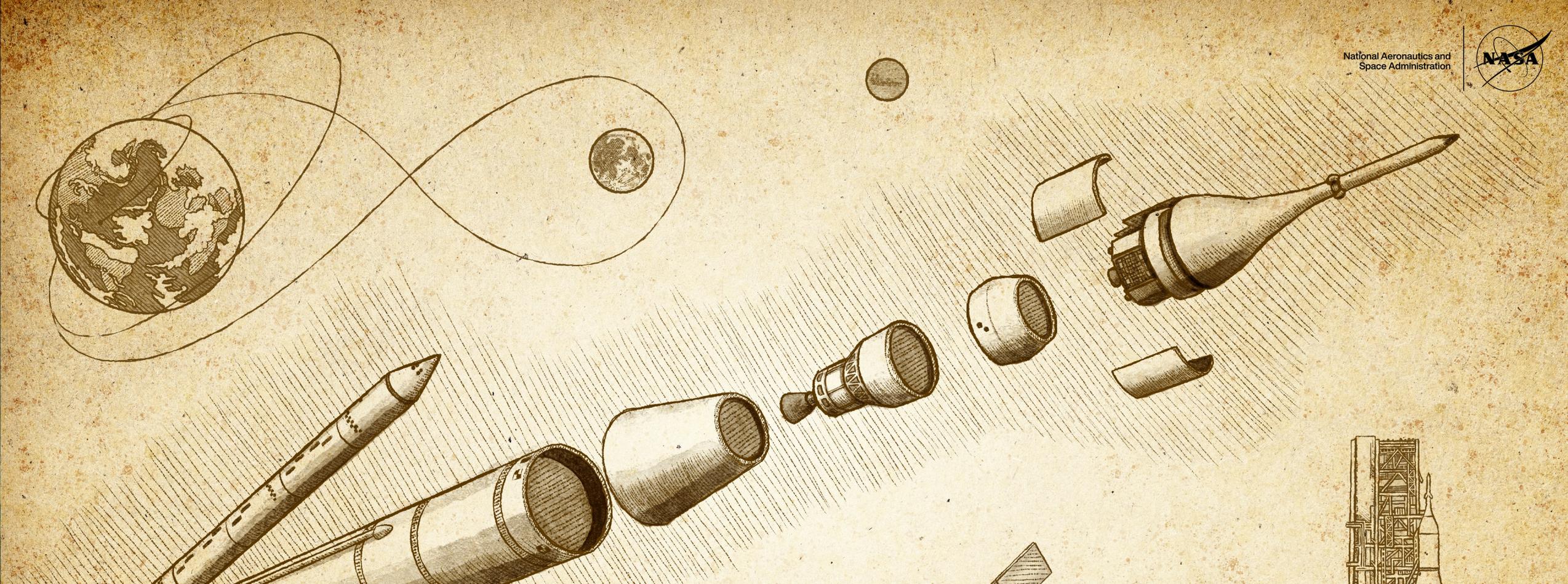




# Moon to Mars Architecture Workshop for International Partners

Co-Hosted with the Italian Space Agency in Rome, Italy



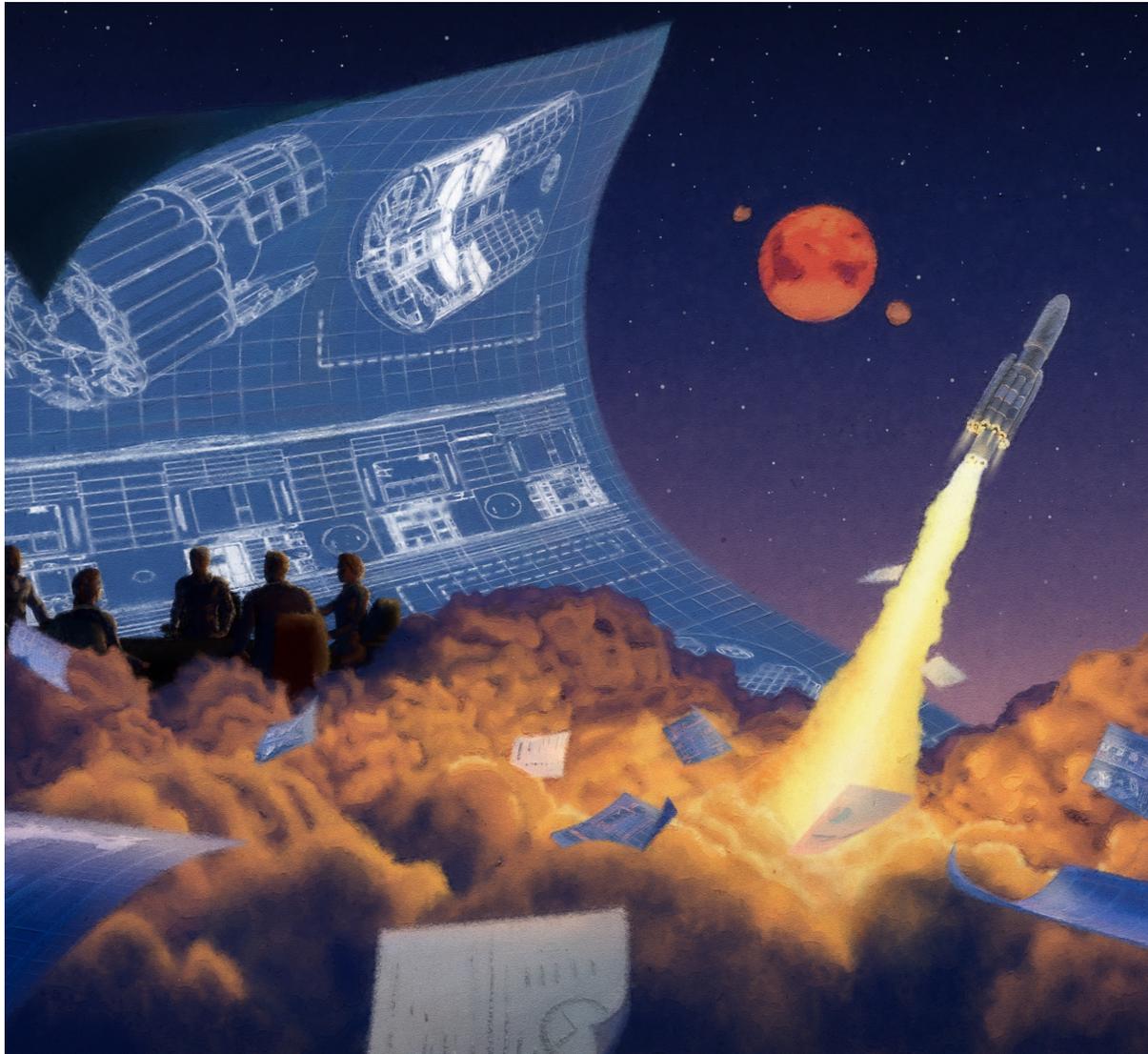
# 2025 Architecture Concept Review Updates

**Nujoud Merancy**  
Deputy Associate Administrator

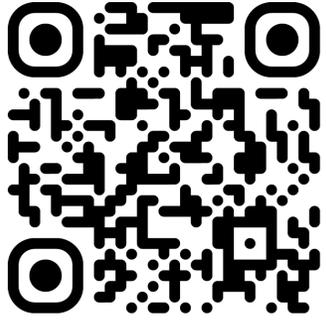
Strategy and Architecture Office  
Exploration Systems Development Mission Directorate  
National Aeronautics and Space Administration



# Welcome!



- Spurred additional communication on topics including Logistics, Mobility, Power, and Comm & Nav, etc
- Adapting engagement to enable more industry studies in priority areas
- Changes to solicitation, procurement, and study approaches
- Informed development of NASA's architecture-driven technology gaps and data gaps
- And More...



## 2025 Architecture Products

### Architecture White Papers

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

Architecture Definition Document  
Revision C and Architecture Update



# Incorporating Your Feedback: Product Revitalization



**Architecture Definition Document  
Revision C**

National Aeronautics and Space Administration

NASA's  
**Moon to Mars Architecture**

Architecture Definition Document  
ESDMD-001 Revision C

## Segments

### 2.1.4 Humans to Mars

The **Humans to Mars** segment will establish a human presence on Mars and employ new extensions on its surface. Since the earliest days of spaceflight, the Red Planet has captured humanity's imagination. The Moon to Mars Architecture was a course to finally step foot on a planet beyond Earth's sky.

Building on previous segments, this segment will include the initial capabilities and systems necessary to safely transit from Earth to the surface, and return safely to Earth. After landing humans on the Red Planet, NASA will prepare for progressively longer and more complex missions there.

### 2.1.4.1 Summary/Objective

The Humans to Mars segment will establish a human presence on Mars and achieve the Mars-specific goals outlined in NASA's Moon to Mars Objectives. These objectives include crewed science and operations goals, as well as Mars-specific infrastructure and transportation and habitation goals. These objectives drive NASA's objective decomposition for the Mars architecture.

## Sub-Architectures

### 2.3.1.2 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Element One Pagers

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Tech Gaps

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Unallocated Functions

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Functional Mappings

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Element Icons

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

## Data Gaps

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

### 2.3.1.2.1 Orion Spacecraft

The Orion spacecraft will be the primary crewed vehicle for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in lunar orbit.

