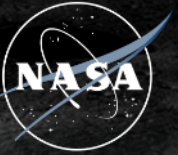


# NASA Artemis Updates

National Aeronautics and  
Space Administration



Sarah Noble and Debra Needham  
LEAG 2025 Artemis Session Chairs

Exploration Science Strategy and Integration Office  
NASA

# NASA Artemis II Updates

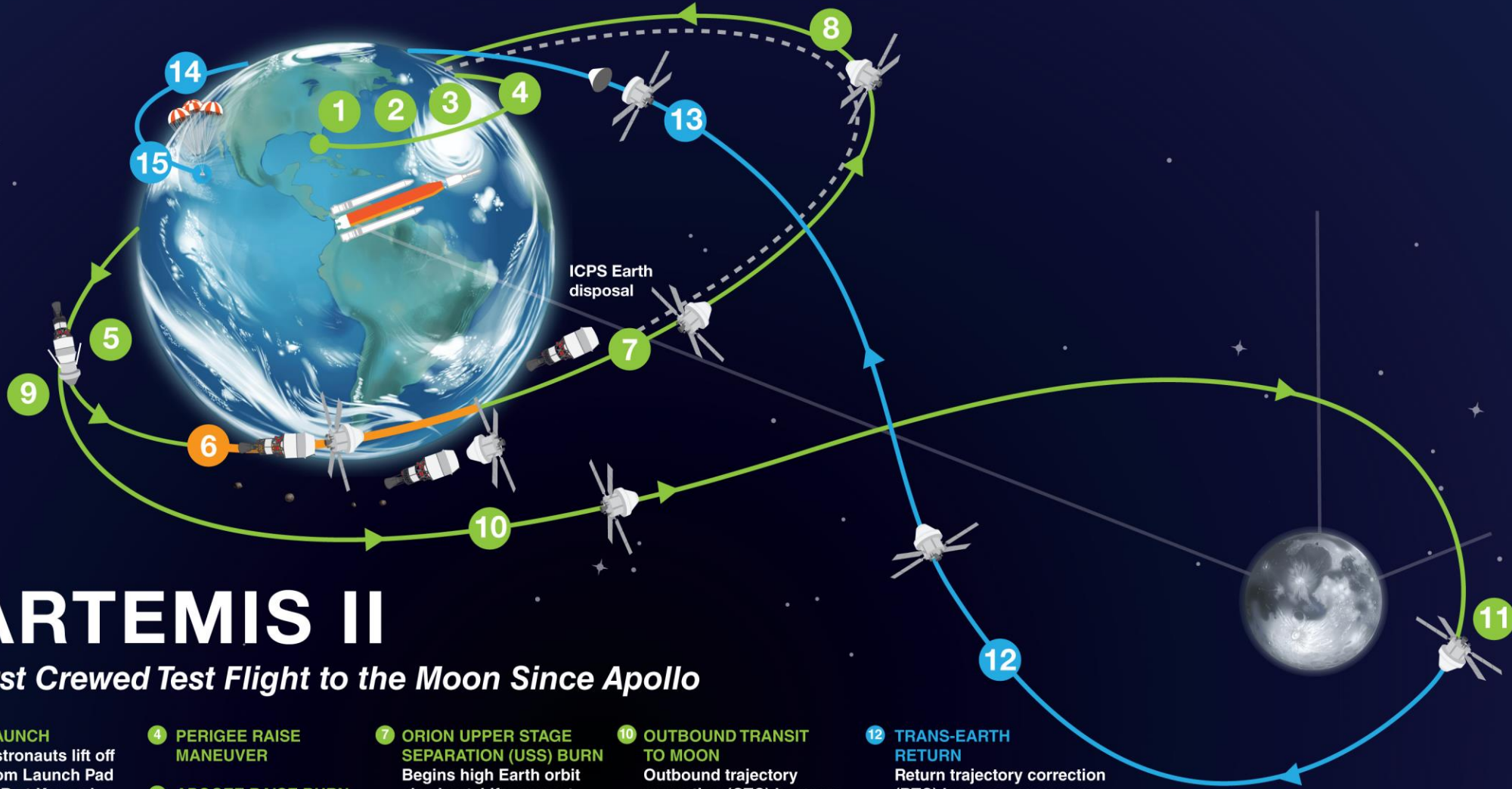
National Aeronautics and  
Space Administration



Kelsey Young and Kevin Sato

Artemis II Lunar Observation Lead - NASA GSFC

Artemis II Bioscience Lead - NASA HQ



# ARTEMIS II

First Crewed Test Flight to the Moon Since Apollo

- 1 LAUNCH**  
Astronauts lift off from Launch Pad 39B at Kennedy Space Center.
- 2 JETTISON SOLID ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**  
With separation.
- 4 PERIGEE RAISE MANEUVER**
- 5 APOGEE RAISE BURN TO HIGH EARTH ORBIT**  
Begin 23.5-hour checkout of spacecraft.
- 6 ORION SEPARATION FROM INTERIM CRYOGENIC PROPULSION STAGE (ICPS) FOLLOWED BY PROX OPS DEMO**  
Plus manual handling qualities assessment for up to 2 hours.
- 7 ORION UPPER STAGE SEPARATION (USS) BURN**  
Begins high Earth orbit checkout. Life support, exercise, and habitation equipment evaluations.
- 8 PERIGEE RAISE BURN**
- 9 TRANS-LUNAR INJECTION (TLI) BY ORION'S MAIN ENGINE**  
Lunar free return trajectory initiated with European service module.
- 10 OUTBOUND TRANSIT TO MOON**  
Outbound trajectory correction (OTC) burns as necessary for lunar free return trajectory; travel time approximately 4 days.
- 11 LUNAR FLYBY**  
4,607 miles/7,414 km (mean) lunar far side altitude.
- 12 TRANS-EARTH RETURN**  
Return trajectory correction (RTC) burns as necessary to aim for Earth's atmosphere; travel time approximately 4 days.
- 13 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 14 ENTRY INTERFACE (EI)**  
Enter Earth's atmosphere.
- 15 SPLASHDOWN**  
Ship recovers astronauts and capsule.

PROXIMITY OPERATIONS DEMONSTRATION SEQUENCE	9
1	10
2	11
3	12
4	13
5	14
6	15
7	16
8	17

# ARTEMIS II

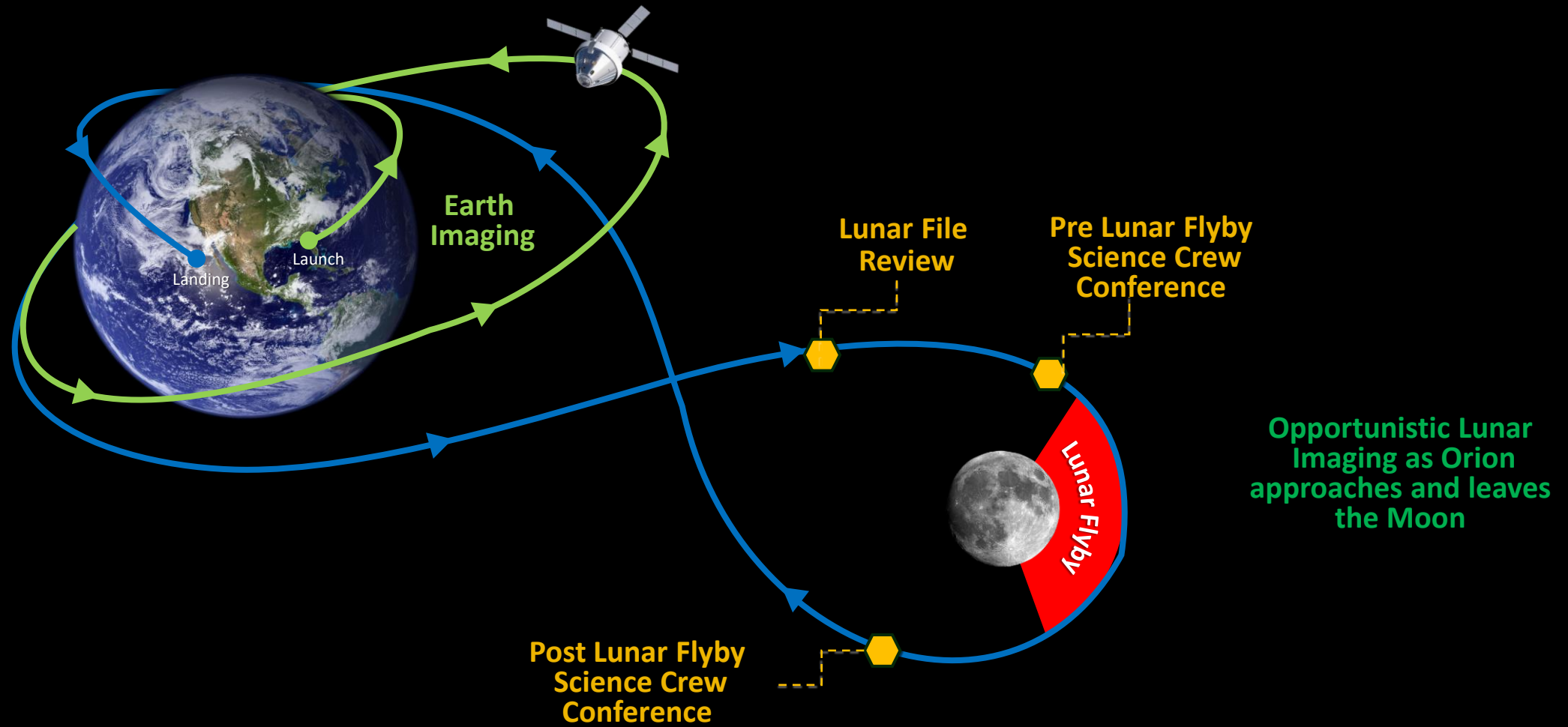
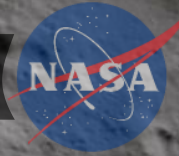
## Lunar Science on Artemis II

- Crew Images: Handheld Nikon
- Crew Verbal Descriptions: Captured via crew tablets
- Crew Annotations: Crew tablet annotated screenshots
- Vehicle Cameras: video and stills before, during, and after crew flyby activities



