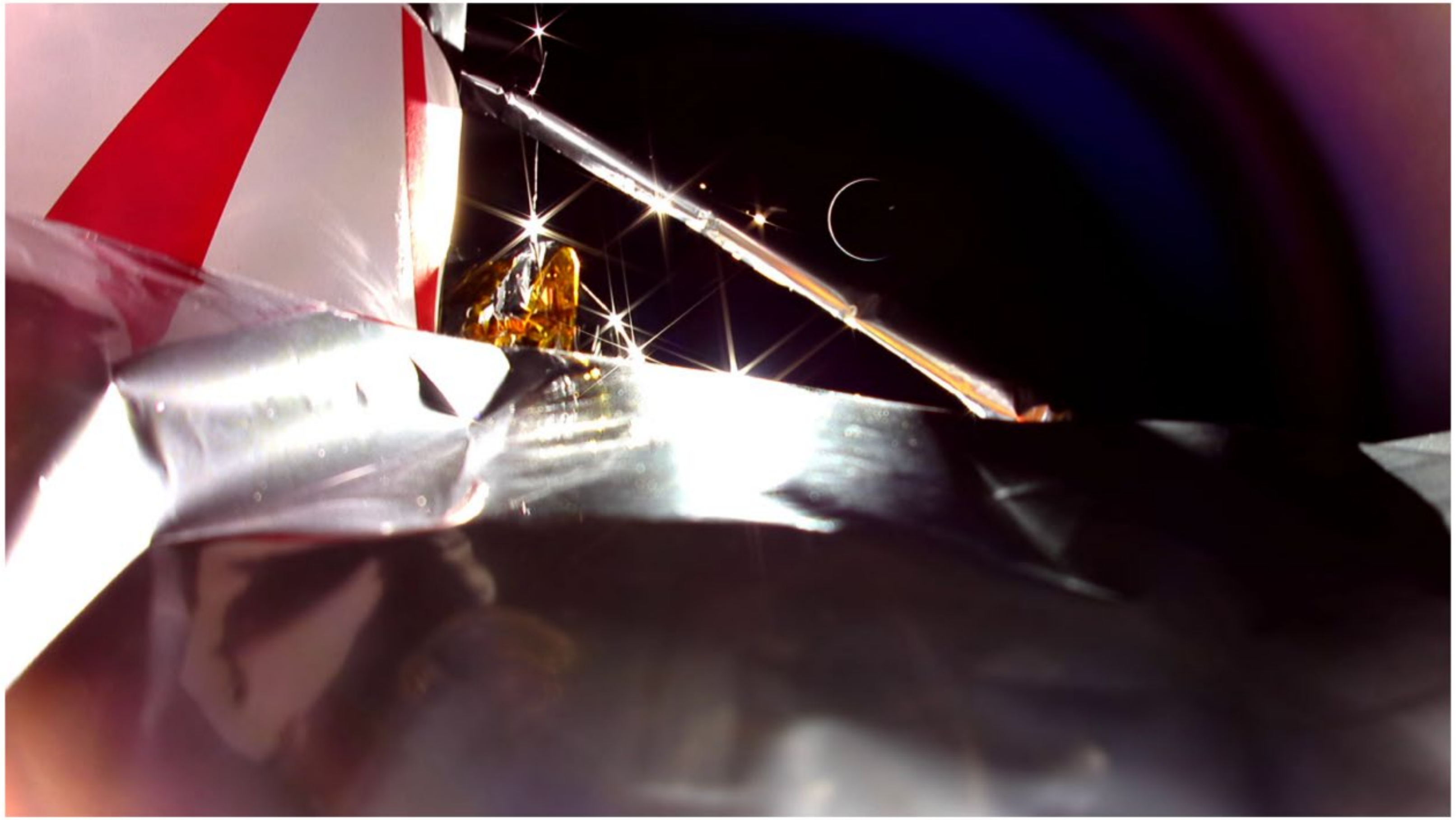
CS-3 & CS-4

Blue Ghost 2

Blue Ghost Lander