# Why Moon and Mars?



## Historical Context



Crawl

### Project Mercury<sup>[2]</sup> 1961 – 1963

Six Crewed Flights

During Project Mercury, NASA developed foundational spaceflight capabilities, successfully placed astronauts in orbits, and returned them safely to Earth.

#### OBJECTIVES

- Place a crewed spacecraft in orbit.
- Investigate human performance in space.
- Recover astronauts and spacecraft safely.



Walk

### Project Gemini<sup>[3]</sup> 1964 – 1966

10 Crewed Flights

During Project Gemini, NASA bridged gaps between capabilities developed under Project Mercury and those needed to send humanity to the Moon.

#### OBJECTIVES

- Test astronauts' ability to fly long-duration missions.
- Understand spacecraft rendezvous and docking.
- Perfect re-entry and landing methods.



Run

### The Apollo Program<sup>[4]</sup> 1967 – 1972

Nine Crewed Flights

During Apollo, NASA leveraged lessons learned, technologies developed, and astronauts trained during Mercury and Gemini to send crews to the Moon.

#### OBJECTIVES

- Land humans on the Moon and return them to Earth.
- Live, work, and conduct science on the lunar surface
- Establish capabilities that meet national interests.

## Building on Experience

### Exploration Challenges by Destination

#### DISTANCE FROM EARTH



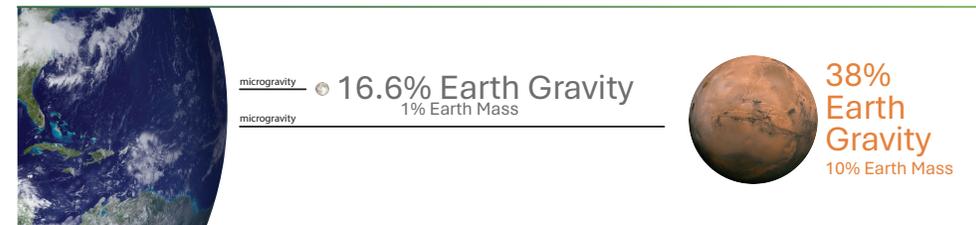
#### ONE-WAY JOURNEY



#### LIGHT-TIME DELAY



#### GRAVITY



## Programmatic Considerations

- American Leadership
- Engineering and Design
- Operations
- Human Systems

Read the White Paper



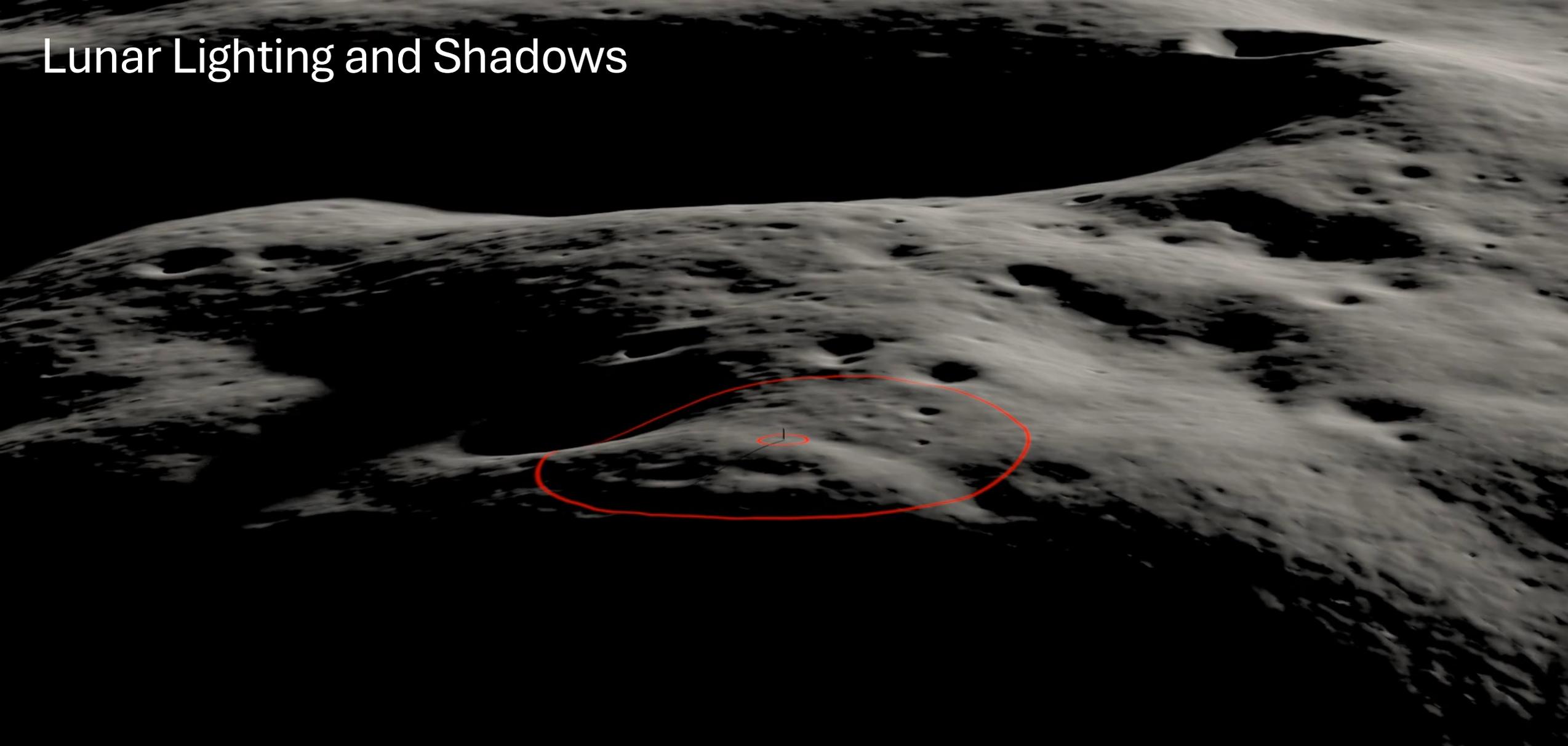
2018  
white paper



# The Lunar South Pole Region



# Lunar Lighting and Shadows



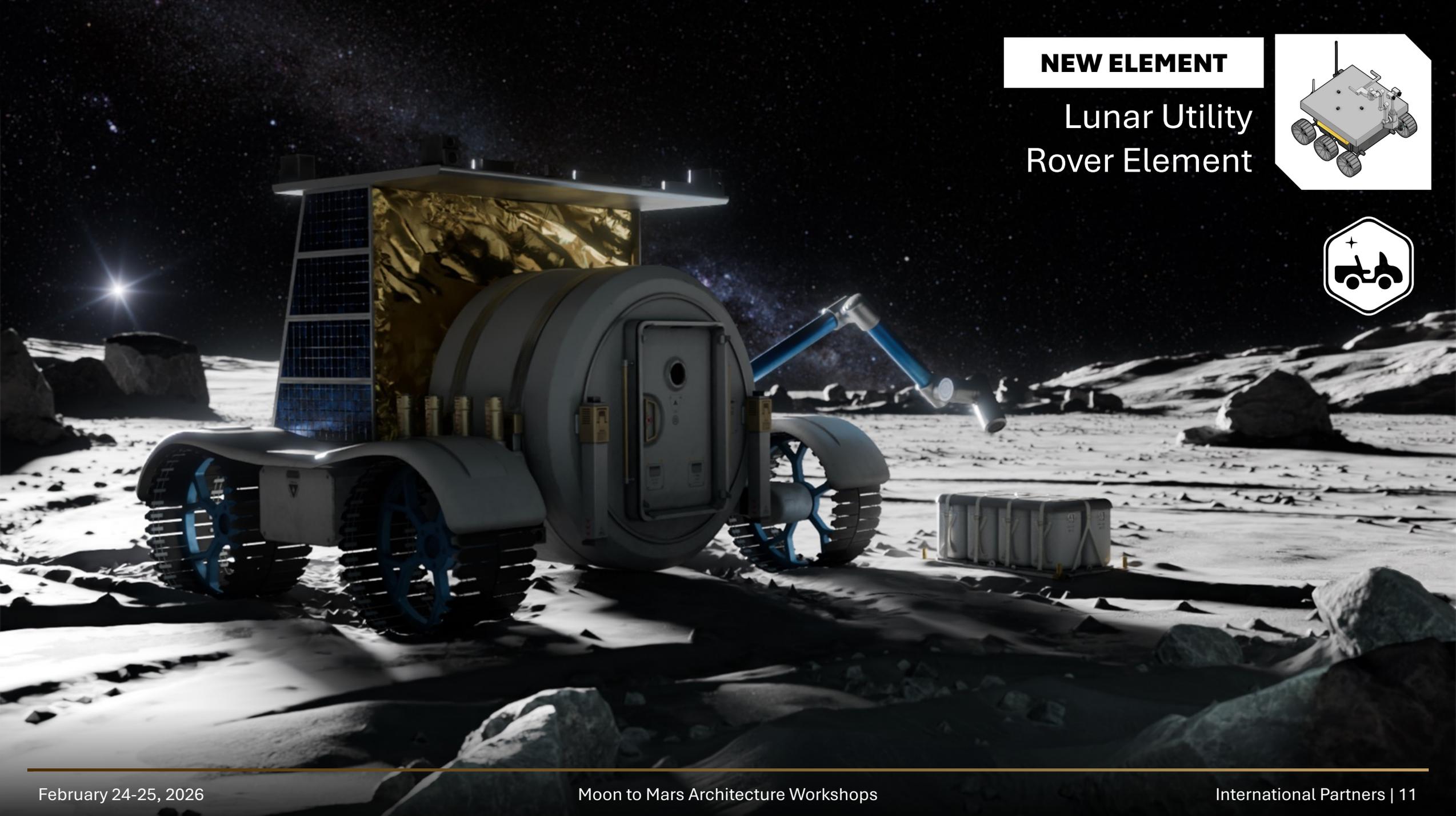
500 m

<b>Time</b>	23 Oct 2026 00:00 UT
<b>Sun Az, Alt</b>	357.60° 6.07°
<b>Earth Az, Alt</b>	316.80° 5.56°