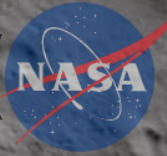


# Artemis II Updates: Major Lunar Science Milestones



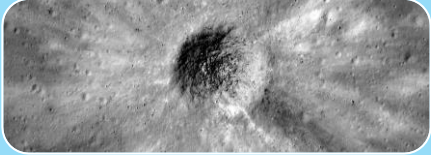


# Artemis II Updates: Lunar Science Objectives



## 10 Science Objectives

### Color Provinces & Albedo Variation



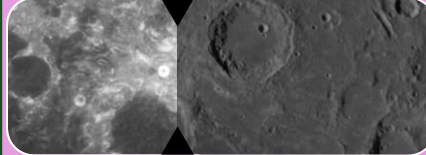
Priority: 1

### Impact Flashes



Priority: 1

### Photometric Changes



Priority: 2

### Landing Sites & Lunar Poles



Priority: 2

### Impact History



Priority: 2

### Dust & Exosphere



Priority: 2

### Tectonics



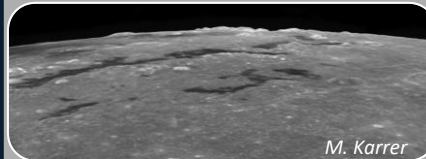
Priority: 2

### Volcanic History



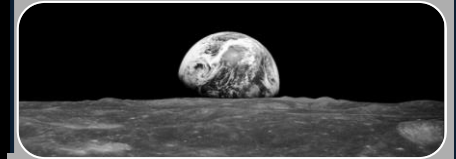
Priority: 3

### Terminator & Limb



Priority: 3

### Earth From Space



Priority: 3

## 4 Exploration Capability Objectives

### Exercise Crew Lunar Imaging/Observation Product Development and Execution



### Exercise Science Flight Team Support

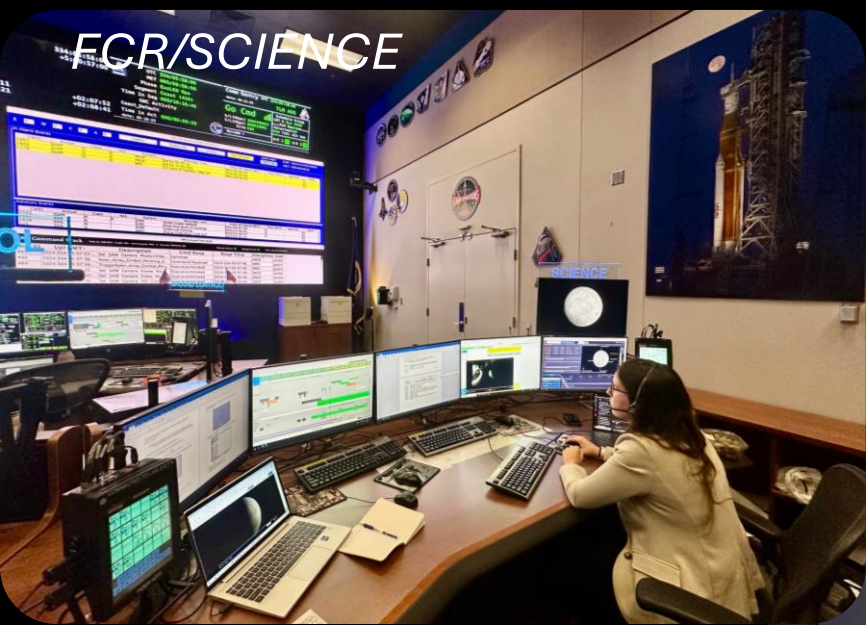


### Exercise Science Data Capture Methods

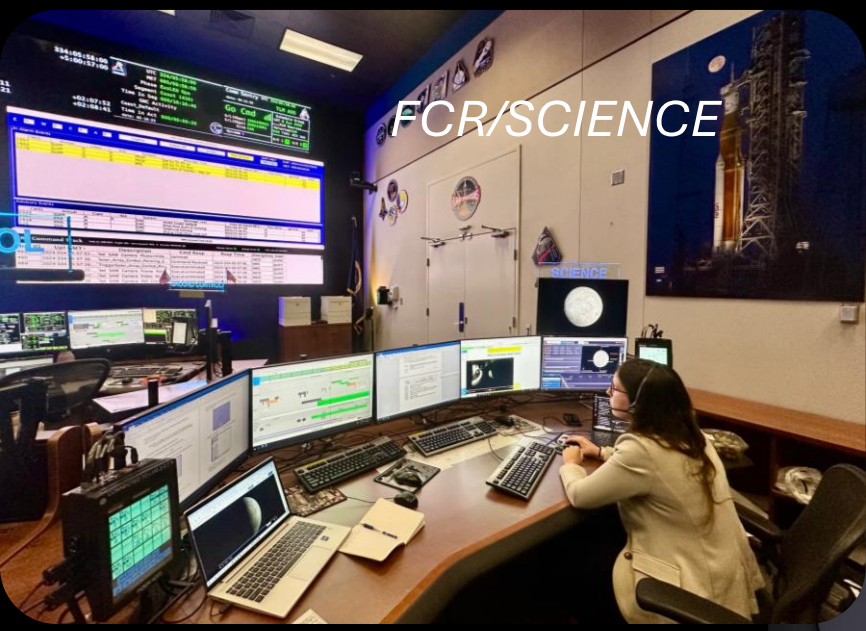


### Exercise Science Data Archiving Methods





*FCR: Flight Control Room  
SER: Science Evaluation Room  
SMOR: Science Mission Operations Room*



FCR/SCIENCE

SER/SMOR: Focus will shift throughout mission.

Focus Areas:

- Lunar Targeting Plan Generation/Validation
- Lunar Flyby Prep/Support (including crew conferences)
- Early Data Analysis



Science Officers



Kelsey Young  
Angela Garcia  
Trevor Graff



SER

JSC/B30



SMOR



JSC/B36

SER Leads



Jacob Richardson  
Marie Henderson

Science 'Scrum'  
Lead

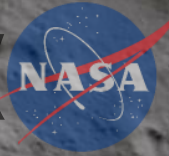


Ariel Deutsch

FCR: Flight Control Room  
SER: Science Evaluation Room  
SMOR: Science Mission Operations Room



# Artemis II Updates: Crew Lunar Science Software



## Lunar Targeting Package

### Lunar Geography Review (LGR)

### Lunar Targeting Plan (LTP)

**Lunar Targeting Package**  
v 2025-12-05 16:00

Views: Nearside, West Limb, Farside, East Limb

Labels: None, Minimum, **Minimum + Scale**, Medium, Maximum

Phases: Full, Third Quarter, Waning Crescent, Waxing Crescent, First Quarter

Geographical Features and Distances:

- Aristarchus Plateau: 240 km
- Mare Serenitatis: 600 km
- Mare Crisium: 550 km
- Mare Tranquillitatis: 765 km
- Copernicus: 96 km
- 66 km
- Lytic



**Lunar Targeting Package**  
v 2025-12-05 16:00

Targets List:

- Whole Moon (1/3) 10:30 GMT
- Oriente Basin 10:35 GMT
- Sundman J Crater 10:40 GMT
- Pierazzo Crater 10:45 GMT
- Vavilov Crater (1/2) 10:50 GMT
- Jackson Crater 10:55 GMT
- Lacus Lunariae Region 11:00 GMT

**2. Oriente Basin** OR-ee-ent-ALL

Target Information:  
• Basin with inner and outer rings  
• Diameter of basin is equivalent to the distance between 100°

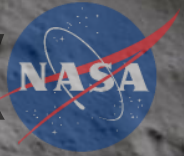
Timeline: 2026-02-21 09:06:27 GMT  
Time Delta: 00:00:00  
LOS Start: 11:45 GMT, LOS End: 12:28 GMT

Thoughts:

- Color & Shadow: Color tone, Albedo, Shadows/Illumination
- Structure & Texture: Structures, Slopes, Texture
- Geologic Relations: Association, Contact habit, Contact relationship
- Thoughts: Impressions, Interpretations, Any changes?



# Artemis II Updates: Lunar Science Mission Result Dissemination



## In-Mission:

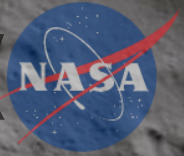
- Press briefing(s)
- Blog(s) and social media posts

## Post-Mission:

- Early results and statuses disseminated at conferences (e.g., LPSC, LSSW HQ Outbrief)
- Three reports & data archive (*Hollibaugh-Baker et al., LPSC 2025*) released no later than six months post-mission
  - Preliminary Mission Lunar Science Report
  - Lunar Science Operations Report
  - Data User's Guide
- Dedicated virtual Artemis II lunar science workshops on results & data user's guide in the works



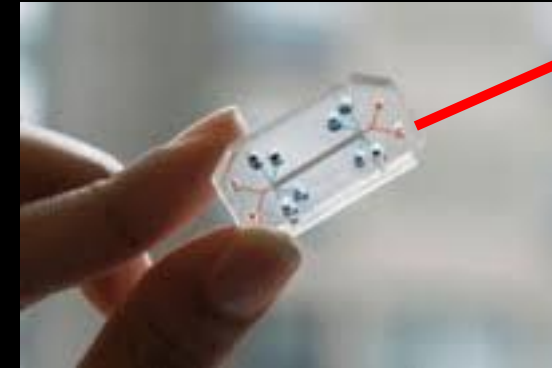
# Artemis II Updates



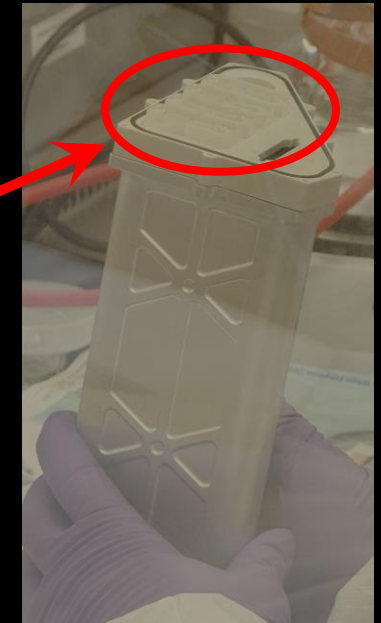
## A Virtual Astronaut Tissue Analog Response (AVATAR)

Development of Precision Health and Personalized Medicine for NASA Astronauts

- Ultimately the data may pave the way for personalized medical care for all who travel in space
- **Scientific Goal**
  - Directly correlate spaceflight changes in the Artemis II astronauts with changes in organ chips, which are derived from cells from the Artemis II astronauts.
- **Objectives**
  - Define the physiological, biochemical, and molecular impacts of combined microgravity and true deep space radiation on tissues cultured on the chips
  - Comparative analysis of changes in the physiology of the tissue chips with crew health measurements and biomarkers
  - Evaluate the engineering systems and functions of the CubeLab in the deep space environment

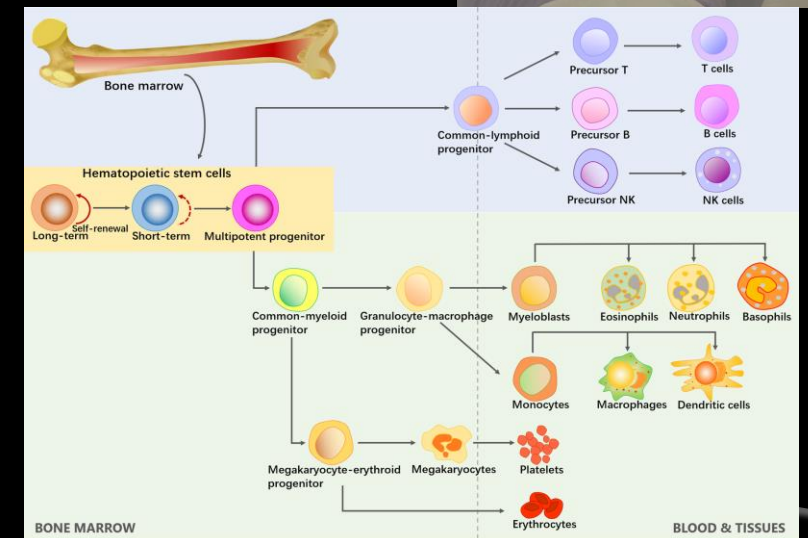


Bone Marrow Organ Chip



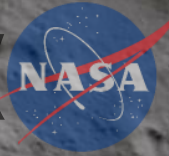
### Bone Marrow Tissue Chip

- Derived from the Artemis II Crew donated blood cells





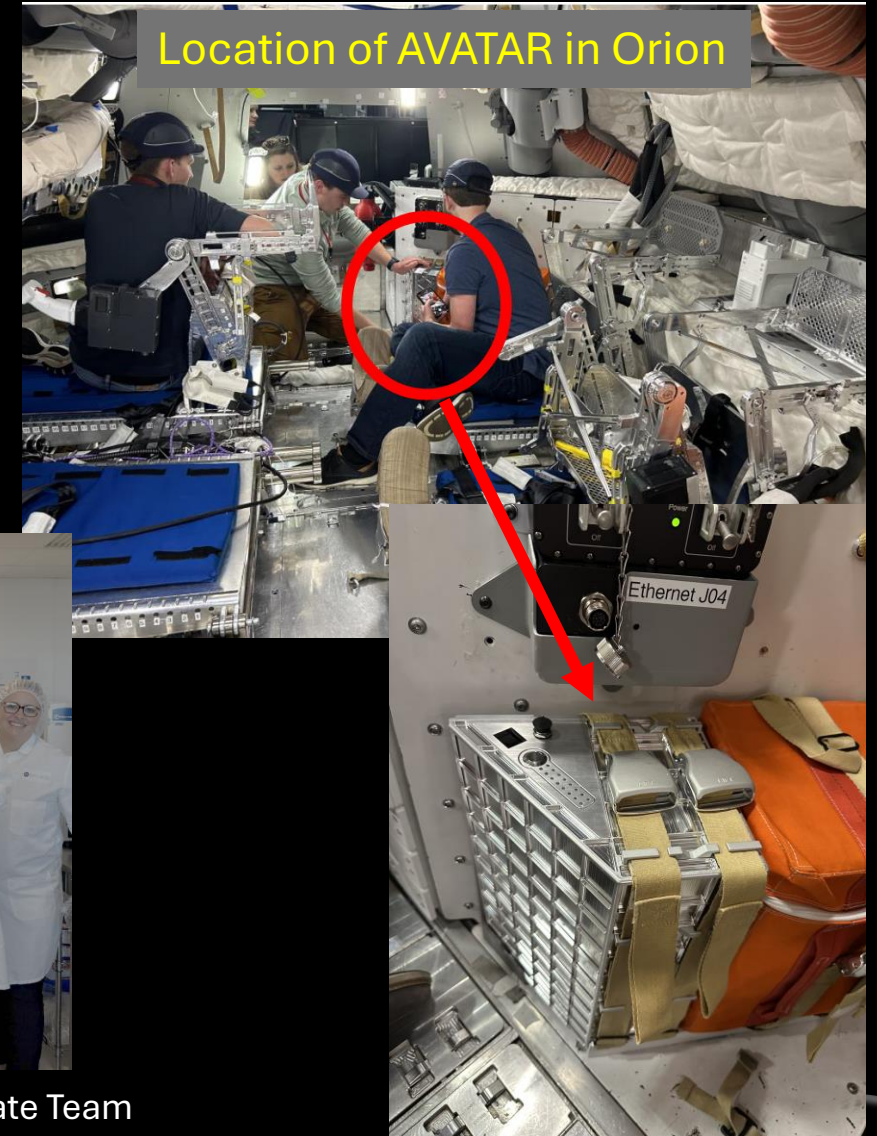
# Artemis II Updates



## A Virtual Astronaut Tissue Analog Response (AVATAR)

### Major Milestones

- MSERP Phase III Safety Review completed (last Artemis safety review)
- 4 Prime Crew and 1 Back-Up Crew volunteered to contribute their cells
- Hardware completed major science/hardware integrated tests
- Flight hardware built and completed all qualification and verification test requirements
- SMD certified AVATAR's flight readiness
- Orion fit-check at the Crew's Orion test in progress
- Mission Verification Test in progress
- Flight Readiness Review – Jan 2026