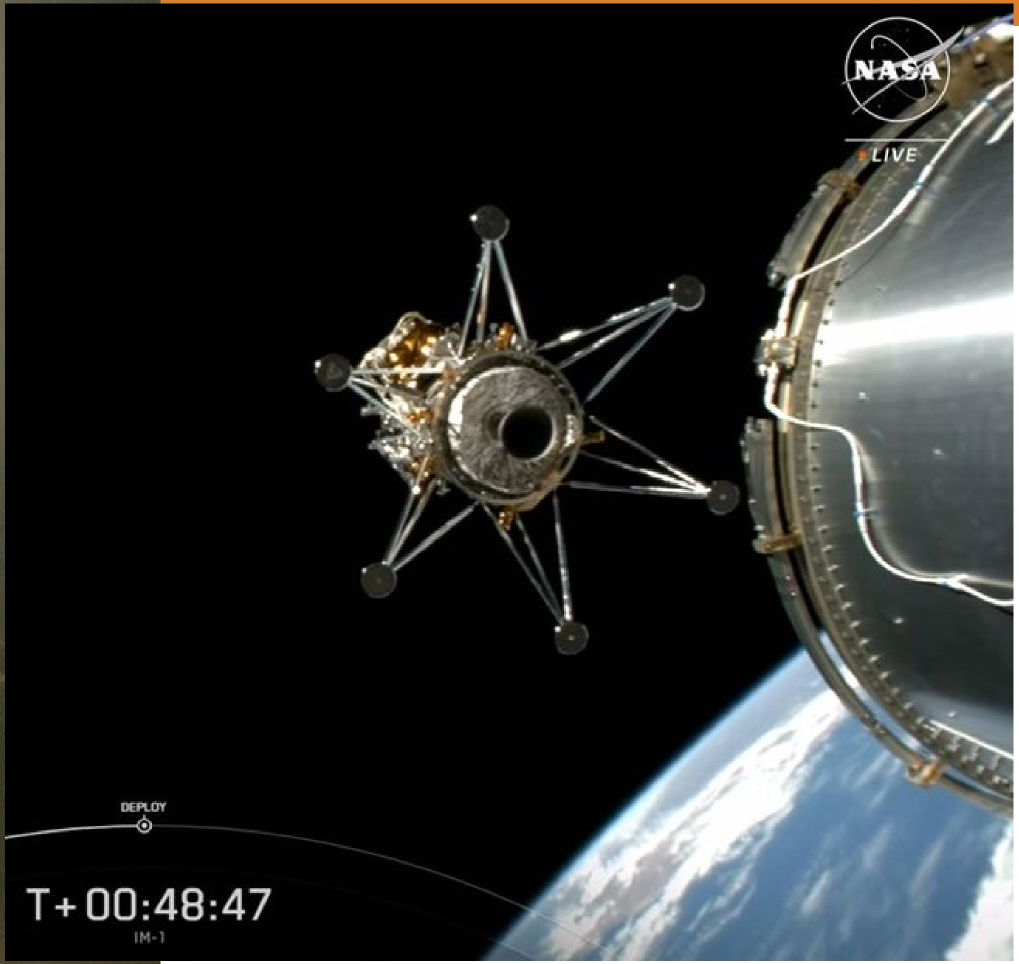
FIREFLY AEROSPACE

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.