# Roving the Lunar Highlands

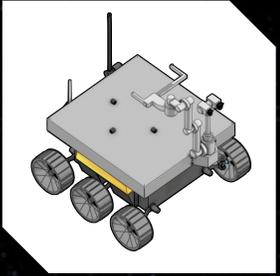
*Apollo 16 - April 1972*





**NEW ELEMENT**

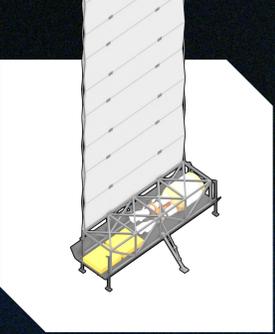
Lunar Utility  
Rover Element





**NEW ELEMENT**

Lunar Nuclear Fission System



ID	Initial Set of Architecture-Driven Data Gaps
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 at the lunar south pole
DN-009 L	Electrostatic properties of highland regolith at the lunar south pole
DN-010 L	South polar lunar regolith elemental and mineral composition
DN-011 L	In situ lunar surface plasma environment characterization
DN-012 L	In situ lunar surface radiation environment measurements and space weather monitoring
DN-013 L	In situ measurements of the composition, distribution, and abundance of volatiles in the near-surface lunar south pole
DN-014 L	High resolution lunar rock size distribution and morphology at the lunar south pole
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

# Measuring Architecture Performance Over Time

## COMMUNICATIONS OPPORTUNITY

## HABITATION OPPORTUNITY

## POWER OPPORTUNITY

## CARGO OPPORTUNITY

## MOBILITY OPPORTUNITY

## CREW TIME OPPORTUNITY

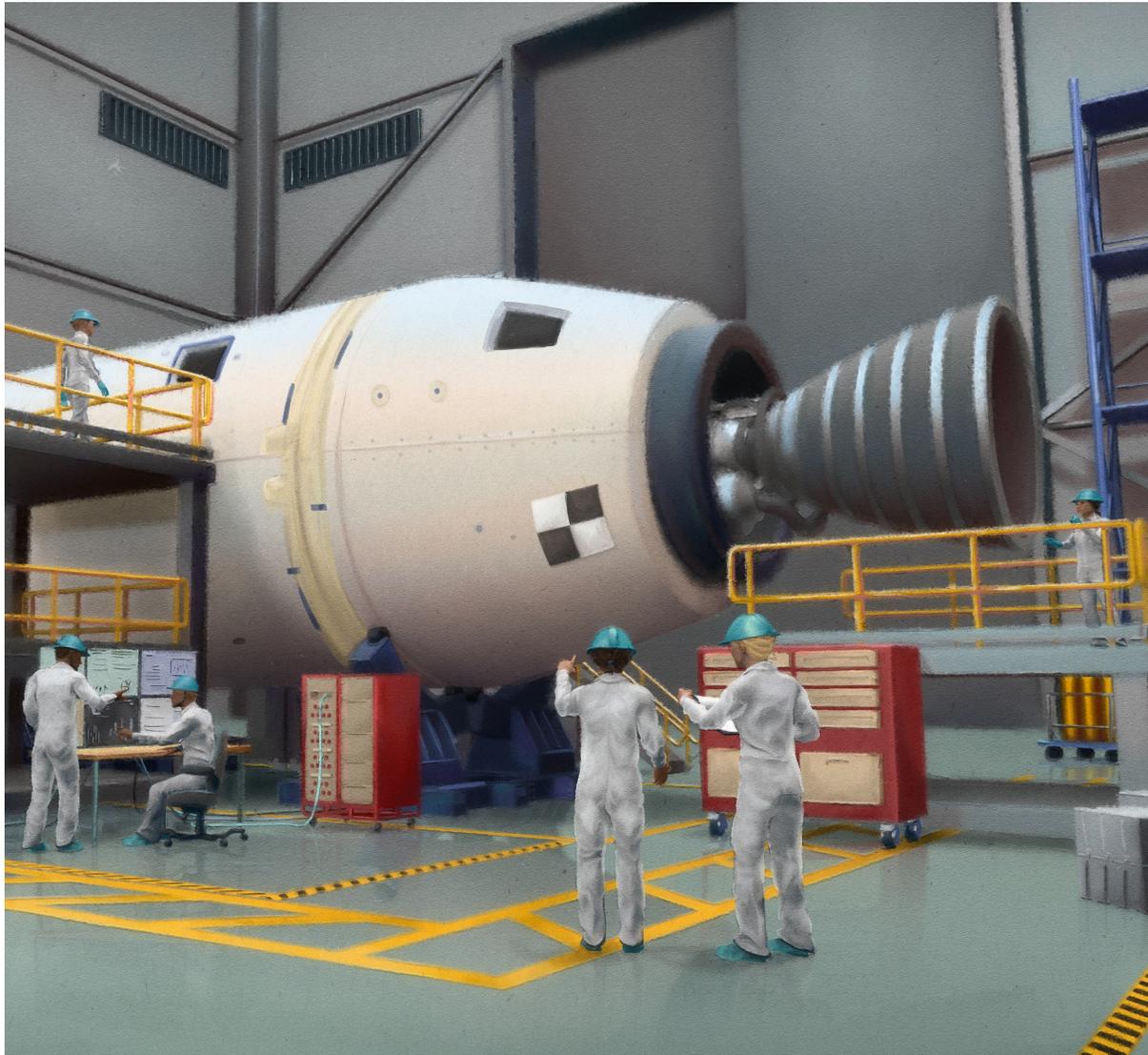


2025  
2024  
2023  
2022

## Architecture Definition Outcome

The Moon to Mars Architecture's initial Humans to Mars segment will target no fewer than four (4) crew to the surface, with consideration for no fewer than six (6) crew to enhance mission capability and/or provide risk reduction.





- As part of the 2025 Architecture Concept Review, NASA elevated three deep space standards to the architecture level, joining the communications standard elevated in 2024.
- You can learn more on the architecture website at the link below:  
<https://www.nasa.gov/international-deep-space-standards/>