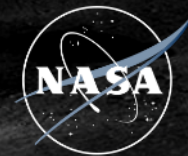
Space Tango Engineers briefing the Crew



NASA, Space Tango, and Emulate Team

# NASA Artemis III Updates

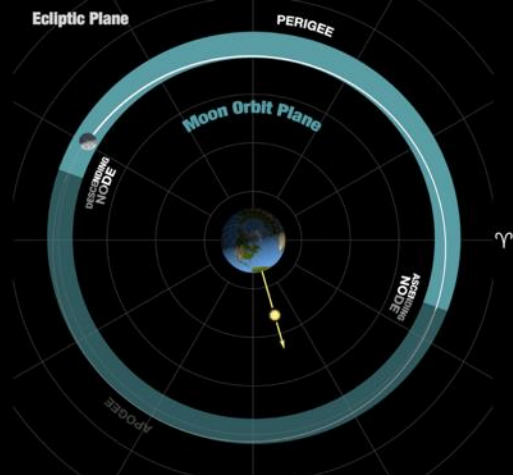
National Aeronautics and  
Space Administration



Noah Petro and Padi Boyd

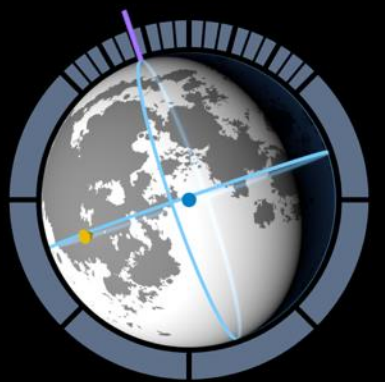
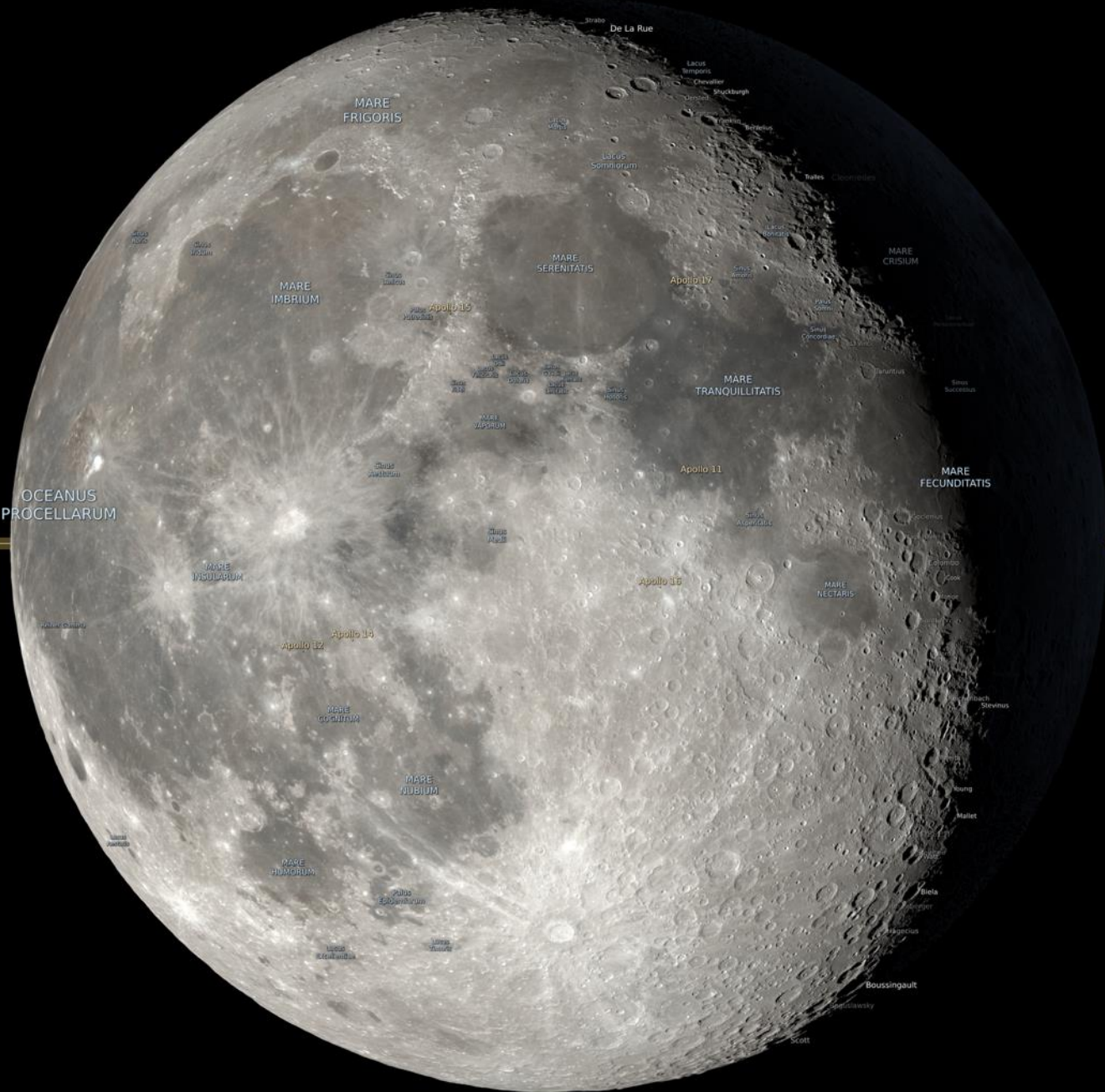
Artemis III Project Scientist - Deputy PS

NASA Goddard Space Flight Center - NASA HQ

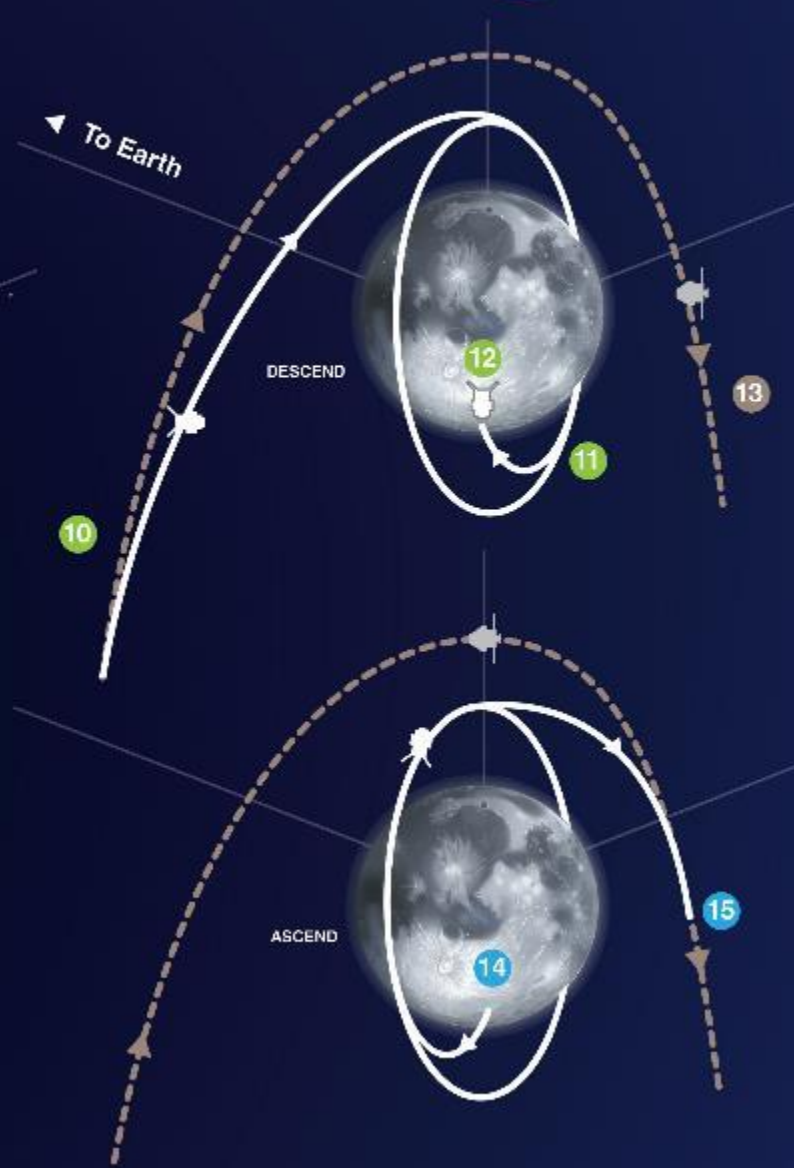
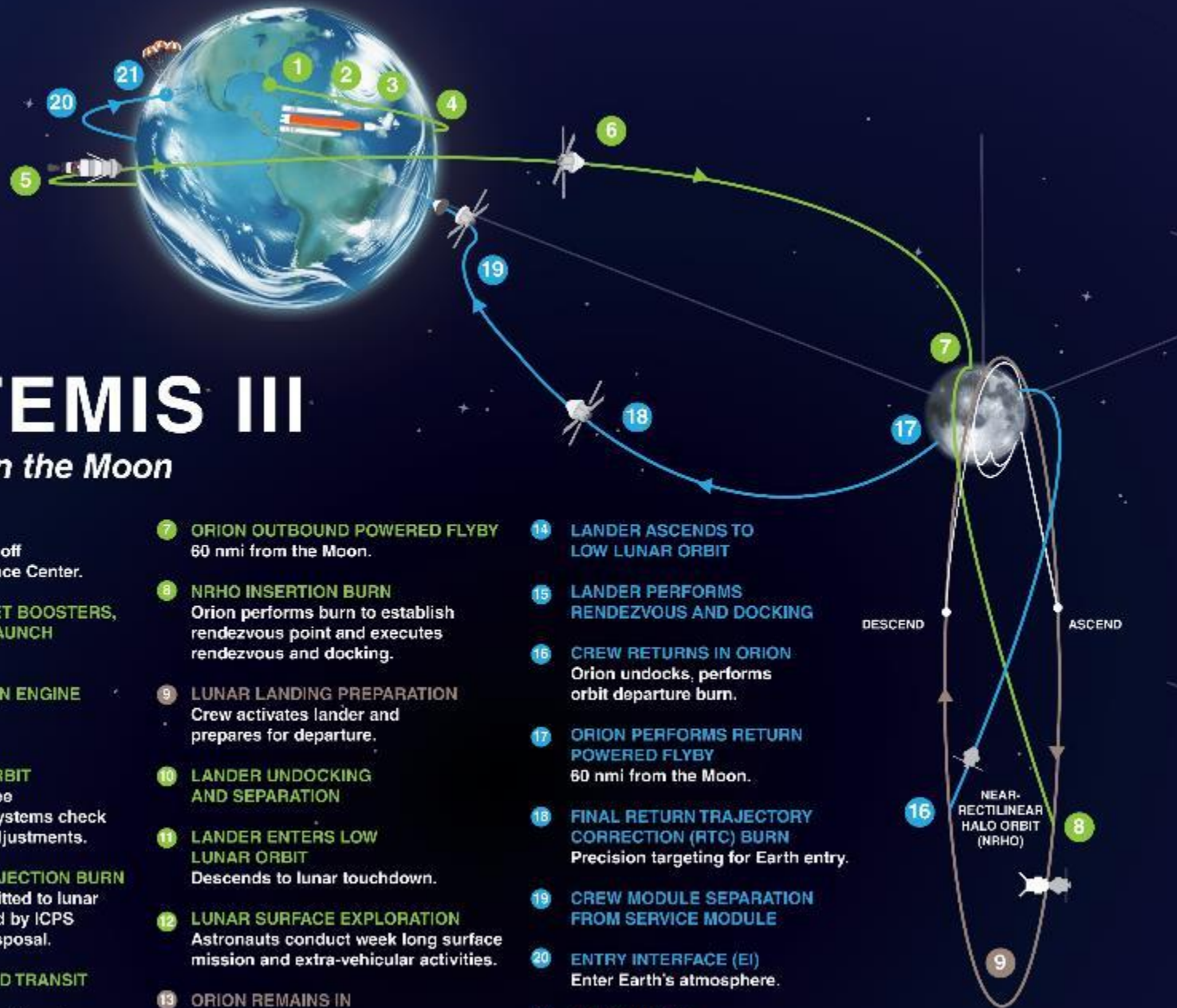


# Moon Phases 2026

Including Libration and Position Angle



TIME  
 06 Jan 2026 16:00 UT  
 PHASE  
 86.5% (17d 14h 17m)  
 DIAMETER  
 1898.7 arcseconds  
 DISTANCE  
 377478 km (29.62 Earths)  
 J2000 POSITION  
 10h 06m 17s, 12° 41' 14"N  
 SUBSOLAR POINT  
 1.249°S 36.191°W  
 SUB-EARTH POINT  
 1.264°S 6.851°E  
 POLE POSITION ANGLE  
 18.972°



# ARTEMIS III

## Landing on the Moon

- 1 LAUNCH**  
SLS and Orion lift off from Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**  
With separation.
- 4 ENTER EARTH ORBIT**  
Perform the perigee raise maneuver. Systems check and solar panel adjustments.
- 5 TRANS LUNAR INJECTION BURN**  
Astronauts committed to lunar trajectory, followed by ICPS separation and disposal.
- 6 ORION OUTBOUND TRANSIT TO MOON**  
Requires several outbound trajectory burns.
- 7 ORION OUTBOUND POWERED FLYBY**  
60 nmi from the Moon.
- 8 NRHO INSERTION BURN**  
Orion performs burn to establish rendezvous point and executes rendezvous and docking.
- 9 LUNAR LANDING PREPARATION**  
Crew activates lander and prepares for departure.
- 10 LANDER UNDOCKING AND SEPARATION**
- 11 LANDER ENTERS LOW LUNAR ORBIT**  
Descends to lunar touchdown.
- 12 LUNAR SURFACE EXPLORATION**  
Astronauts conduct week long surface mission and extra-vehicular activities.
- 13 ORION REMAINS IN NRHO ORBIT**  
During lunar surface mission.
- 14 LANDER ASCENDS TO LOW LUNAR ORBIT**
- 15 LANDER PERFORMS RENDEZVOUS AND DOCKING**
- 16 CREW RETURNS IN ORION**  
Orion undocks, performs orbit departure burn.
- 17 ORION PERFORMS RETURN POWERED FLYBY**  
60 nmi from the Moon.
- 18 FINAL RETURN TRAJECTORY CORRECTION (RTC) BURN**  
Precision targeting for Earth entry.
- 19 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 20 ENTRY INTERFACE (EI)**  
Enter Earth's atmosphere.
- 21 SPLASHDOWN**  
Ship recovers astronauts and capsule.