IM-1



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

IM-1

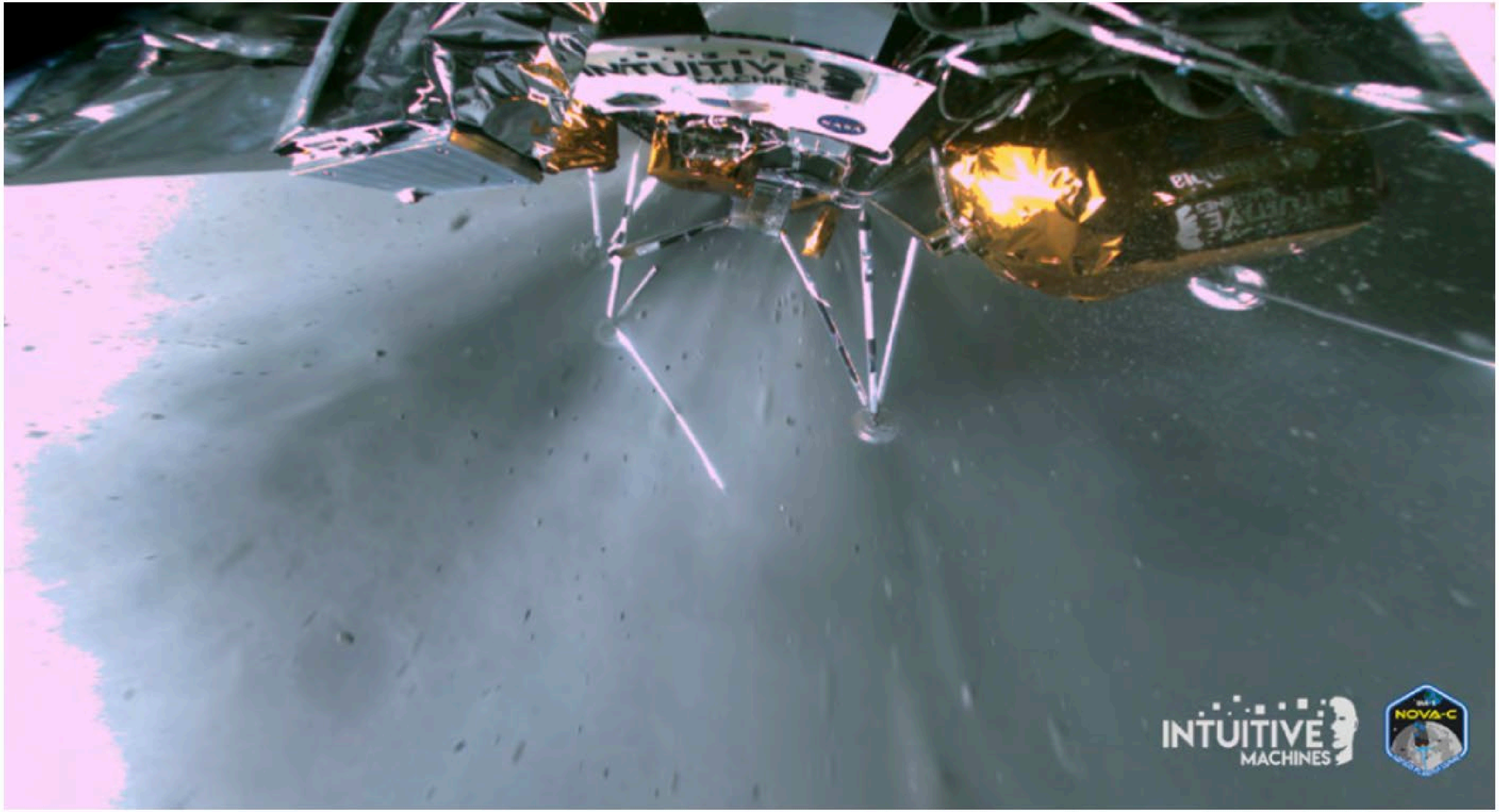
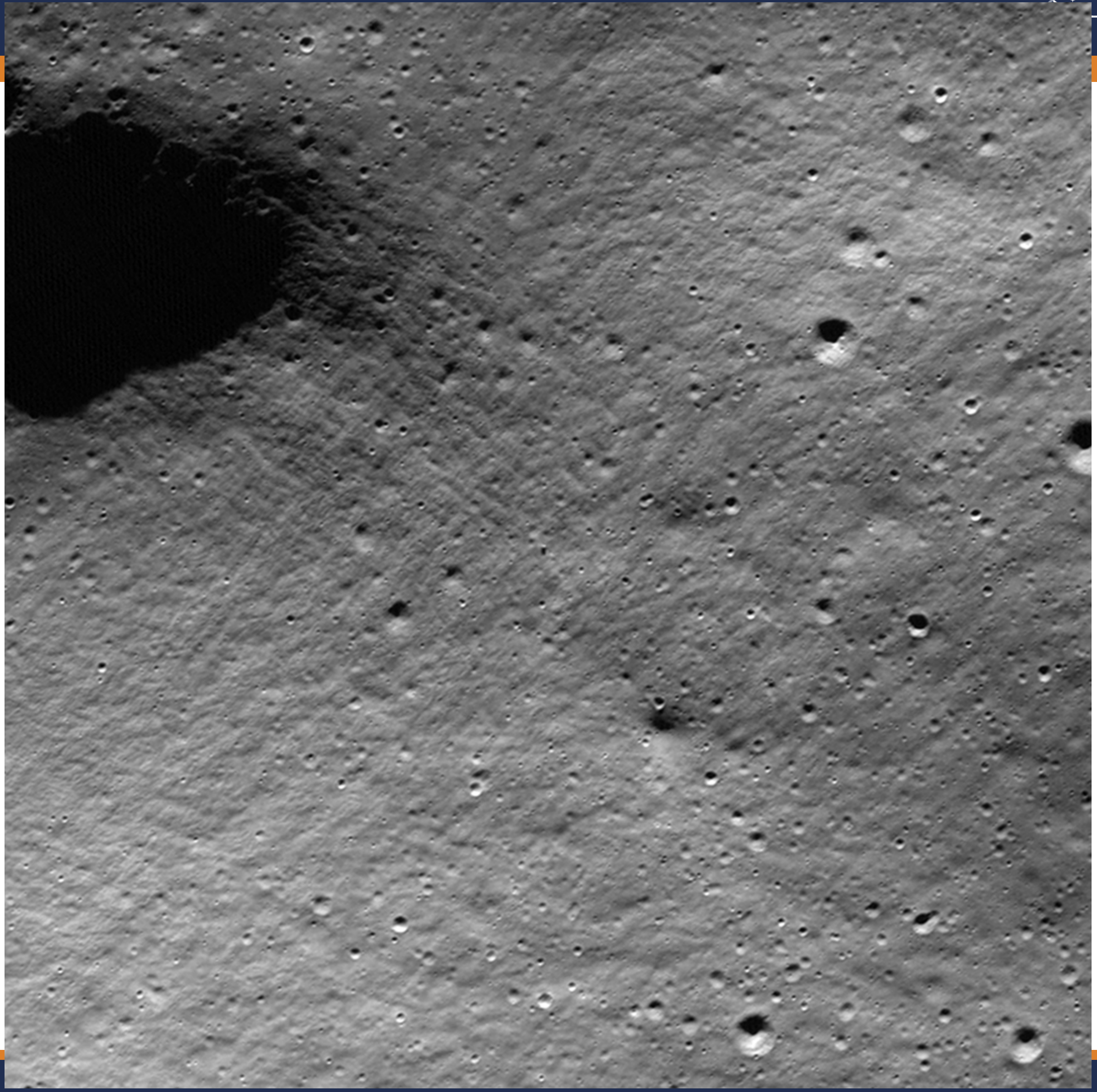