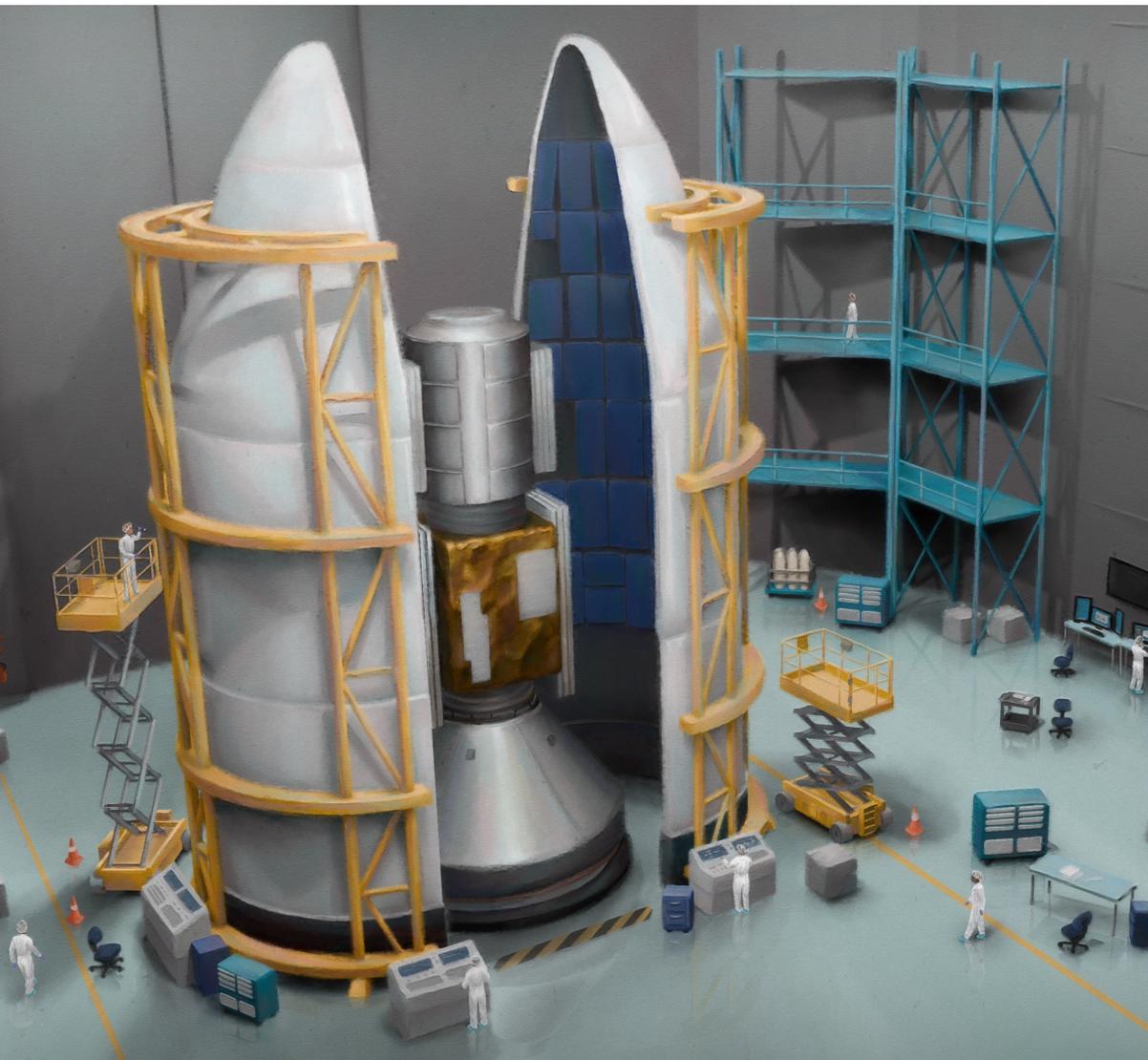
ADOPTED 2024



ADOPTED 2025



- NASA is not looking for passive participants at these workshops; **we desire and appreciate your honest feedback on the evolution of NASA's Moon to Mars Architecture.**
- To facilitate open conversation, NASA will not record sessions; nor have we invited media or press. **However, NASA will take notes in all sessions to ensure we capture your feedback.**
- After the event, NASA will make all presentations available on our website at the link below:  
<https://www.nasa.gov/moontomarsarchitecture-architectureworkshops/>



- The **NextSTEP Appendix B Industry Day** is a separate event with independent registration; Please hold all questions about Appendix B until the industry day.
  - In the meantime, you can find additional information here: <https://www.nasa.gov/general/nextstep-3-b-moon-to-mars-architecture-studies/>
  - If you have questions about registration for the industry day, you may reach out to the email below: [hq-nextstep3appb@mail.nasa.gov](mailto:hq-nextstep3appb@mail.nasa.gov)
- Most NASA representatives may not discuss **fission surface power system proposals** during the pre-solicitation and solicitation periods.
  - For procurement information, see the draft announcement for partnership proposals: <https://sam.gov/workspace/contract/opp/f653f35bd344451d990625943861caa0/view>
  - For technical information, consult the fission power system technical library: <https://sam.gov/workspace/contract/opp/f0167a10dd41487c91b3a7202a19e3b2/view>



# Questions?



FIRESIDE CHAT

# Your Feedback Matters: How Partners Shape the Architecture



# Incorporating Your Feedback: ADD Before and After



Architecture Definition Document  
Revision C

National Aeronautics and Space Administration

NASA's  
**Moon to Mars  
Architecture**

Architecture Definition Document  
ESDMD-001 Revision C

Rev-B

3.1.4.8.2 Orion<sup>12</sup> Overview

**Figure 3-9. Orion Spacecraft**

The Orion spacecraft, NASA's next-generation spacecraft to take astronauts on a journey of exploration to the Moon and on to Mars, is shown in Figure 3-9. The Orion spacecraft serves as the primary crew vehicle for Artemis missions for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the SLS. The Orion spacecraft includes the Crew Module (CM), Service Module (SM), and Launch Abort System (LAS). The CM is capable of transporting four crew members beyond the Moon, providing a safe habitat from launch through landing and recovery. The SM, made up of the NASA-provided Crew Module Adapter (CMA) and the ESA-provided European Service Module (ESM), provides support to the crew module from launch through separation prior to entry. The SM provides in-space propulsion for orbital transfer, power and thermal control, attitude control, and high-altitude ascent aborts. While mated with the crew module, the SM also provides water and air to support the crew. The LAS, positioned on a tower atop the CM, can activate within milliseconds to propel the vehicle to safety and position the CM for a safe landing.

The functions the Orion spacecraft fulfills in the HLR campaign segment are shown in Table 3-9.

<sup>12</sup> For more information, please visit: [www.nasa.gov/exploration/systems/orion/index.html](http://www.nasa.gov/exploration/systems/orion/index.html)

Moon to Mars Architecture Definition Document (ESDMD-001 Rev-B MD-01) 96

Rev-C

Architecture Components

Elements

2.3.12 Orion Spacecraft

**Element Description**

The Orion spacecraft serves as the primary crew vehicle for Artemis missions for transporting crew between Earth and lunar orbit. The vehicle can conduct regular in-space operations in conjunction with payloads delivered by the Space Launch System and can dock with the Human Landing System and Gateway in cislunar orbit.

The Orion spacecraft includes the Crew Module, Service Module, and Launch Abort System. The Crew Module can transport four crew members beyond the Moon, providing a safe habitat from launch through landing and recovery.

The Service Module, made up of the NASA-provided Crew Module Adapter and the ESA-provided European Service Module, provides support to the crew module from launch through separation prior to entry. The Service Module provides in-space propulsion for orbital transfer, power and thermal control, attitude control, and high-altitude ascent aborts. While mated with the crew module, the Service Module also provides water and air to support the crew.

The Launch Abort System, positioned on a tower atop the Crew Module, can activate within milliseconds to propel the vehicle to safety and position the Crew Module for a safe landing.

Implementing Program		Functional Mappings	
Orion Program Moon to Mars Program Office		Appendix B B.3.12	
Segments	Sub-Architecture	Element Icon	
Human Lunar Return	Foundational Exploration	Transportation Systems	

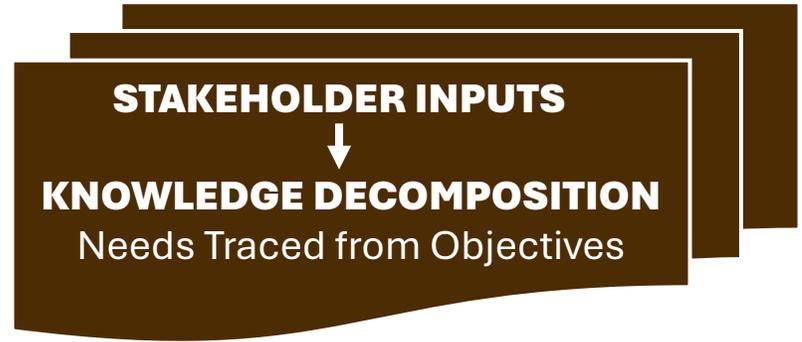
*Header Image: Orion captures a unique view of Earth and the Moon, seen from a camera mounted on one of the spacecraft's solar arrays during the uncrewed Artemis I mission. (Credit: NASA)*