# Artemis III

## ARTEMIS FIRSTS:

- Human landing in South Pole region and return
- Orion to human landing system direct mission including crew docking activity
- Use of Near Rectilinear Halo Orbit (NRHO)
- Four astronauts to lunar orbit
- Two astronauts to lunar surface to collect scientific samples and data
- Conducting new science and technology demonstrations

## NEW ELEMENTS:

- Orion full up rendezvous, proximity operations, and docking systems
- Starship human landing system
- Advanced spacesuits and tools to explore the surface and collect samples

## COMMON ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1



# Artemis III: Starship HLS Fueling and Pre-staging

## MISSION SUMMARY:

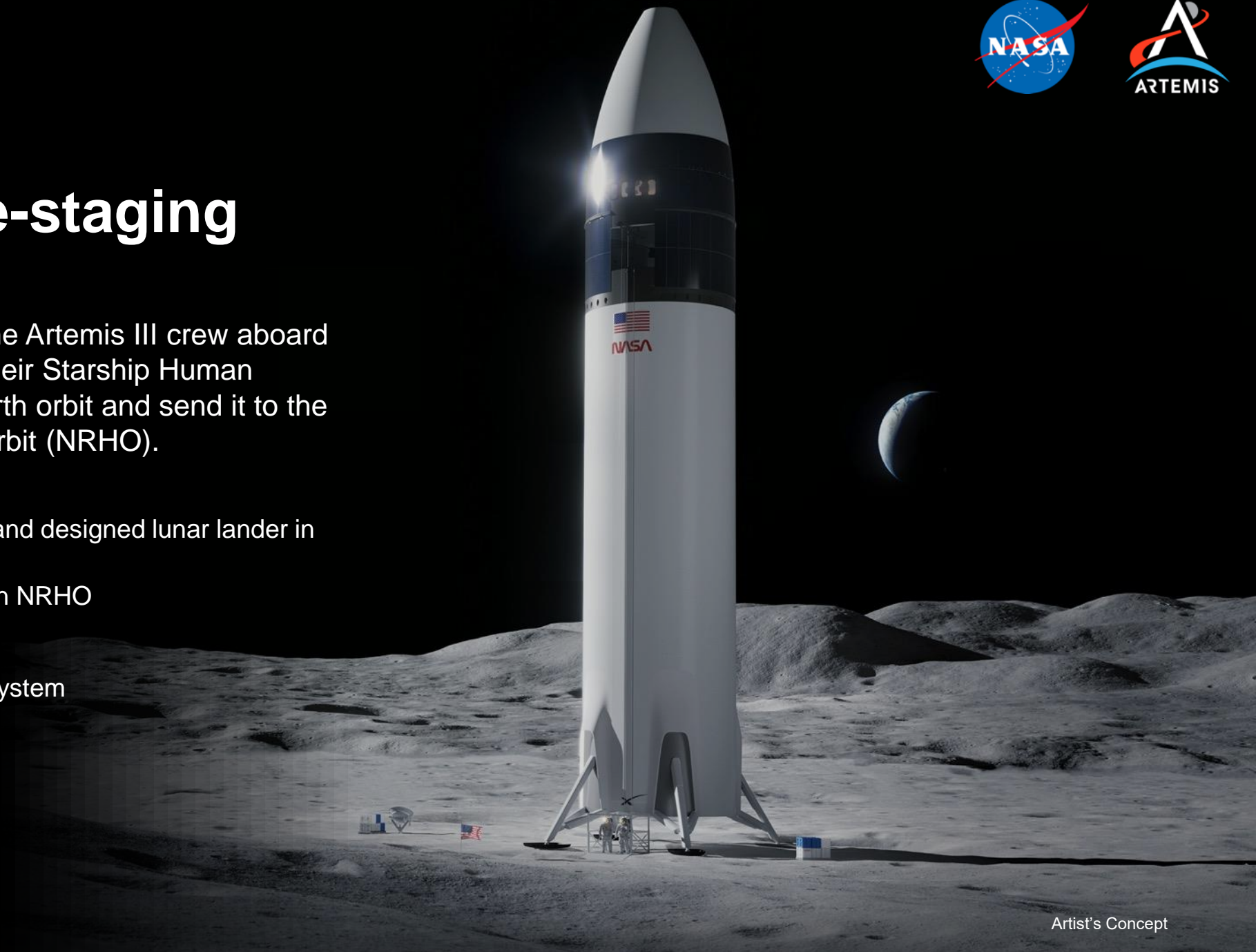
In preparation for the launch of the Artemis III crew aboard Orion on SLS, SpaceX will fuel their Starship Human Landing System (HLS) in low-Earth orbit and send it to the selected Near Rectilinear Halo Orbit (NRHO).

## ARTEMIS FIRSTS:

- Fueling of a commercially owned and designed lunar lander in low Earth orbit
- Lunar lander pre-staged for crew in NRHO

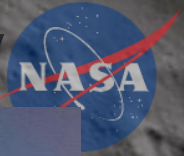
## NEW ELEMENTS:

- SpaceX Starship human landing system
- SpaceX Starship fuel depot
- SpaceX Starship tanker

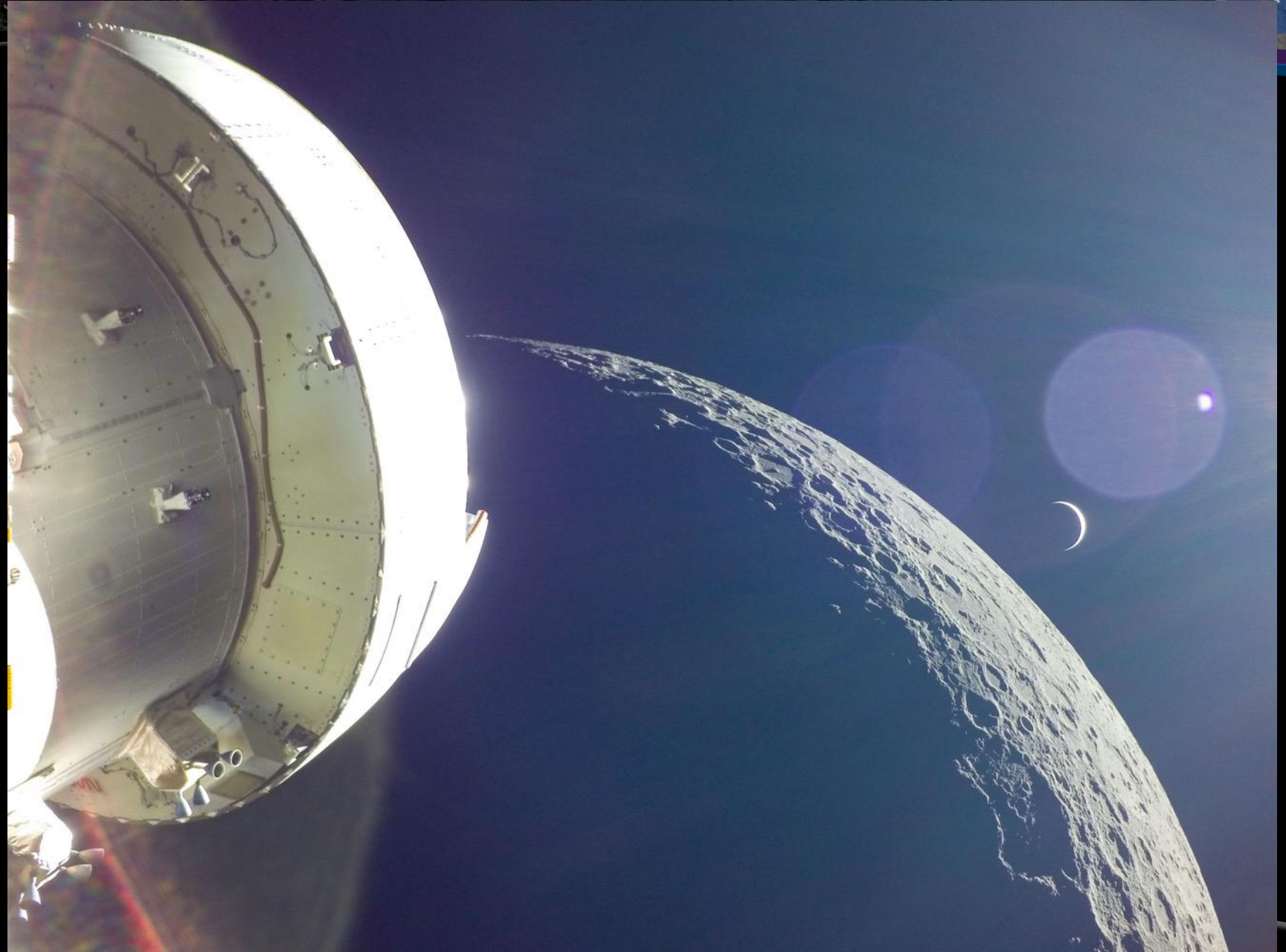




# Artemis III Updates

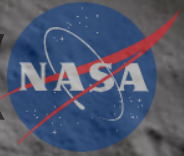


“Don’t look back. Something might be gaining on you”  
-Stachel Paige

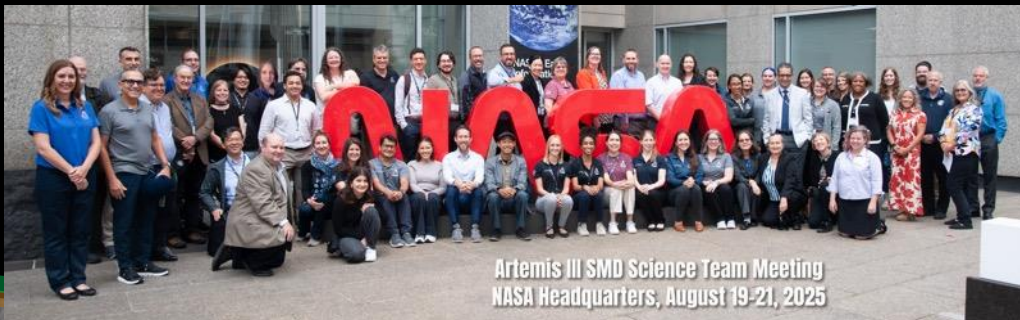




# Artemis III Updates – 2025 Highlights

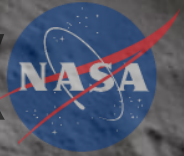


- Artemis III multi-EVA Simulation at JSC w/ geology team
- Lunar excitement mounting with Artemis II
- Deployed Instrument progress
  - Instrument Deployment sim at JSC
  - LEMS testing at Exolith Lab at UCF
- CLPS Successes
  - Blue Ghost Mission 1 and IM-2!
  - ALLR predecessor and lessons – NGLR
- Evaluation of a microbiology experiment for flight
- Brought on Dr. Padi Boyd as D-PS
- *Solicitation of the Artemis III Participating Scientists*
- Face-to-face team meeting in DC
- *Coordinating with the PDS for SMD's contribution to Artemis III*
- Lauren Edgar is an astronaut candidate





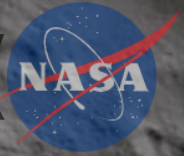
# Artemis III Updates – 2026 Highlights



- Special issue on Artemis III SMD Science in the Planetary Science Journal
- Simulations and tests
- Instrument deliveries
- PSI testing and development
- Artemis II flies!
  - Flight opportunity for lunar imaging, a precursor for Artemis III
- Onboarding of PSP's
- Internal team organization and coordination, improvements
- Face-to-face team meeting deux
- More CLPS deliveries



# Artemis III Updates – Microbiology Experiment in Orion (BPS)

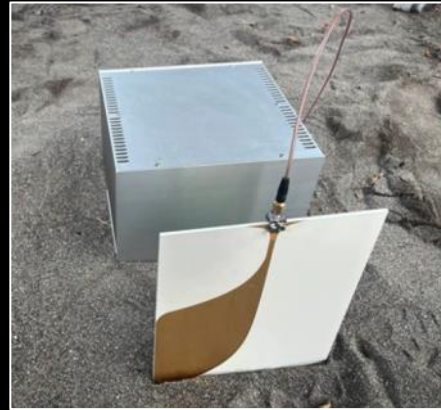


- The overarching objective of microbiology experiments on Artemis III is to obtain seminal data on the microbial flora of a spacecraft traveling in deep space using an *in situ* analysis DNA sequencing instrument to eliminate sample and instrument return to Earth. The obtained data will inform and guide future more comprehensive studies of the microbial flora of Artemis and Gateway.
- Survey and Characterize the microbial flora of the Artemis III Orion capsule
  - Identify the different microbial species that colonize the surface of selected surfaces in Orion
  - Identify the different microbial species of the crew and assess for transfer between crew and Orion surfaces
  - Obtain air filters and stored water to assess the microbial flora, if available, or just obtain data if already being analyzed by JSC Microbiology Lab
- Technology Demonstration of the *in situ* analysis sequencing system
  - Evaluate the function and operations of the ISS minION sequencing system for near real-time identification of the different microbial species\
- Operations to occur on Orion only during two-crew operations, with potential opportunity for sampling and analyses of elements in HLS post-lunar return
  - No sample return

## Lunar Dielectric Analyzer (LDA)

### More at 3:20

Monitors regolith property differences caused by surface temperature changes. Data will be used to identify possible frost formation as well as the presence of subsurface water ice deposits.