Image of Odysseus landing on the Moon with one landing leg broken. The darker area is lunar regolith being disturbed by the engines, which are still firing. Credit: Intuitive Machines

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

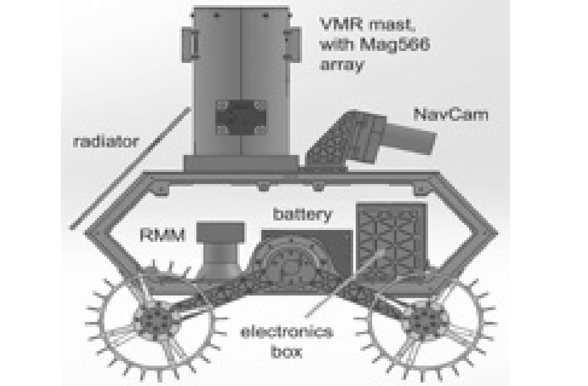


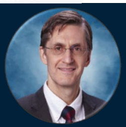
ESSIO

PRISM 1

CP-11

Lunar Vertex

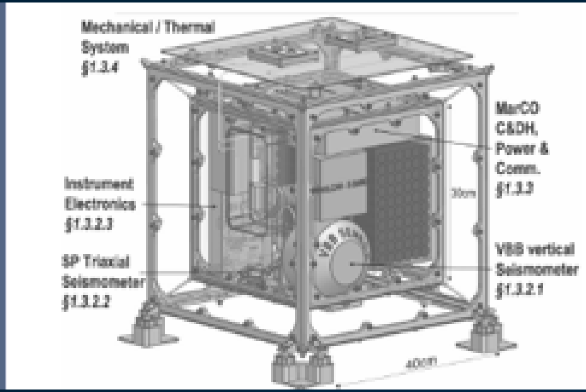


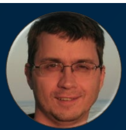


Lunar Vertex
PI: David Blewett, APL

CP-12

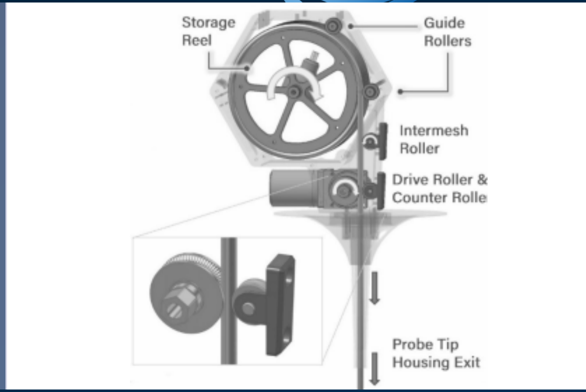
FSS





Farside Seismic Suite
PI: Mark Panning, JPL

LITMS

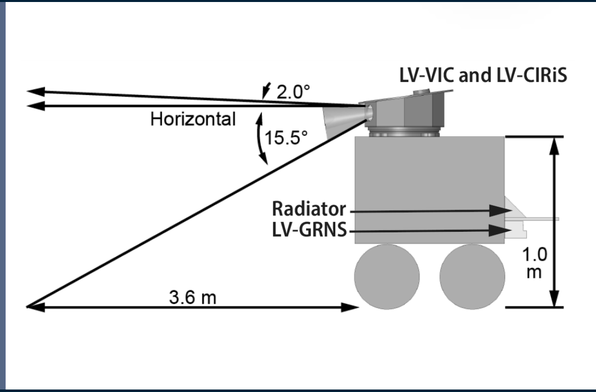


Lunar Interior Temperature and Materials Suite
PI: Bob Grimm, SwRI

PRISM 2

CP-21

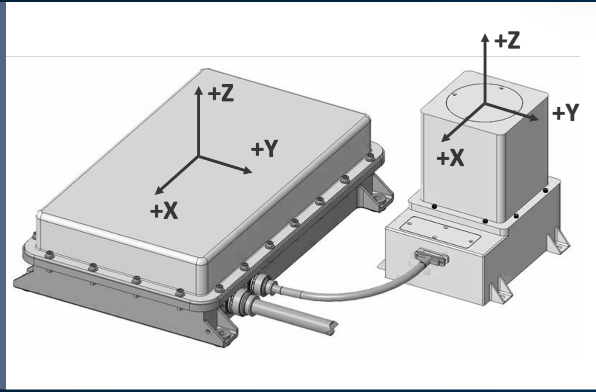
Lunar-VISE



Lunar Vulkan Imaging and Spectroscopy Explorer
PI: Kerri Donaldson Hanna, UCF

CP-22

LEIA

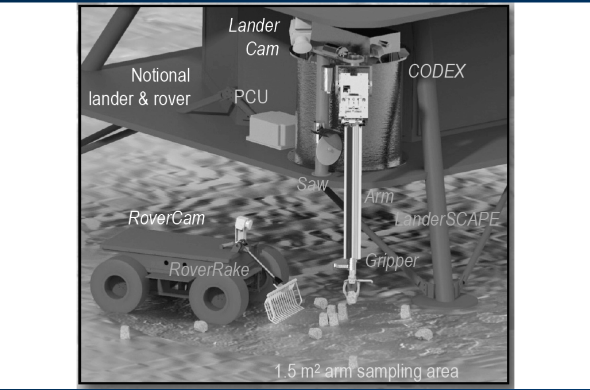


Lunar Explorer Instrument for space biology Applications
PI: Mark Settles, NASA Ames

PRISM 3

CP-32

DIMPLE



Dating an Irregular Mare Patch with a Lunar Explorer
PI: F. Scott Anderson, SwRI

Payloads and Research Investigations on the Surface of the Moon (PRISM)