Architecture Definition Document – Element One Pager

Moon to Mars Architecture Definition Document 62



# Data Gaps Definition



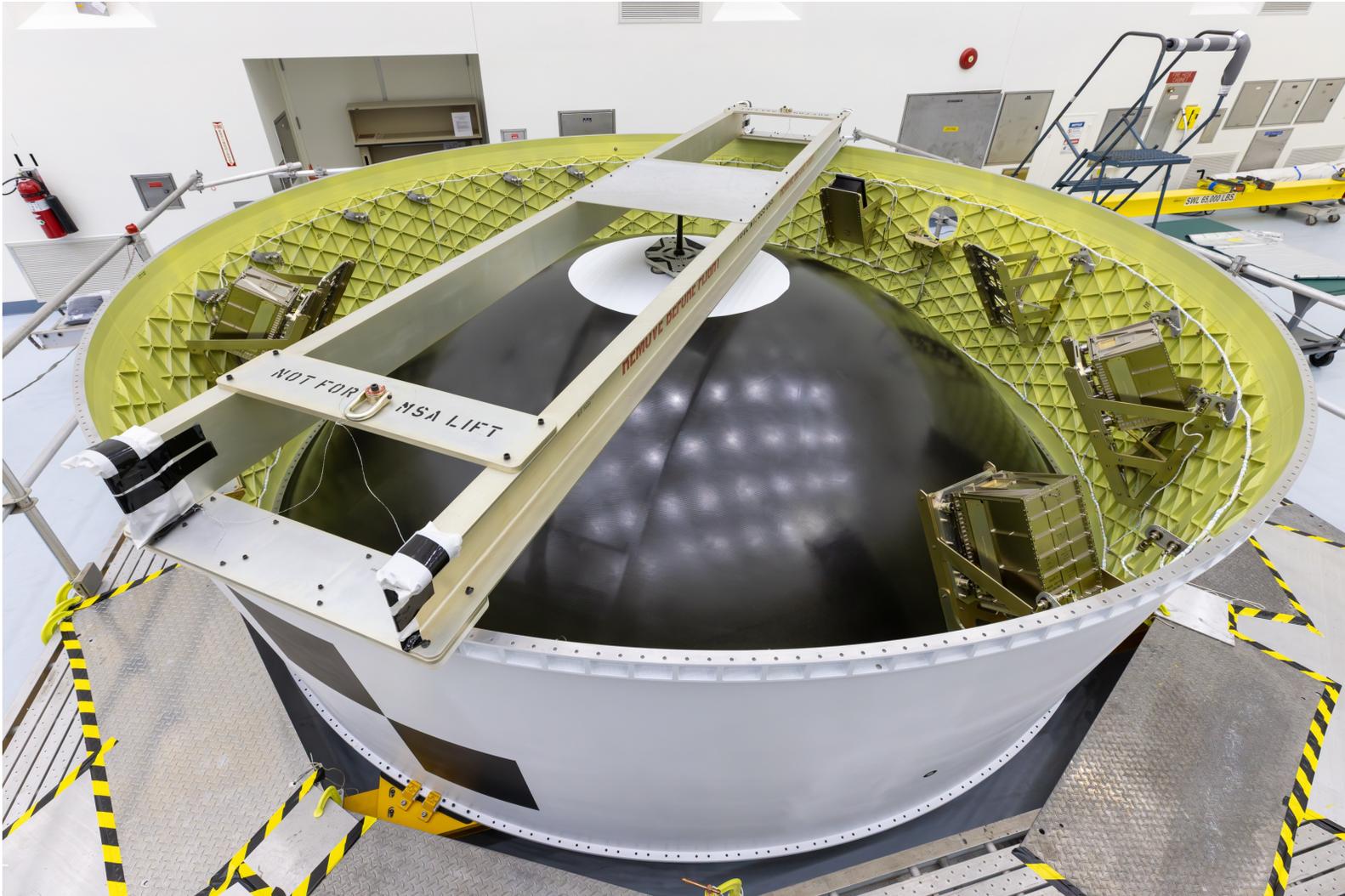
**DATA GAP**  
 A Data Need that is not satisfied by available information, requiring the acquisition of new or improved data

**DATA NEED**  
 Information, such as a specific measurement, that has value to Artemis and Moon to Mars activities through enabling the advancement of science, technology, utilization, exploration, or operations

**DATA AVAILABLE**  
 Information that can be used to generate data products that can be acquired (or currently exists but may not satisfy the needs of stakeholders)

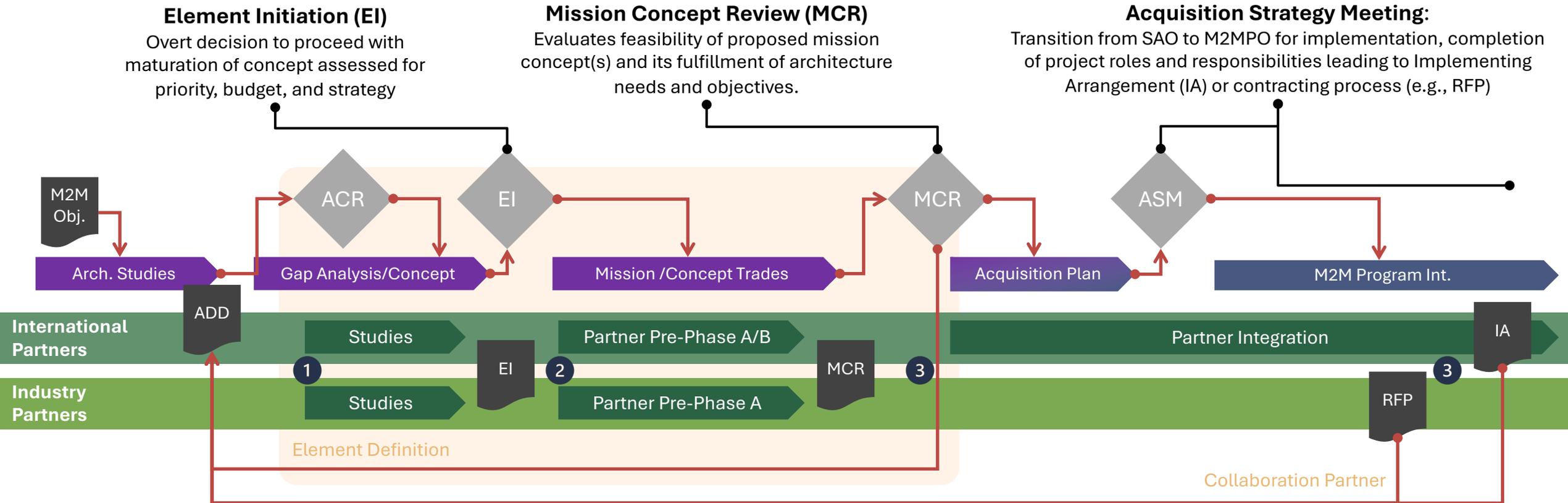
**DATA GAP**

- Impact and Benefits**  
 Defines Value of Closing Gap to Stakeholders
- Target Measurement Parameters**  
 Defines Measurable Goals for Data Providers



CubeSats installed  
on the Artemis II Space Launch  
System Orion stage adapter

# Pre-Formulation Process for Architecture Elements



# South Pole 2026



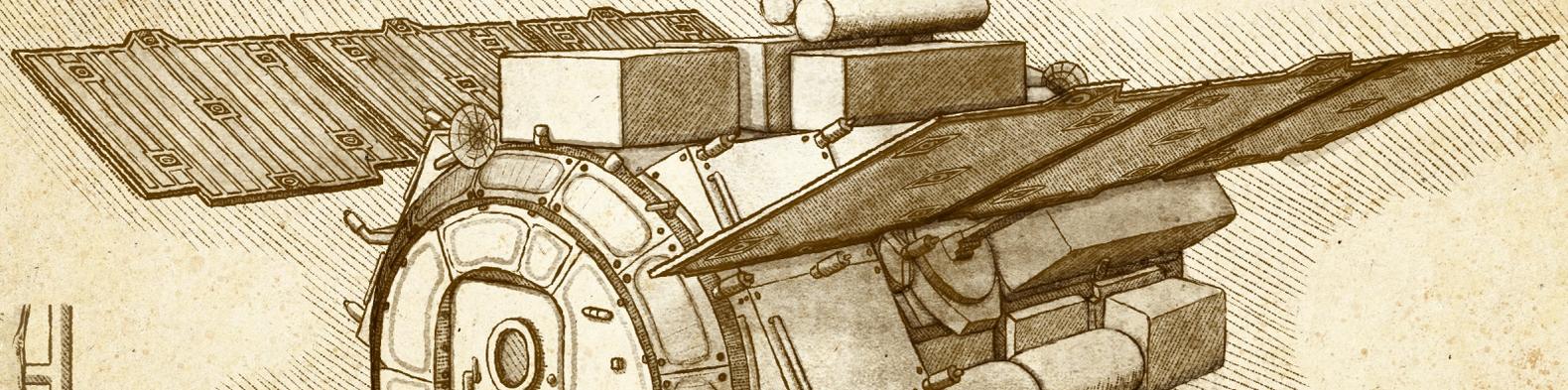
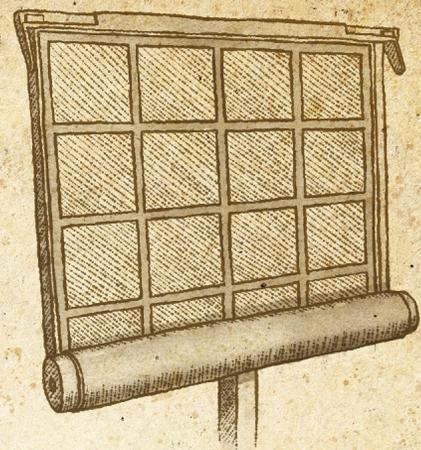
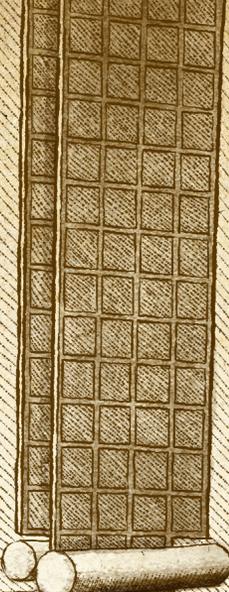
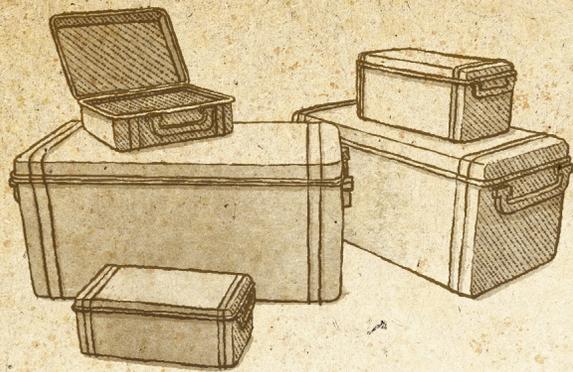
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**Phase** 91.4% (11d 22h 17m)  
**Diameter** 1985.1 arcseconds  
**Distance** 361045 km (28.34 Earths)  
**Position** 04h 14m 05s, 26° 20' 14"N  
**Subsolar** 1.346°S 32.520°E  
**Sub-Earth** 6.556°S 1.279°W  
**Pos. Angle** 349.893°