JAXA/U. of Tokyo

## Lunar Effects on Agriculture Flora (LEAF)

A self-contained experiment to investigate the effects of the radiation environment and lunar gravity's influence on the growth of seedlings.

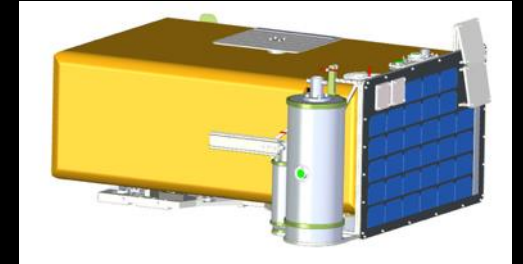


Space Lab Technologies

## Lunar Environment Monitoring Station (LEMS)

### More at 3:30

Will measure the seismic environment in the South Polar region from three months to two years.



GSFC/UMD/UArizona

## Artemis Lunar Laser Retroreflector (ALLR)

A target for Earth-based lasers to measure the distance to the Moon over decadal timescales. Changes in lunar distance provide insight for properties to the lunar interior.

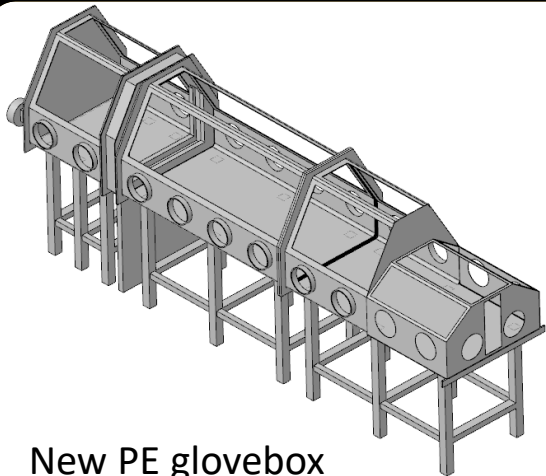
Measurements can also be used to measure changes to optical systems on the Moon.



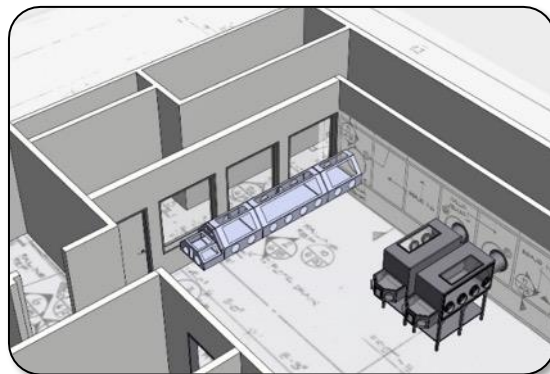
GSFC

The new Artemis Curation Team, led by Artemis Sample Curation Lead Juliane Gross, is making great progress towards Mission and Curation readiness for receiving new lunar samples:

- a new curation team has been established that is 26 team members strong (and counting).
- team includes contractors and civil servants, sample processors, engineers, mission and curation coordination support, database and contamination knowledge collection developers, lab and mock-up training facility planner, photographers, and many more.
- already meeting milestones for mission and curation readiness, including glovebox procurement; sample imaging plan; lab space assessment; CK database and collection storage establishment
- temporary curation facility has been designed and approved by EGS (Exploration Grounds System) for the recovery vessel operations



New PE glovebox

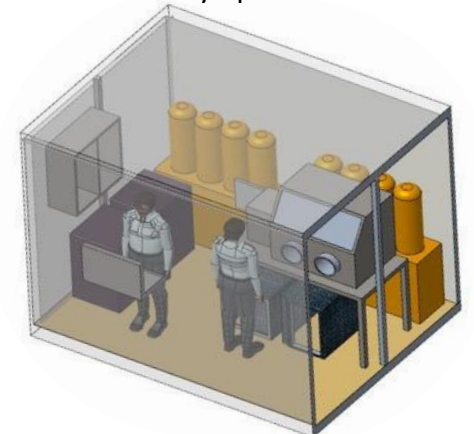


Lab space assessment



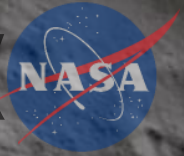
CK collection storage

Temporary Curation Facility during recovery operations





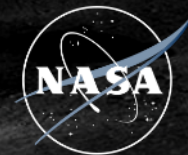
## Get Ready – A Request



- The Artemis III SMD Science Team is preparing for a return of humans to the Moon.
- Each team member is working hard to maximize science return for the planetary science community (including Lunar Science and Biological and Physical Sciences).
- We need continued community support of manuscript review, proposal panel participation, and continued lunar science that advocates for a crewed return to the Moon.
- Work within your communities to remind/educate them on the importance of lunar science
- Artemis II will be a \*prime opportunity\* to remind the world of the importance of lunar exploration and science
- *Lunae Facem Gerimus* “We bear the torch of the Moon.”

# NASA Artemis IV Updates

National Aeronautics and  
Space Administration



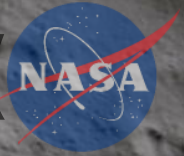
Barbara Cohen and Jennifer Heldman

Artemis IV Project Scientist; Deputy Project Scientist

NASA Goddard Space Flight Center; NASA Ames Research Center



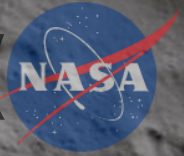
# Artemis IV Updates



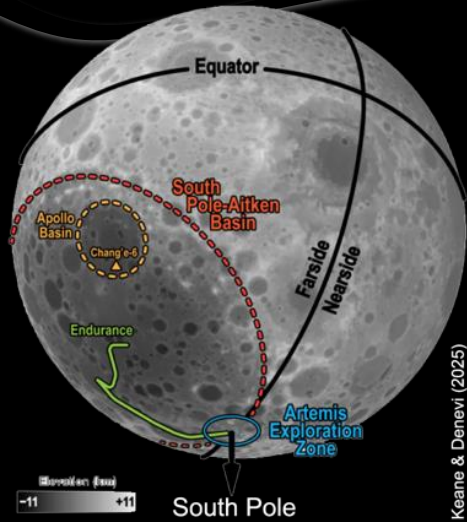
- Artemis IV science plan is under development, building on community-driven science goals
  - Building foundational documents and structure for the specific architecture
  - Science leadership is developing our science inputs to guide Mission Priorities
  - Artemis Internal Science Team is looking across mission capabilities
- AIV Instruments
  - Two A4DI were selected for Planetary Science – SPSS and DUSTER
  - Several other payloads under consideration by other SMD divisions
- AIV Landing Site Workshop: September 10, 2025
  - We received excellent inputs to help develop quantifiable figures of merit
- AIV science/geology team and PS calls will be coming
  - More opportunities for community involvement!



# Artemis IV Architecture



- Artemis IV architecture options are under review
- In current POR, HLS will be SpaceX Starship
- Science/utilization capabilities for Artemis IV will be broadly similar to Artemis III
  - IVA opportunities in transit and orbit
  - Lunar south polar landing
  - 6.5-day surface mission with multiple on-foot EVAs (~1 km radius)
  - Unconditioned sample return
- **Gateway** may afford new opportunities for science!



Keane & Denevi (2025)

## Theme 1: Early Lunar Basin Chronology

An integrated field geology and instrumented campaign to investigate the formation, evolution, and age of the South Pole-Aitken Basin to anchor lunar chronology and test the lunar cataclysm hypothesis. [LPS-1]

## Theme 2: Enabling Safe Human Exploration

Build a comprehensive understanding of human biology in the exploration environment and catalog the microbiological flora of exploration vehicles over their occupancy life providing predictive care needs. [HBS-1, HBS-3]



## Theme 3: Characterizing the Modern Lunar and Cislunar Environments

Measuring the radiation environment, solar particles, and solar wind from LEO to lunar orbit to the lunar surface to keep crew and hardware safe on their journeys to the Moon and Mars. [AS-1, HS-1, HS-2, HS-4]