PRISM 1

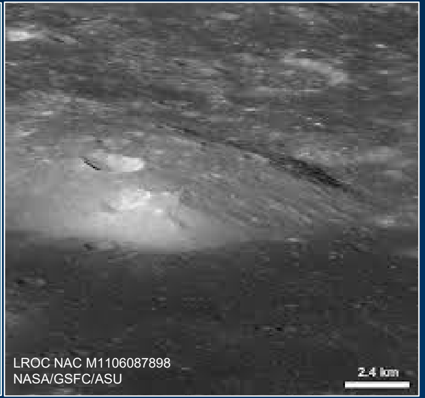
- Task Order CP-11: Lunar Vertex will land at Reiner Gamma, a lunar swirl feature on the near side, in 2024 with 2 partnered international payloads: ESA's MoonLIGHT Pointing Actuator (MPAc) and KASI's Lunar Space Environment Monitor (LUSEM)
  - Decadal science: understand how lunar surface has been modified by geological processes within a lunar magnetic anomaly and determine the origin of magnetized crust
- Task Order CP-12: Farside Seismic Suite (FSS) and Lunar Interior Temperature and Materials Suite (LITMS) will land at Schrödinger Basin, the first CLPS lunar farside delivery
  - Decadal science: characterize differentiation and evolution of the Moon’s interior using geophysical techniques

PRISM 2

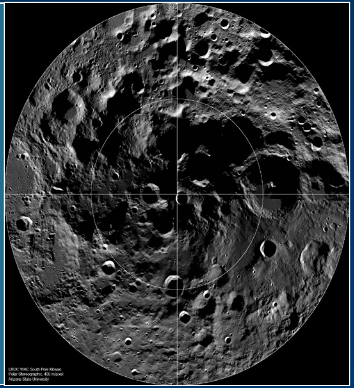
- Task Order CP-21: The Lunar Vulkan Imaging and Spectroscopy Explorer (Lunar-VISE) will land at the Gruithuisen Domes, a location of rare silicic volcanism on the lunar near side.
  - Decadal science: understand how the interior of solid bodies evolve and how this is recorded in the body’s physical and chemical properties by investigating the origin and composition of the domes
- Task Order CP-22: The Lunar Explorer Instrument for Space Biology Applications (LEIA) will land in a south polar region.
  - Decadal science: LEIA will study the biological response of yeast to the lunar environment to determine how partial gravity and deep space radiation influence biological processes

Reiner Gamma

Gruithuisen Domes



South Pole



Future Direction of CLPS

- Continue building the commercial market; CLPS service options are expected to expand as market and company capabilities evolve
- Estimating periodic on-ramp opportunities into the CLPS Vendor Pool going forward depending upon need and service availability
- Maintain flexibility of the CLPS IDIQ to award Task Orders for upcoming capabilities, data buys
- SMD manifests will continue to be competitively-selected payloads
- Expect to continue cadence of ~2 flights per year
- Support of other mission directorates and international partners through delivery of priority science/technology investigations to the lunar surface
- Support of Artemis crewed activities through delivery of scientific equipment, supplies for longer duration missions, human-centric infrastructure
(e.g., LTV, ISRU demos/equipment, etc.)
- New capabilities that would enhance science return, ops, and open new avenues for scientific investigations
    - Mobility
    - Orbital Drop-off
    - Comm Relay
    - EMI Quiet Operation
    - Increased Delivery Mass
    - Surviving/operation throughout the lunar night
    - Articulation
    - PSR/Cold Operations
    - Sample Return

Questions with a focus on FE and SLE Segments

Image Credit: Gene and Cell Magazine

Image Credit: NASA

Image Credit: Journal of Petroleum Technology

1. Are the functions, needs, characteristics, and use cases appropriate to accomplish the defined Science Objectives or are there some required to support the objectives that are not yet in the ADD?

2. What science is necessary to be conducted on the Moon to be ready for humans to perform science on Mars?

3. Which science is best achieved through human exploration vs. robotic missions? Or a combination?

Get Involved in Artemis!

- Upcoming Artemis-related calls:
    - Lunar Mapping Program – proposals due 6/12
    - Analog Activities Program – proposals due 12/6
    - Artemis 3 Participating Scientist Program
    - Artemis 4 Deployed Instruments
    - Artemis Handheld Instruments
    - Lunar Terrain Vehicle Instruments
    - PRISM-SALSA CLPS Solicitation
    - PRISM-4 Solicitation
- Opportunities to provide input:
    - LSSWs
    - LEAG, ExMAG, MEPAG
        - Joint SAT on samples
    - Upcoming NAS and SDT studies