**Azimuth, Elevation**  
**Sun** 335.15° 6.85°  
**Earth** 300.80° 9.42°  

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**01 Jan 2026 00:00 UT**



# Architecture-Driven Data Gaps

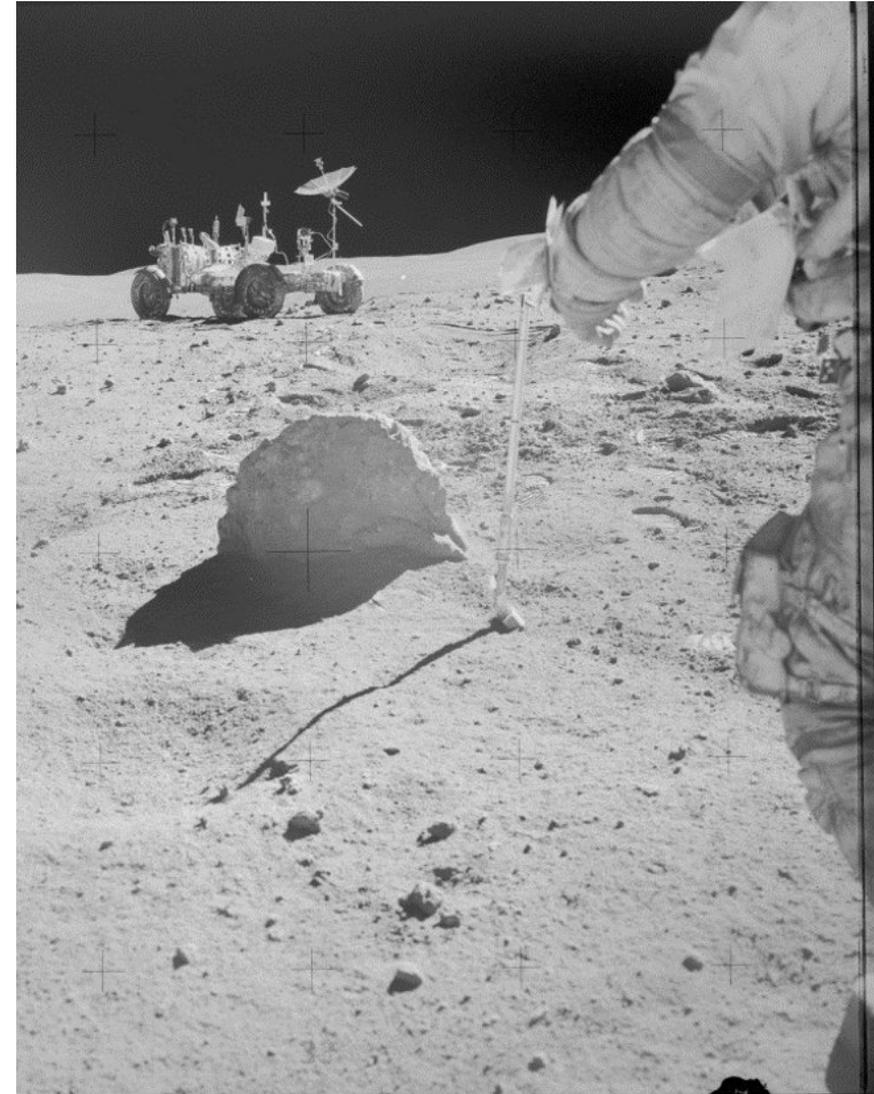
**Audrey Morris-Eckart**  
Deputy Manager

Science, Technology Utilization & Integration  
Strategy and Architecture Office

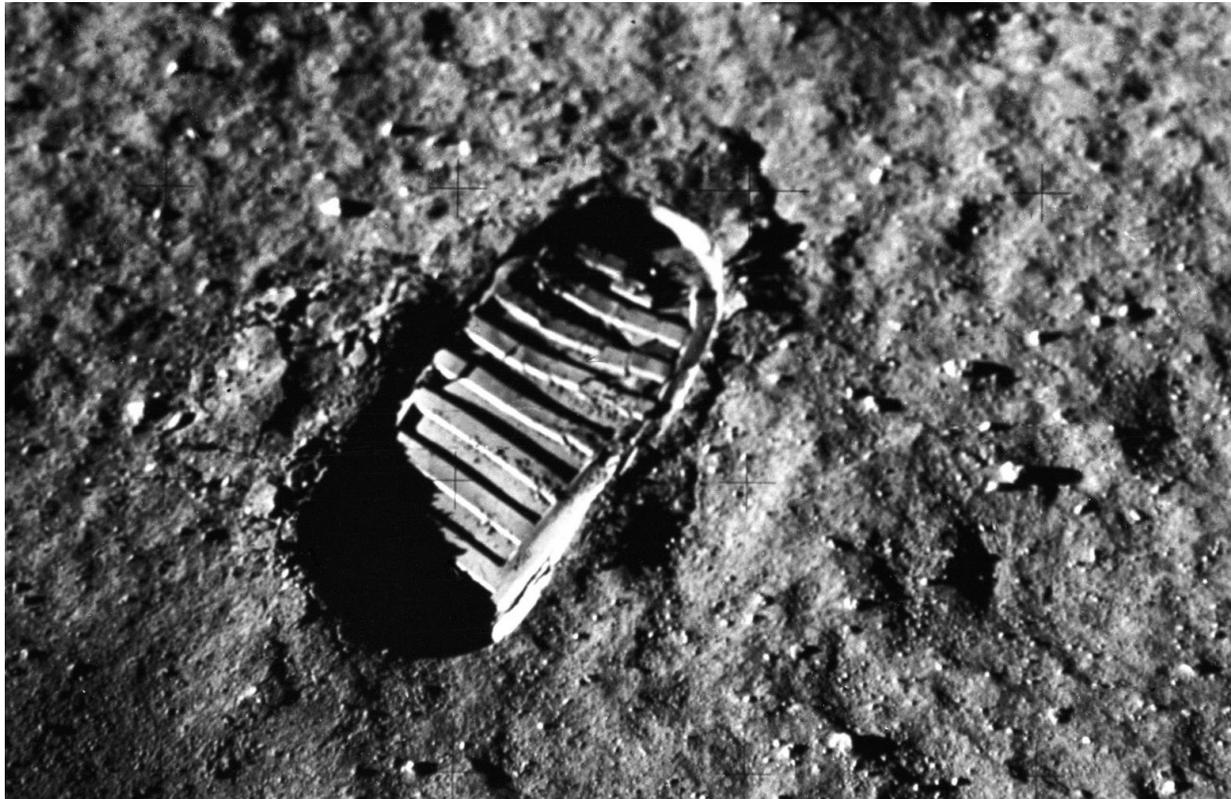
- Define and communicate integrated NASA data needs
- Focus limited resources strategically
  - To inform payload missions
  - To enable data acquisition
  - To optimize asset designs
- Build knowledge base necessary to enable M2M Architecture and future elements
- Characterize natural and induced environments, resources, terrain on surface, in space, in atmosphere, etc.
- **Reduce risk on M2M Missions**



- Incomplete initial data gap sample set to start
  - Grow and refine this year
- Initial set includes high priority needs, but not in order
- Sufficient data exist to enable initial Artemis Missions in Human Lunar Return (HLR)
  - Beyond initial missions, additional data is needed
    - To enable model validation
    - To reduce uncertainty
    - To reduce mission risk
- Incremental progress is valuable to enable immediate response



# Data Gaps Examples and Drivers

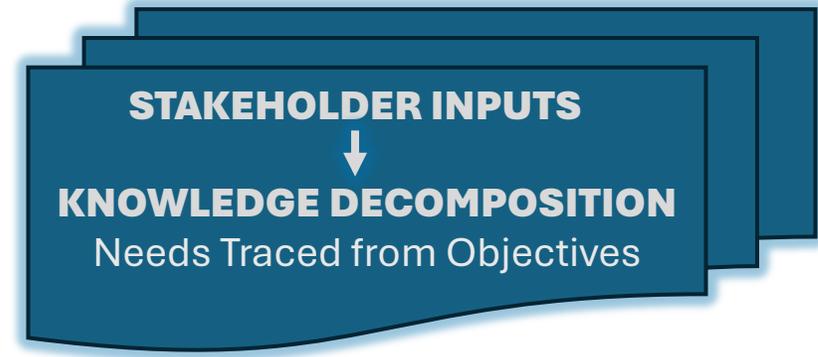
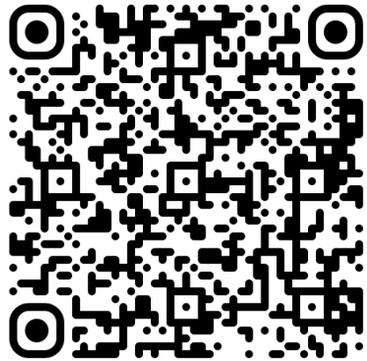


## Technology Gap Replaced with Data Gaps

Former Tech Gap ID and Title	New Data Gap IDs
0602: In-Situ Resource Identification, Characterization, and Mapping	DN-006 L, DN-007 L, DN-008 L, DN-010 L, DN-013 L