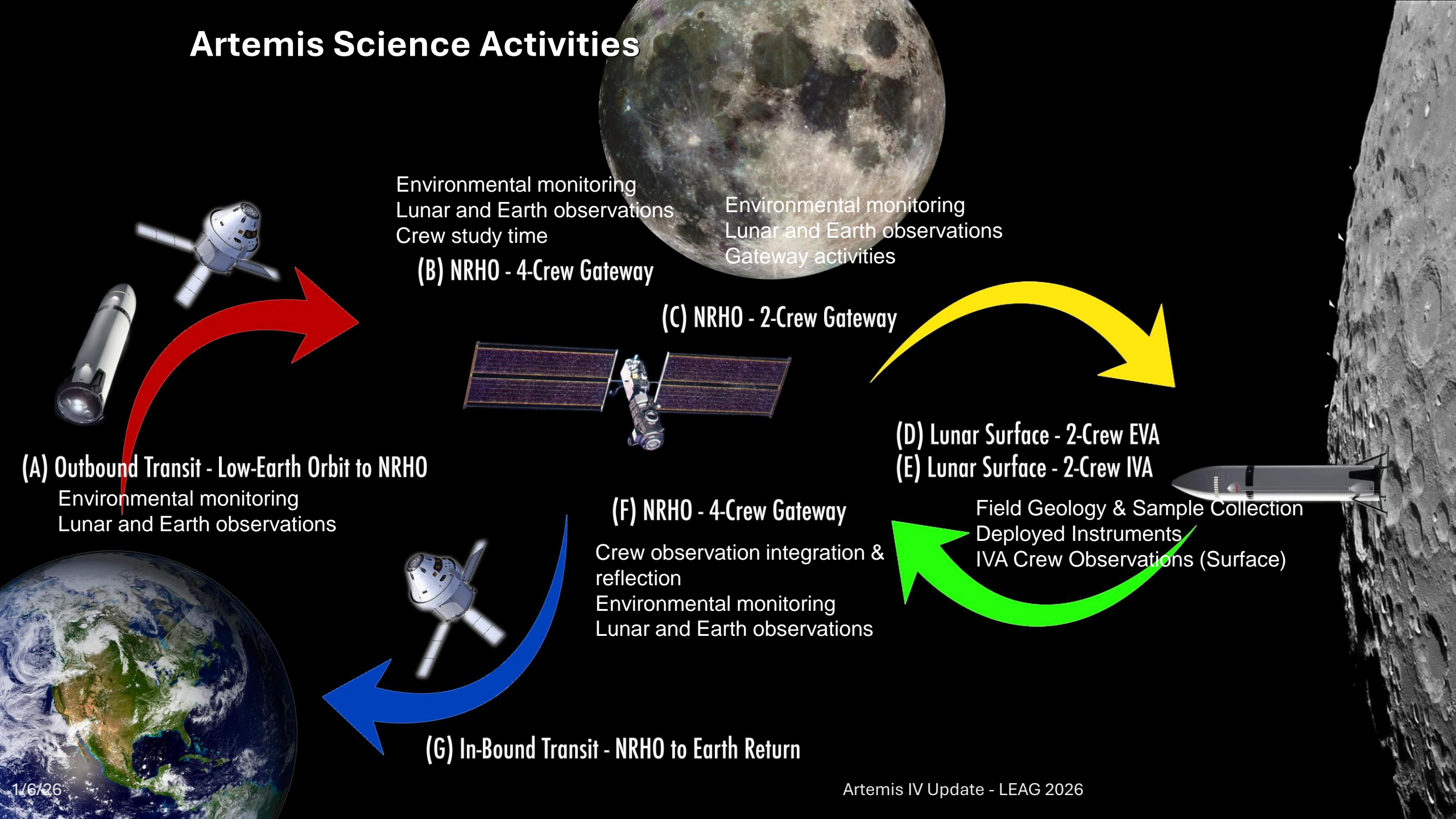


## Theme 4: Fundamental Science for a Sustainable Future

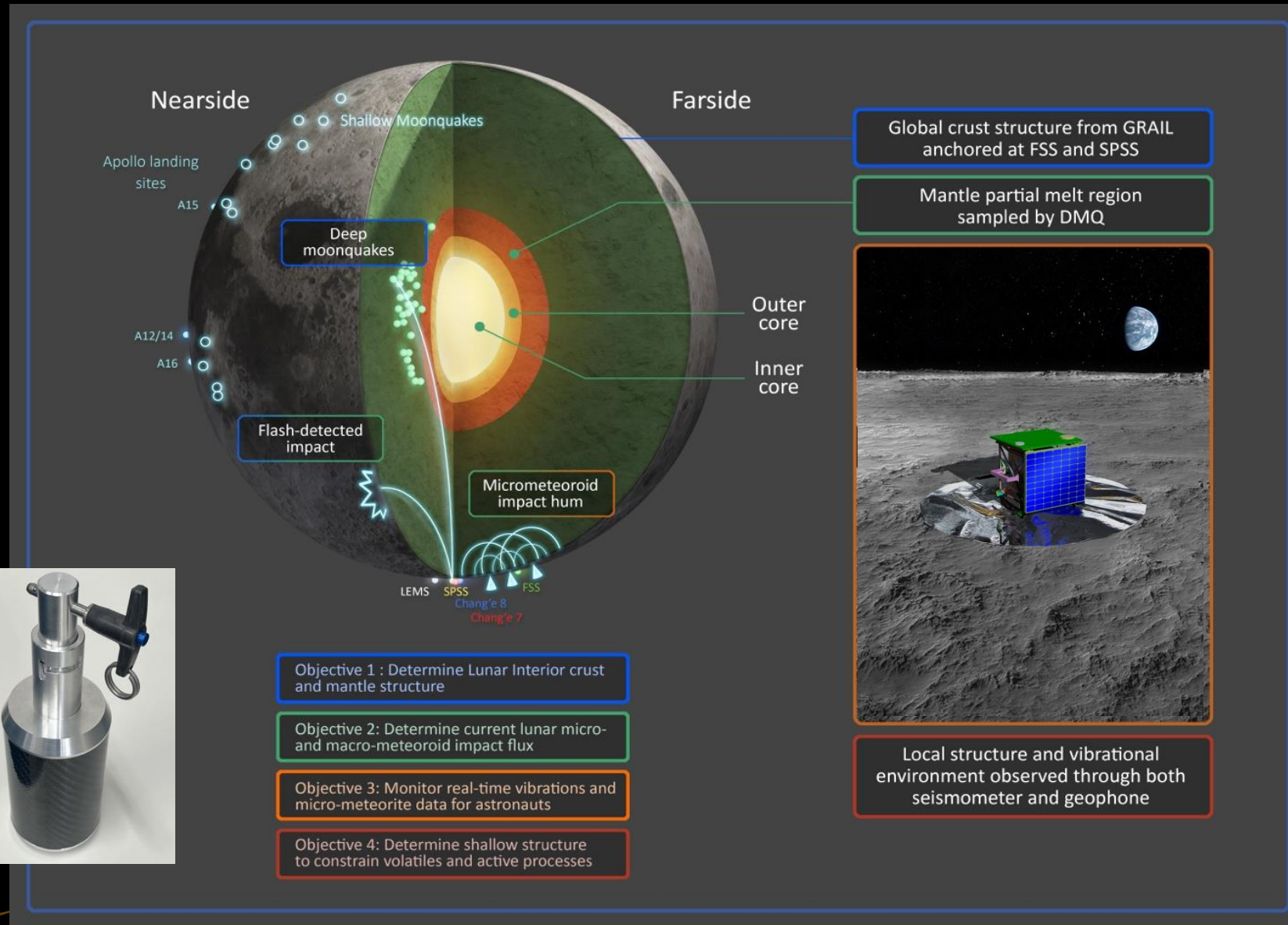
Interact, observe, image, and sample in ways that underpin prospecting, proving, building, and sustaining human activities on the Moon and extending humanity further into the Solar System. [AS-3, LPS-2, LPS-3]



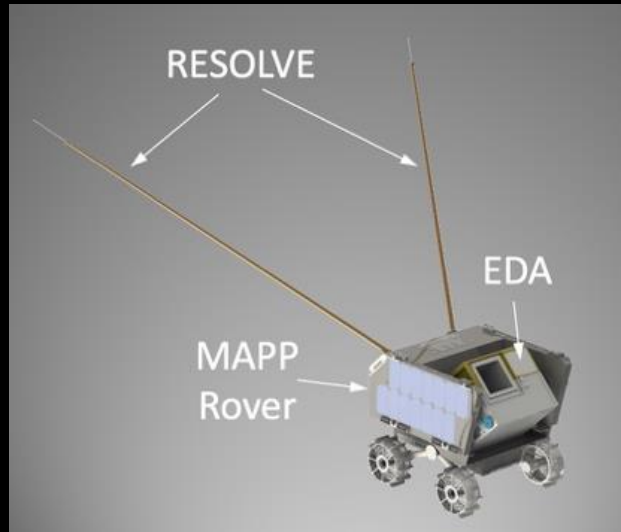
# Artemis Science Activities



- Seismic station deployed to surface by astronauts
- Astronaut activates JAXA-provided seismic source recorded by geophones attached to SPSS
- CNES-provided Very Broadband (VBB) Seismometer records day and night for 3 months
- Addresses both global and local structure



- DUSTER will develop a full picture of the dust and plasma environment around the Artemis IV landing site in the lunar south polar region
- DUSTER will characterize the near-surface plasma, electrostatically lofted dust, micrometeoroid impacts, and dust ejecta generated during lander liftoff
- DUSTER will provide crucial results to gauge the safety, ensure the success of future crewed/robotic missions, and enable a sustained human presence on the lunar surface



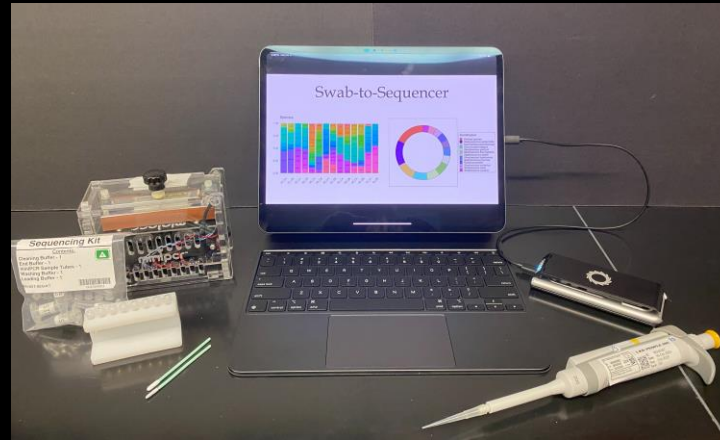
DUSTER carries the Electrostatic Dust Analyzer (EDA) and RELaxation SOunder and differential VoltagE (RESOLVE) instruments accommodated on the Mobile Autonomous Prospecting Platform (MAPP) rover.

- EDA measures electrostatically lofted dust
- RESOLVE measures plasma density, micrometeoroid impacts, and high-speed ejecta generated during lander liftoff.



DUSTER will be deployed by an astronaut, then drives and operates by ground command for the rest of the mission.

## Microbiology of the Built Environment (MoBE)



- Based on the ISS minION sequencing system for near real-time identification of microbial species
- Survey and Characterize the microbial flora of the Gateway habitat
  - Identify the different microbial species that colonize the surface of selected surfaces of Gateway
  - Identify the different microbial species of the crew and assess for transfer between crew and Gateway
  - Obtain baseline microbial population for understanding microbial survival, ecosystem changes, and population dynamics – analog for Mars transit vehicle and long duration lunar orbital habitation of the gateway
- Crew operations on Gateway only, which will include limited sampling post-lunar return from elements on HLS



## A Virtual Astronaut Tissue Analog Response (AVATAR)

- Human-Derived Tissue-on-a Chip Physiological System
- Evaluate the hardware incubation system during in Artemis transit, gravity, and lunar radiation environments
- Understand the physiological response of the tissue to the lunar environment
- Conduct comparative analyses between Artemis and data from relevant crew health biomarkers and ground controls



**European Radiation Sensors Array (ERSA):** The European Space Agency's (ESA's) radiation instrument package will help provide an understanding of how to keep astronauts and hardware safe by monitoring the radiation at higher energies with a focus on space weather



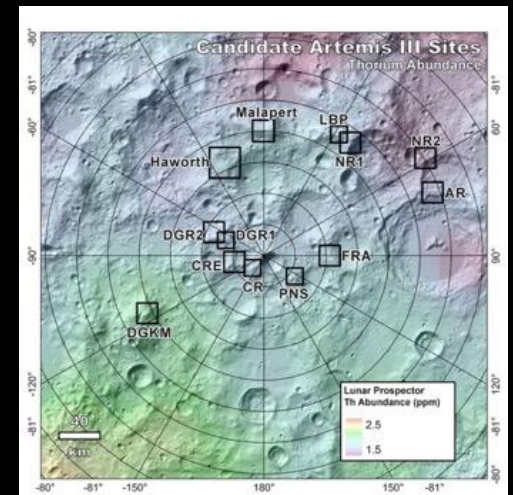
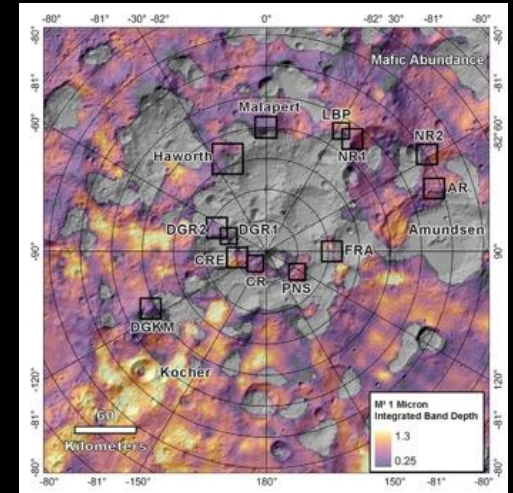
**ESA's Internal Dosimeter Array (IDA):** Instruments including those provided by Japan Aerospace Exploration Agency (JAXA) will inform for improvements in radiation physics models for cancer, cardiovascular, and central nervous system effects, helping assess crew and hardware risk on exploration missions



**Heliophysics Environmental Radiation Measurement Experiment Suite (HERMES)** pictured left: NASA's space weather instrument suite will observe lower energy solar particles critical to scientific investigations of the Sun including the solar winds

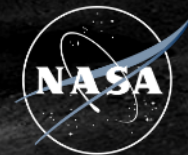
*Gateway's polar orbit will offer unique opportunities for heliophysics, human health research, space biology and life sciences, astrophysics, and fundamental physics investigations. As new modules are added, science capability will increase.*

- The community input process focused on developing objective criteria for site evaluation to enable AIV science objectives, rather than specific sites
- Provide an update on the current state of planning and anticipated architecture capabilities for Artemis IV - **ESDMD & CASSA overview talks**
- Review the Artemis IV science focus and other science objectives to be incorporated into landing site FOMs – **SMD overview talk**
- Identify important characteristics of exploration areas necessary to achieve SPA and other high-priority science – **Community abstracts**
- Facilitate discussion and provide a mechanism for community input in formulating the science figures of merit that will be used by NASA to evaluate potential Artemis IV landing sites – **Breakout groups and reports**
- Foster collaborations among US and international science communities, including across planetary science, biological science, and physical science disciplines – **Virtual attendance** and **published report**



# NASA Artemis V Updates

National Aeronautics and  
Space Administration



Debra Needham

Exploration Science Strategy and Integration Office  
NASA HQ



# Artemis V

## ARTEMIS FIRSTS:

- Use of the lunar terrain vehicle (LTV) rover by crew to access more of the lunar surface and collect diverse scientific samples
- Use of second lunar lander design
- Use of new RS-25 engines

## NEW ELEMENTS:

- Blue Moon human landing system
- LTV unpressurized rover with scientific instruments

## COMMON ELEMENTS:

- Space Launch System rocket Block 1B configuration
- Orion crew spacecraft
- Mobile Launcher 2 with supporting ground systems
- Spacesuits and support systems
- Gateway space station and Deep Space Logistics
- Conducting science and demonstrating technology in orbit and on the surface



Artist's Concept



# Artemis V: Blue Moon HLS Fueling and Pre-staging

## MISSION SUMMARY:

In preparation for the launch of the Artemis V crew aboard Orion on SLS, Blue Origin will launch its Blue Moon Human Landing System (HLS) and fuel it in the selected Near Rectilinear Halo Orbit (NRHO).

## ARTEMIS FIRSTS:

- Crewed demonstration of the Blue Moon lander
- Lunar lander fueled in NRHO for a crewed mission

## NEW ELEMENTS:

- Blue Moon lander
- Cislunar transporter



# ARTEMIS V

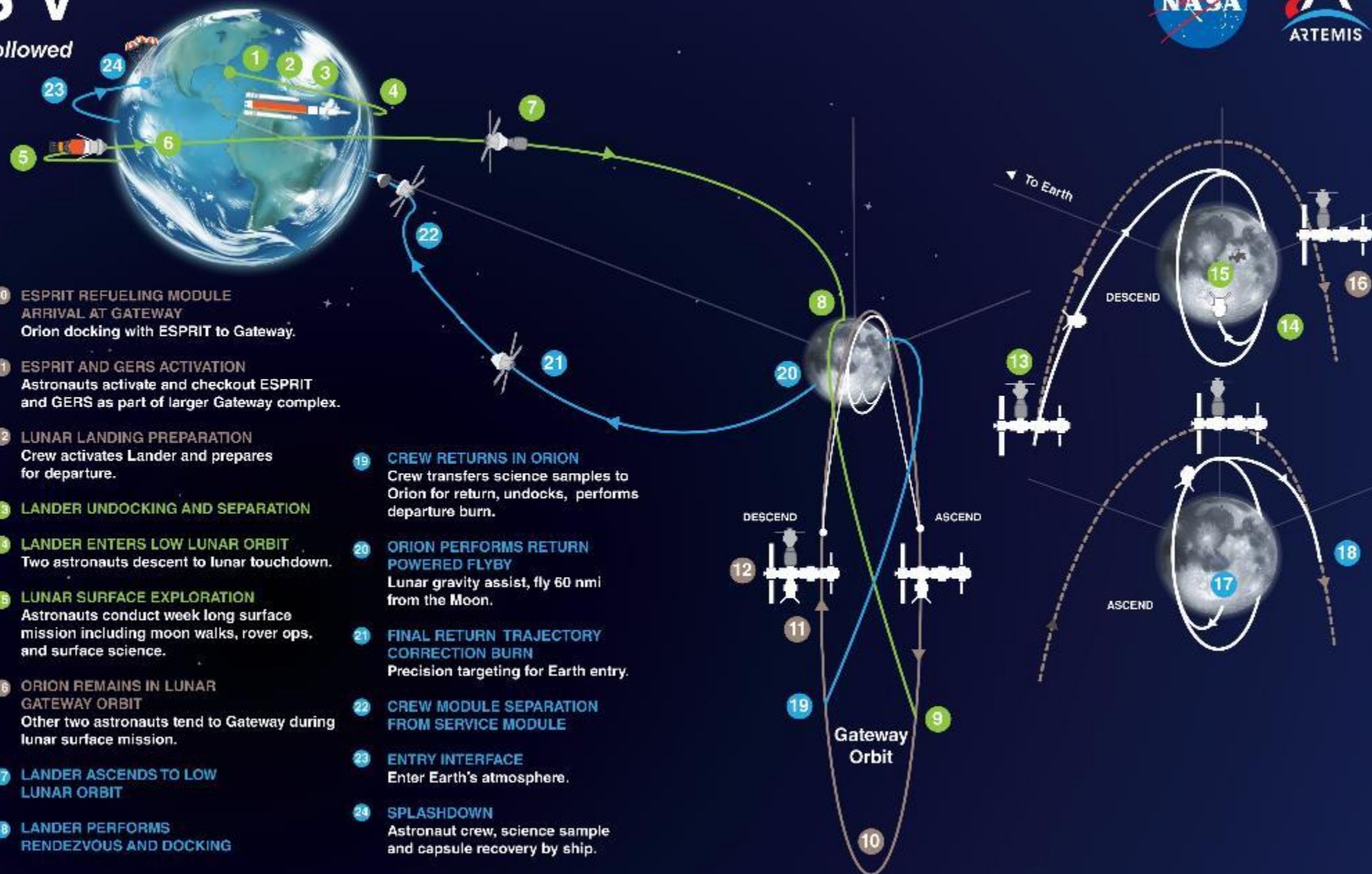
*ESPRIT delivery to Gateway followed by Crewed Lunar Landing*



- 1 LAUNCH**  
SLS with ESPRIT payload and crewed Orion lift-off from Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**  
With separation.
- 4 ENTER EARTH ORBIT**  
Exploration Upper Stage performs circularization of Low Earth Orbit. Systems check and solar panel adjustments.
- 5 TRANS LUNAR INJECTION BURN**  
Exploration Upper Stage commits Astronauts in Orion and ESPRIT to lunar trajectory.
- 6 ORION TUGS ESPRIT TO MOON**  
Orion separation from USA, docking with ESPRIT and extraction from USA followed by Orion tug of ESPRIT to Gateway orbit and EUS disposal.
- 7 ORION OUTBOUND TRANSIT TO MOON**  
Perform periodic outbound trajectory correction maneuvers.
- 8 ORION OUTBOUND POWERED FLYBY**  
Lunar gravity assist, fly 60 nmi from the Moon.
- 9 GATEWAY ORBIT INSERTION BURN**  
Orion performs burn to establish rendezvous point and executes rendezvous.

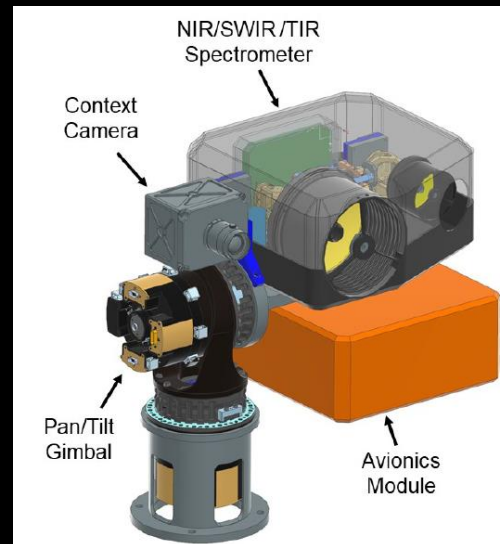
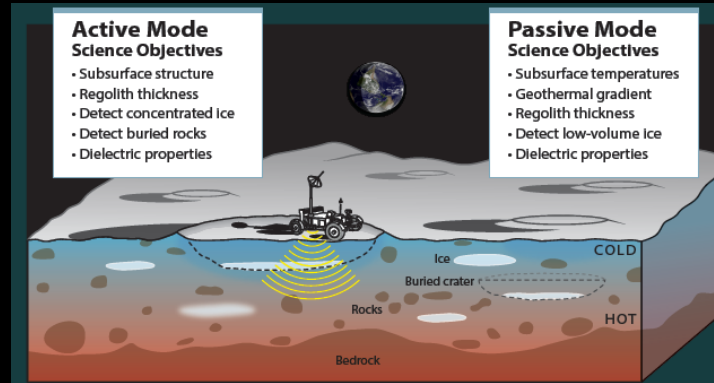
- 10 ESPRIT REFUELING MODULE ARRIVAL AT GATEWAY**  
Orion docking with ESPRIT to Gateway.
- 11 ESPRIT AND GERS ACTIVATION**  
Astronauts activate and checkout ESPRIT and GERS as part of larger Gateway complex.
- 12 LUNAR LANDING PREPARATION**  
Crew activates Lander and prepares for departure.
- 13 LANDER UNDOCKING AND SEPARATION**
- 14 LANDER ENTERS LOW LUNAR ORBIT**  
Two astronauts descent to lunar touchdown.
- 15 LUNAR SURFACE EXPLORATION**  
Astronauts conduct week long surface mission including moon walks, rover ops, and surface science.
- 16 ORION REMAINS IN LUNAR GATEWAY ORBIT**  
Other two astronauts tend to Gateway during lunar surface mission.
- 17 LANDER ASCENDS TO LOW LUNAR ORBIT**
- 18 LANDER PERFORMS RENDEZVOUS AND DOCKING**

- 19 CREW RETURNS IN ORION**  
Crew transfers science samples to Orion for return, undocks, performs departure burn.
- 20 ORION PERFORMS RETURN POWERED FLYBY**  
Lunar gravity assist, fly 60 nmi from the Moon.
- 21 FINAL RETURN TRAJECTORY CORRECTION BURN**  
Precision targeting for Earth entry.
- 22 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 23 ENTRY INTERFACE**  
Enter Earth's atmosphere.
- 24 SPLASHDOWN**  
Astronaut crew, science sample and capsule recovery by ship.

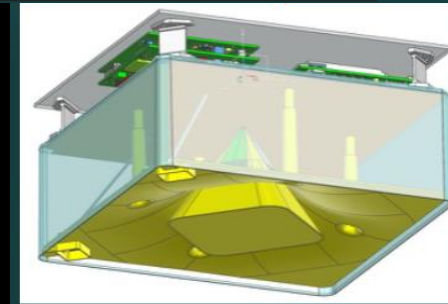


## Lunar Terrain Vehicle Selected!

NASA has selected



Artemis Infrared Reflectance and Emission Spectrometer (AIRES; Ariz State Univ), a near/short-wavelength infrared spectrometer, thermal infrared spectrometer



## LTV Instruments Selected!

Lunar Microwave Active Passive Spectrometer (L-MAPS; Univ Hawaii) is a dual passive microwave spectrometer and ground penetrating radar system



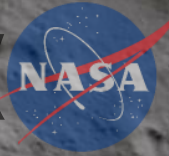
## NASA Selects Freezer for Artemis V+!

University of Alabama, Birmingham selected to develop and build the freezer for Artemis (expected for Artemis V+), to enable return of cold conditioned science samples for analysis on Earth.

Polar, developed by UAB, is a -95°C freezer designed for use on the International Space Station and provides storage for a broad range of science samples during transportation to and from the ISS and while aboard the ISS.



# Other Moon2Mars Updates of Note



- 2025 Architecture Definition Document published!
  - Reorganized for clarity but much of the content is the same
  - New elements added – Lunar Utility Rover and Lunar Nuclear Fission System
  - Updates made to Technology Gaps
  - Initial release of new Exploration-derived Data Gaps
  - New White Papers (6) released, including a “Why: Moon to Mars” that explains the iterative process NASA is taking to build capabilities that overcome the challenges of deep space exploration



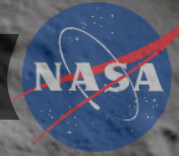
Moon to Mars Architecture Update  
2025 Architecture Concept Review

Exploration Systems Development Mission Directorate  
National Aeronautics and Space Administration

[www.nasa.gov/architecture](http://www.nasa.gov/architecture)



# 2025 Products – Architecture Definition Document Revision C



### Segments

Architecture Components: Segments

**3.1.4 Humans to Mars**



The Humans to Mars program will establish a human presence on Mars and establish self-sustaining operations on the surface. Since the earliest stage of development, the Red Planet has captured the imagination. The Human to Mars architecture will deliver a truly step-by-step approach to human exploration.

Building on previous programs, the program will include the initial exploration and settlement activities on Mars, followed by the return to Earth. After initial human presence on the Red Planet, NASA will support the program to explore and colonize Mars.

**3.1.4.1 Surface Operations**

The Human to Mars program will support the Mars Surface Operations in the Red Planet to establish the Mars surface operations in Mars. The program will include the initial exploration and settlement activities on Mars, followed by the return to Earth. After initial human presence on the Red Planet, NASA will support the program to explore and colonize Mars.

**3.1.4.1.1 Human Exploration**

Human Exploration on Mars will include the initial exploration and settlement activities on Mars, followed by the return to Earth. After initial human presence on the Red Planet, NASA will support the program to explore and colonize Mars.

Human to Mars Architecture Definition Document 47

### Sub-Architectures

Architecture Components: Sub-Architectures

**3.3.12 Communications Systems and Facilities**

This sub-architecture includes the communications systems and facilities that will support the Human to Mars program. It includes the communications systems and facilities that will support the Human to Mars program.

**3.3.12.1 Communications Systems and Facilities**

The Communications Systems and Facilities sub-architecture includes the communications systems and facilities that will support the Human to Mars program. It includes the communications systems and facilities that will support the Human to Mars program.

Human to Mars Architecture Definition Document 41

### Element One Pagers

Architecture Components: Element One Pagers

**3.3.12.1.1 Orion Spacecraft**



The Orion spacecraft is the primary element of the Human to Mars program. It will support the Human to Mars program by providing the crew with the necessary life support and propulsion systems.

The Orion spacecraft includes the Crew Module, Service Module, and Launch Abort System. The Orion spacecraft will support the Human to Mars program by providing the crew with the necessary life support and propulsion systems.

Human to Mars Architecture Definition Document 40

### Tech Gaps

Appendix B: Architecture Design Technology Gaps

Identifying Technology Gaps

This appendix identifies the technology gaps that will be required to support the Human to Mars program. It includes the technology gaps that will be required to support the Human to Mars program.