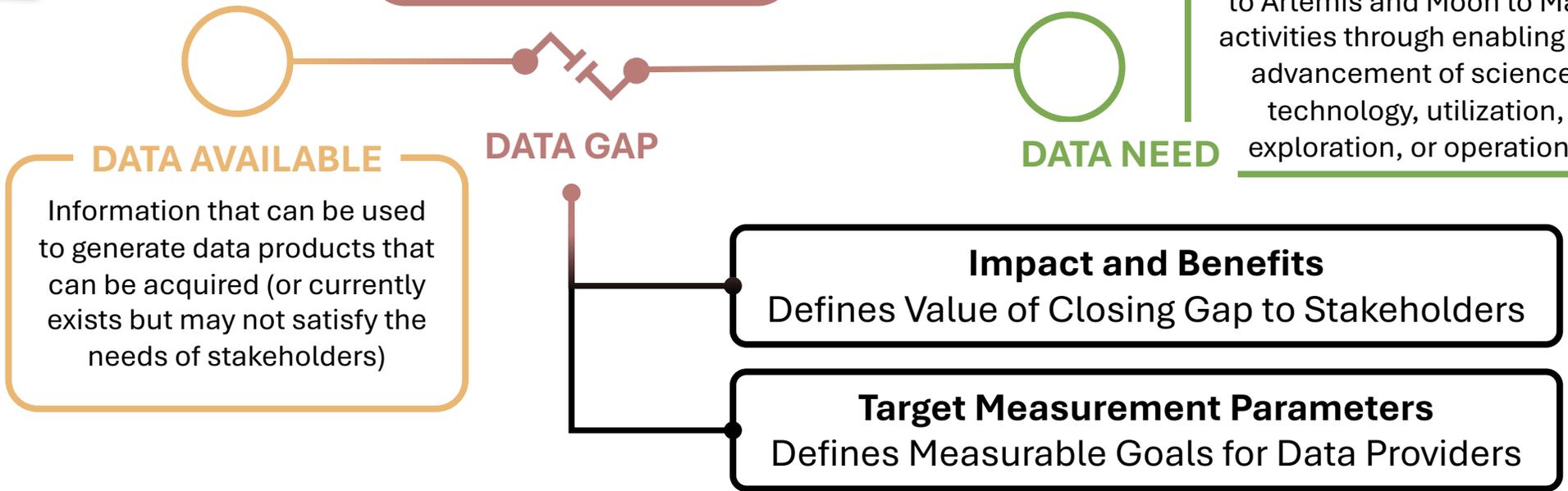
ID	Data Gap	Data Utility
DN-002 L	Comprehensive, high-fidelity elevation map coverage of lunar south pole exploration zones and sites	To better enable characterization of lunar landing sites and increase confidence in landing accuracy and mobility system navigation.
DN-007 L	In situ measurements of the horizontal and vertical distribution, abundance, and physical makeup of shallow bulk water ice	To enable better identification of potential sites for in-situ resource utilization activities.
DN-008 L	Geotechnical properties of highland regolith at the lunar south pole	To enable higher certainty in the landing environment to inform lander design and site selection.
DN-017 L	In situ measurement of particle velocity during lunar plume surface interaction (PSI) phenomena	To enable better modelling of the interactions between landers and surface regolith to mitigate risk of damage to hardware.

# Data Gaps Definition



**DATA GAP**  
A Data Need that is not satisfied by available information, requiring the acquisition of new or improved data

Information, such as a specific measurement, that has value to Artemis and Moon to Mars activities through enabling the advancement of science, technology, utilization, exploration, or operations



**DATA AVAILABLE**  
Information that can be used to generate data products that can be acquired (or currently exists but may not satisfy the needs of stakeholders)