Human to Mars Architecture Definition Document 38

### Unallocated Functions

Appendix B: Architecture Design Technology Gaps

Unallocated Functions by Use Case

**UC-A-204 L** Communications and navigation, and timing for crew and surface operations.

**UC-A-205 L** Communications and navigation, and timing for crew and surface operations.

**UC-A-206 L** Communications and navigation, and timing for crew and surface operations.

**UC-A-207 L** Communications and navigation, and timing for crew and surface operations.

**UC-D-201 L** Storage and processing of data on the surface.

Human to Mars Architecture Definition Document 48

### Functional Mappings

Appendix B: Architecture Design Technology Gaps

Element Function Mappings

**B.2.3 Exploration Ground Systems**

**B.2.3.1 Mission Level System**

UC ID	Function	UC ID	Function
PA-0141	Provide ground services on Earth	PA-0142	Manage communications and propulsion
PA-0143	Manage communications and propulsion	PA-0144	Provide multiple access elements for vehicles
PA-0145	Manage communications and propulsion	PA-0146	Manage communications and propulsion
PA-0147	Manage communications and propulsion	PA-0148	Manage communications and propulsion
PA-0149	Manage communications and propulsion	PA-0150	Manage communications and propulsion

Human to Mars Architecture Definition Document 46

### Element Icons

Architecture Components: Element Icons

Element Icons

Architecture Component	Icon	UC ID	Function	UC ID	Function
Communications and Navigation	[Icon]	UC-01	Communications and navigation	UC-01	Communications and navigation
Propulsion and Power	[Icon]	UC-02	Propulsion and power	UC-02	Propulsion and power
Life Support	[Icon]	UC-03	Life support	UC-03	Life support
Thermal Protection	[Icon]	UC-04	Thermal protection	UC-04	Thermal protection
Structural	[Icon]	UC-05	Structural	UC-05	Structural
Human Factors	[Icon]	UC-06	Human factors	UC-06	Human factors
Medical	[Icon]	UC-07	Medical	UC-07	Medical
Electronics	[Icon]	UC-08	Electronics	UC-08	Electronics
Software	[Icon]	UC-09	Software	UC-09	Software
Manufacturing	[Icon]	UC-10	Manufacturing	UC-10	Manufacturing
Testing	[Icon]	UC-11	Testing	UC-11	Testing
Operations	[Icon]	UC-12	Operations	UC-12	Operations
Support	[Icon]	UC-13	Support	UC-13	Support
Training	[Icon]	UC-14	Training	UC-14	Training
Acquisition	[Icon]	UC-15	Acquisition	UC-15	Acquisition
Integration	[Icon]	UC-16	Integration	UC-16	Integration
Verification	[Icon]	UC-17	Verification	UC-17	Verification
Validation	[Icon]	UC-18	Validation	UC-18	Validation
Deployment	[Icon]	UC-19	Deployment	UC-19	Deployment
Operations	[Icon]	UC-20	Operations	UC-20	Operations
Support	[Icon]	UC-21	Support	UC-21	Support
Training	[Icon]	UC-22	Training	UC-22	Training
Acquisition	[Icon]	UC-23	Acquisition	UC-23	Acquisition
Integration	[Icon]	UC-24	Integration	UC-24	Integration
Verification	[Icon]	UC-25	Verification	UC-25	Verification
Validation	[Icon]	UC-26	Validation	UC-26	Validation
Deployment	[Icon]	UC-27	Deployment	UC-27	Deployment
Operations	[Icon]	UC-28	Operations	UC-28	Operations
Support	[Icon]	UC-29	Support	UC-29	Support
Training	[Icon]	UC-30	Training	UC-30	Training

Human to Mars Architecture Definition Document 44

### Data Gaps

Appendix C: Architecture Design Technology Gaps

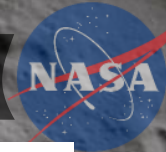
E.2 Catalog of Data Gaps

This appendix provides a catalog of data gaps that will be required to support the Human to Mars program. It includes the data gaps that will be required to support the Human to Mars program.

Human to Mars Architecture Definition Document 36



# Architecture-Driven Technology and Data Gaps



## D.2 Prioritized List of Technology Gaps

This list below captures the architecture-driven technology gaps in priority order. The technology gaps fall into priority bins based on similar level of preference. This list includes gap identification number, title, rating, overall prioritization rating, and priority bin. For the full details for any given technology gap, refer to Appendix D.3.

ID	Gap Title	Priority Rating	Priority Bin
0801	Lunar Dust-Tolerant Systems and Dust Mitiga		
0201	Extreme Environment Avionics		
0301	Systems to Survive and Operate through Exter Shadow		
1107	Cryogenic Fluid Transfer		
0103	High-bandwidth, High-reliability Surface-to-S		
1104	Mars Transportation Propulsion		
0806	Payload Offloading, Handling, and Manipulat		
0805	Autonomous Surface Mobility and Navigation		
0305	Food and Nutrition Capabilities for Long-Dura		
1103	Mars Entry, Descent, and Landing for Human		
0304	Habitat Environmental Monitors and Capabili Missions		
1105	Mars Ascent Propulsion for Human Exploratic		
0901	Scalable Lunar Surface Power Generation		
1001	High-performance Actuators, Sensors, and In		
0807	Docking and Berthing between Surface Eleme		
0303	Dormancy Recovery for Habitat Water Storage Reclamation		
0307	Radiation Monitoring and Forecasting	17	
1003	Integrated System Fault/Anomaly Diagnosis, Decision Support, and Response	18	
0804	Robotic and Mobility Systems in Extreme Cold Environments on the Lunar Surface	19	
0101	Positioning, Navigation, and Timing for Lunar Surface Extreme Environments	20	
0702	Waste Management	21	
0302	Fire Safety Upgrades for Surviving Exploration Mission Environments	22	
0701	Packing, Transport, and Use of Conditioned Supplies and Commodities	23	
0903	Power Management and Distribution between Surface Elements	24	
0808	Relocation of Large Assets on the Lunar Surface	25	
0202	High-Performance Onboard Computing	26	
1101	Lunar Precision Landing and Hazard Avoidance for Human Exploration	27	
1005	Safe Human-Robot Interaction and Teaming	28	
0505	In-Situ Additive/Subtractive Construction on the Lunar Surface	29	
0504	Autonomous Lunar Surface Structure Assembly and Construction	30	
0803	Extravehicular Activity (EVA) and Intravehicular Activity (IVA) Suit System and Capabilities for Mars Missions	31	
1106	Cryogenic Fluid Storage	32	
1004	Trustworthy Autonomy for Planning and Decision-making	33	
1002	Autonomous Monitoring for Exploration Missions	34	4
0802	Mars Dust-Tolerant Systems and Dust Mitigation	35	
0501	Robotic Inspection, Maintenance, and Repair	36	
1102	Mars Precision Landing and Hazard Avoidance for Human Exploration	37	
1201	In-Situ Sample Storage and Processing	38	5

## E.1 List of Data Gaps

The current list of data gaps represents a snapshot in time. Future revisions of this document will update the list as gaps close and new gaps are identified. The current list is a representative sample — it is neither comprehensive nor complete. While the current data gaps are not listed in priority order, they all represent near-term, high-priority needs.

ID	Data Gap Title
DN-001 L	Sustained, site-specific sub-meter scale imaging of lunar south pole exploration zones and sites
DN-002 L	Comprehensive, high-fidelity digital elevation map (DEM) coverage of lunar south pole exploration zones and sites
DN-003 L	High-resolution, time-resolved thermal mapping of lunar south pole exploration regions and sites
DN-004 L	Collection of imagery over lunar surface exploration sites to monitor impacts of human exploration
DN-005 L	Optical images from lunar surface at the lunar south pole
DN-006 L	Orbital observations of water ice deposits in the south polar region
DN-007 L	In situ measurements of the horizontal and vertical distribution, abundance, and physical makeup of shallow bulk water ice
DN-008 L	Geotechnical properties of highland regolith
DN-009 L	Electrostatic properties of highland regolith
DN-010 L	South polar lunar regolith elemental and m
DN-011 L	In situ lunar surface plasma environment cl
DN-012 L	In situ lunar surface radiation environment monitoring
DN-013 L	In situ measurements of the composition, c near-surface lunar south pole
DN-014 L	High resolution lunar rock size distribution
DN-015 L	Flux and size measurements of lunar meteoroid ejecta
DN-016 L	Lunar surface seismic activity characterization and monitoring
DN-017 L	In situ measurement of particle velocity during lunar plume surface interaction (PSI) phenomena
DN-018 L	In situ measurement of landing site alteration imaging at small scale on the lunar surface
DN-019 L	In situ measurement of lunar regolith (dust) particle flux and charge
DN-001 M	Geotechnical properties of Mars regolith, rocks, and bedrock at diverse geographic locations
DN-002 M	Surface and subsurface water content at surface exploration sites
DN-003 M	Localized and predictive Mars surface weather characterization
DN-004 M	Human-scale EDL atmospheric entry environment characterization
DN-005 M	In situ measurement of particle velocity during Martian plume surface interaction (PSI) phenomena
DN-006 M	In situ measurement of landing site alteration imaging at small scale on Mars

# Architecture Measures of Performance

COMMUNICATIONS  
OPPORTUNITY

HABITATION  
OPPORTUNITY

POWER  
OPPORTUNITY

CARGO  
OPPORTUNITY

MOBILITY  
OPPORTUNITY

CREW TIME  
OPPORTUNITY



2025

2024

2023

2022



## Architecture White Papers

- 1 Why Moon and Mars? Building an Evolutionary Architecture
- 2 Integrated Lunar Power Considerations
- 3 Architecture-Driven Planetary Protection Considerations
- 4 Comms and Navigation Needs for Foundational Exploration
- 5 Architecture-Driven Data Gaps
- 6 Architecture Definition (*update to prev. papers*)



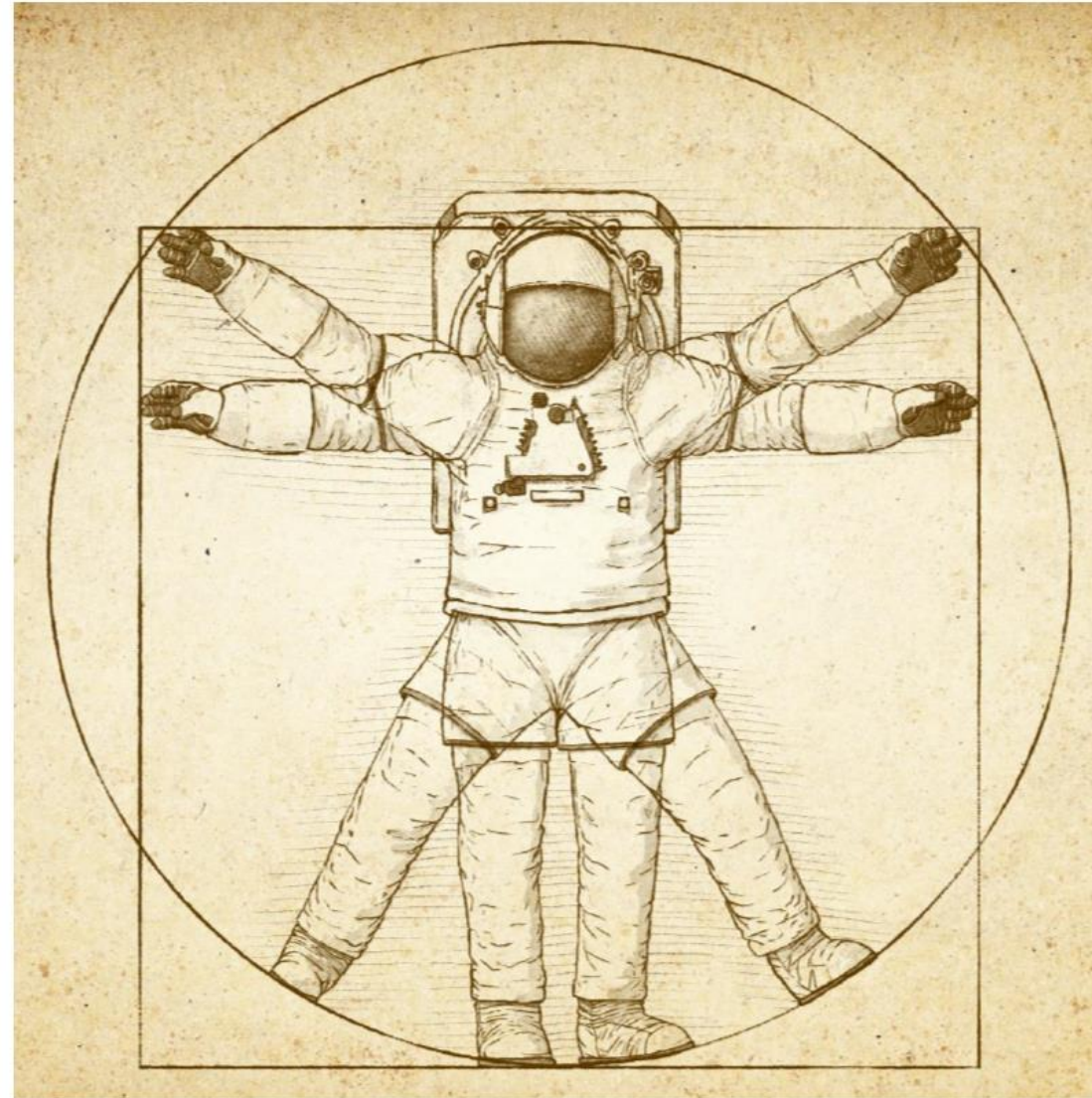
## Industry and Academia

January 21-22, 2026  
Washington, DC



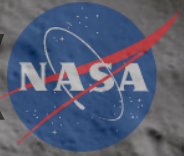
## International Partners

February 24-25, 2026  
Rome, Italy





# Other Moon2Mars Updates of Note



- 2025 Architecture Definition Document published!
  - Encourage community review, comments accepted anytime
    - [HQ-M2M@mail.nasa.gov](mailto:HQ-M2M@mail.nasa.gov)
- Moon to Mars Architecture Workshops:
  - Domestic Industry and Academia Workshop January 21-22, 2026 Washington, D.C.
  - International Partner Workshop February 24-25, 2026 Rome, Italy
  - Attendance is by invitation only; to register (deadline January 7, 2025), go to [www.nasa.gov/architecture](http://www.nasa.gov/architecture)



Moon to Mars Architecture Update  
2025 Architecture Concept Review

Exploration Systems Development Mission Directorate  
National Aeronautics and Space Administration

[www.nasa.gov/architecture](http://www.nasa.gov/architecture)