**Impact and Benefits**  
Defines Value of Closing Gap to Stakeholders

**Target Measurement Parameters**  
Defines Measurable Goals for Data Providers

# Example of Data Gap details in ADD Rev C, Appendix E

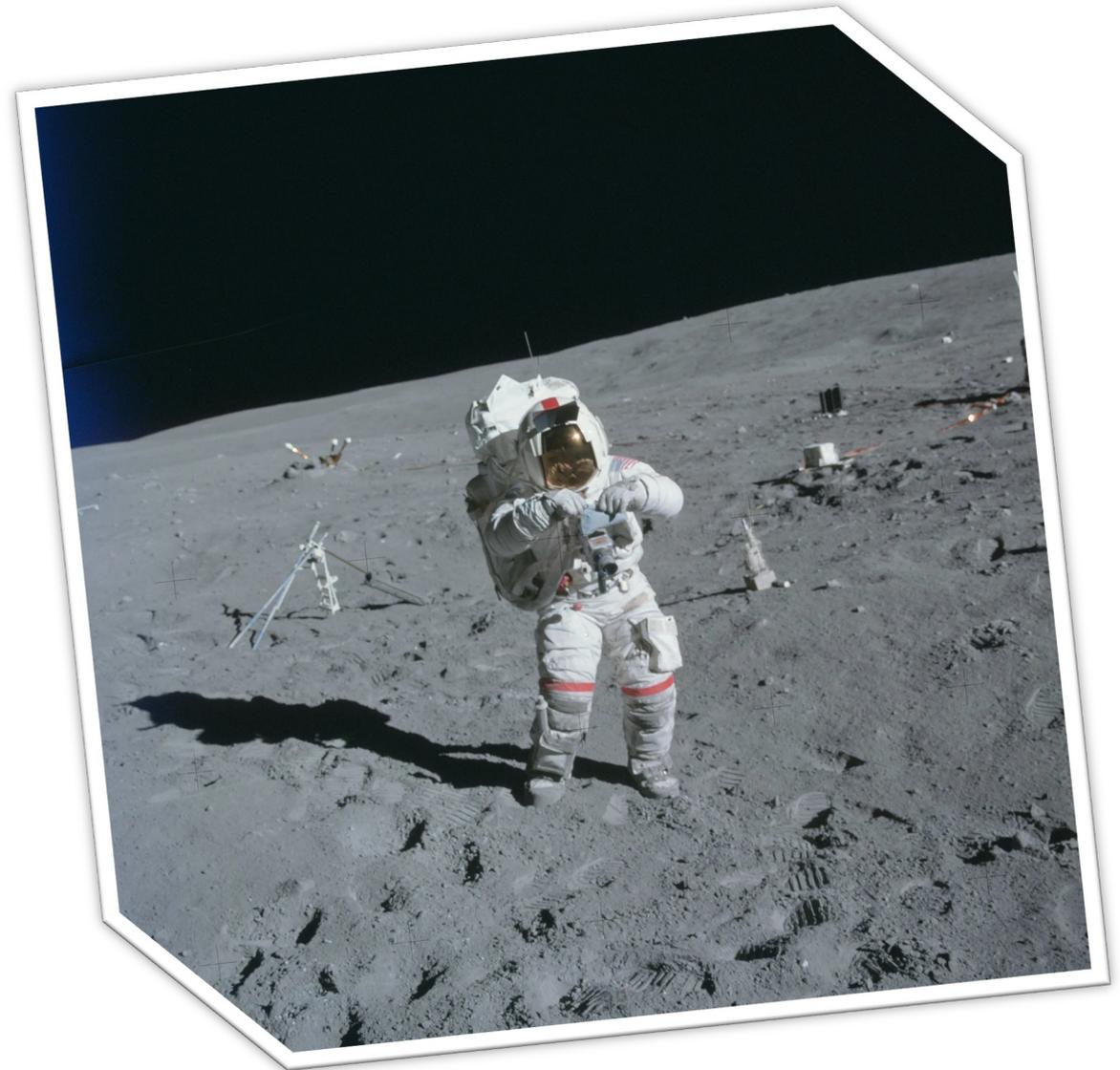


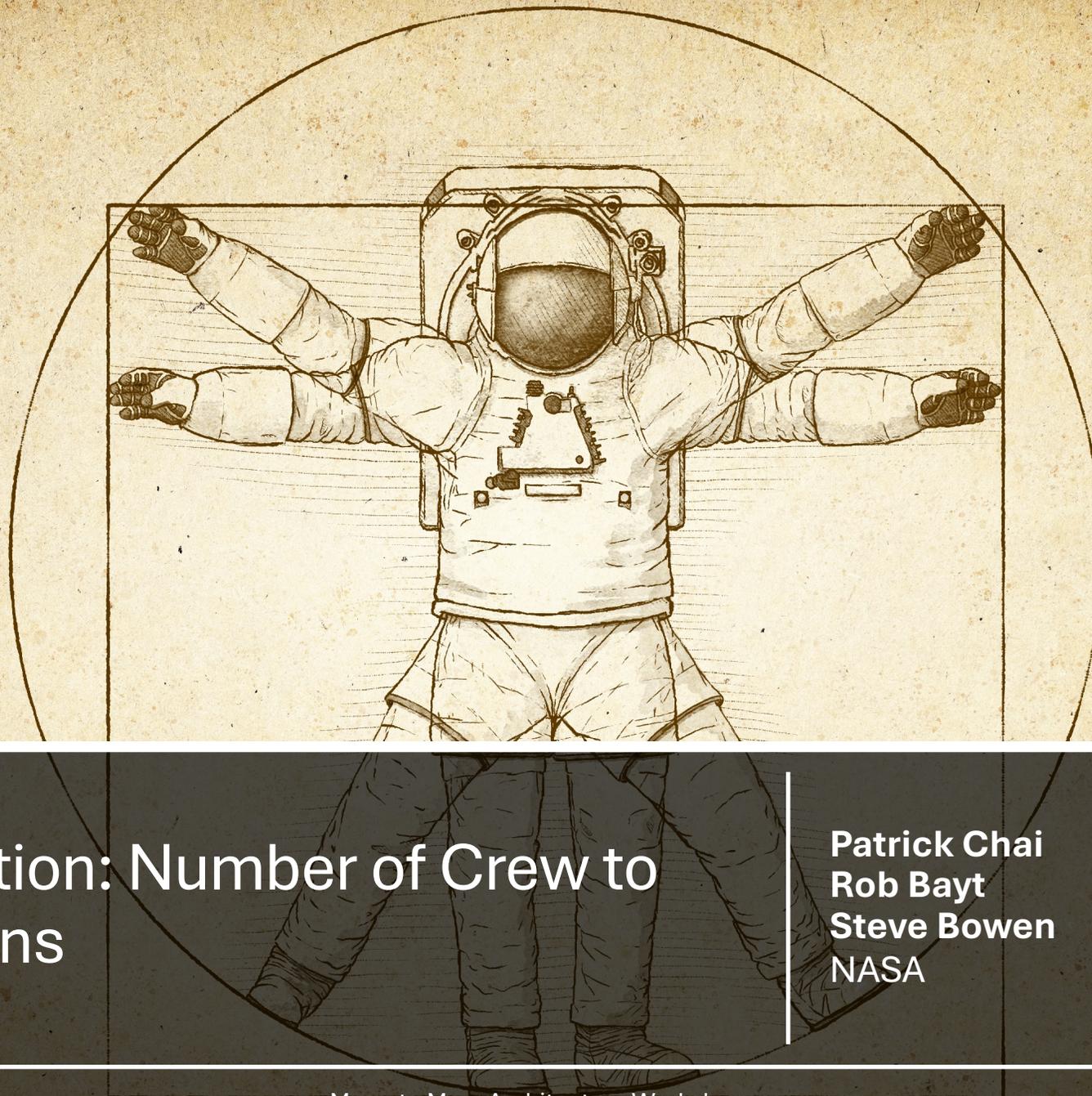
- Section 3.3 Initial Architecture-Driven Data Gaps
  - Summarizes the methodology and purpose
- Appendix E
  - List of Data Gaps and defines attribute details for each gap
    - ADD Rev C Includes 25 initial Data Gaps
- Built from rigorous systems engineering principles which were also used to define technology gaps
  - All fields defined by integrated input of stakeholders/SMEs
  - Traced to NASA Blueprint Objectives & categorized by drivers
  - Specific Target Measurement Parameters
  - Context provided in Impacts and Benefits
  - Snapshot of Current State of the Data
  - Solution-agnostic
  - A single data collection solution can contribute to multiple gaps

In situ measurement of particle velocity during lunar plume surface interaction (PSI) phenomena		ID No. DN-017 L Objective SE-07 LM, LI-05 L, TH-03 L Data Type In Situ Measurement
Gap Description	Need Driver	Segment
Characterize the lunar regolith ejected by rocket exhaust plumes interacting with the lunar surface at different sites and under different plume conditions (i.e. lander types). During final descent and landing, material may be lofted toward the landing vehicle and/or ejected away. As material leaves the influence of the exhaust plume, and given the lack of a substantial lunar atmosphere, it will travel on a trajectory dictated by those initial conditions.	<b>Lunar Surface Induced Environment Characterization</b>	 Human Lunar Return
Target Measurement Parameters		
Regolith particle sizes, speeds, and angles of ejection caused by rocket exhaust interacting with the lunar regolith.		
Impacts and Benefits		Current State of Data
Impacts if Data is Unavailable		Modeling reports for preliminary site comparisons have been generated using regolith data gathered during Apollo coupled with engine performance data. Plume surface interaction is a complex phenomenon, and current estimates are insufficient to accurately predict the behavior of regolith and its effects on vehicle performance.
Increased uncertainty in risk to landing vehicle and surrounding assets caused by debris strike or the "sandblasting", abrasive effects of ejected material. Increased uncertainty to scientific operations near the landing site, as the probability of surface alteration caused by ejected material may not be well constrained. Inability to determine PSI effects during landing and ascent events, including vehicle and hardware lunar dust loading. Inability to predict visibility expectations for spacecraft during ascent and landing. Inability to determine effectiveness of radar and range finding hardware, particularly those used during landing and ascent events.		
Benefits if Data is Available		
Understanding and characterization of this will translate to vehicle hardware which is better designed to withstand the effects of PSI during ascent and landing events and mitigate the risk of damage to this hardware. Increased confidence in ejecta hazard analyses that affect the landing vehicle and nearby assets. Tighter design constraints for protection from hazards/operating conditions. Better understanding of induce landing environment to inform lunar surface science goals.		

## Data gained will help

- Perform architecture analyses
- Characterize and reduce mission risk
- Develop optimized hardware
- Mature necessary technology
- Advance science objectives
- Support space exploration





# Mars Key Definition: Number of Crew to Surface Decisions

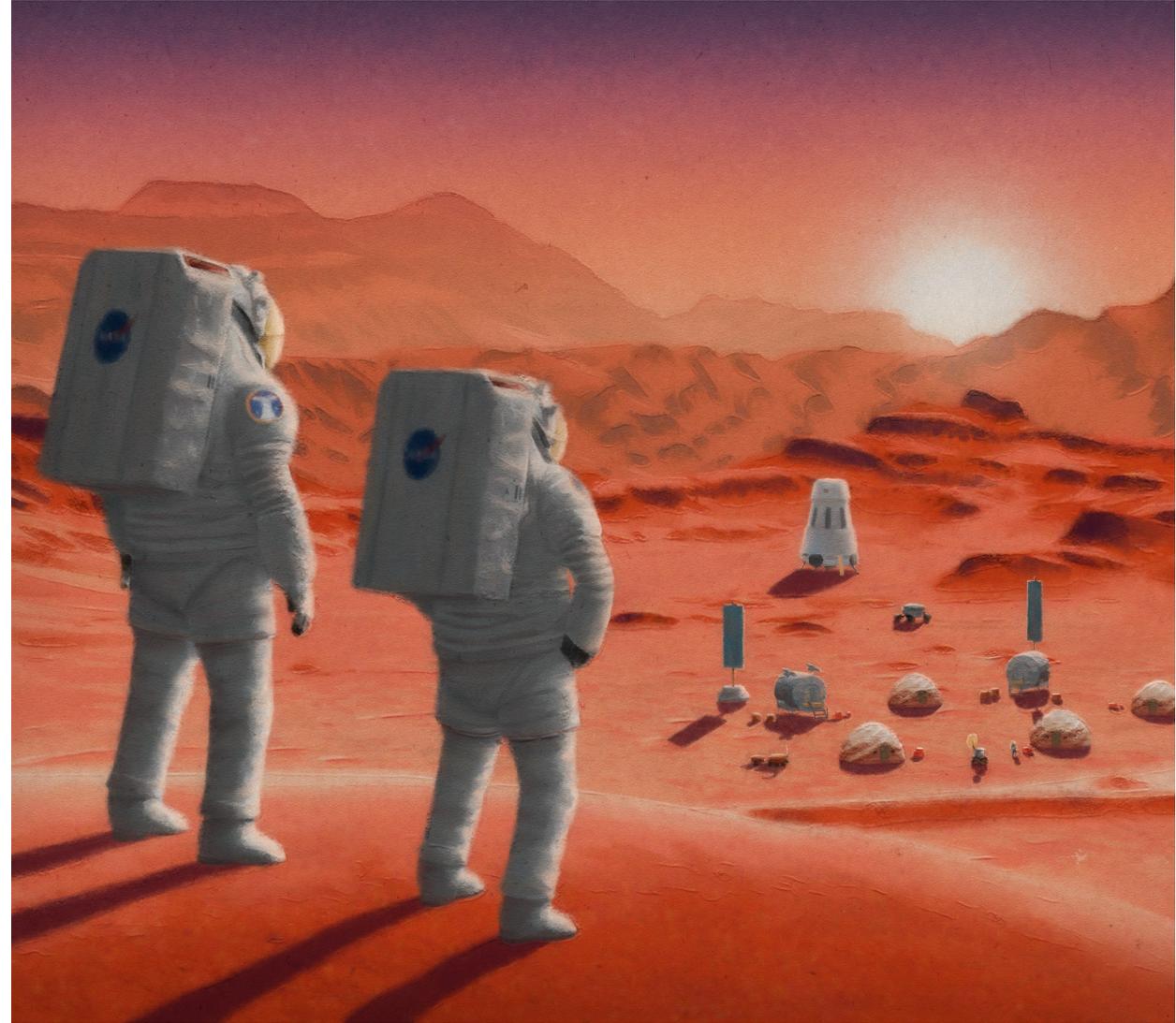
Patrick Chai  
Rob Bayt  
Steve Bowen  
NASA



*The Moon to Mars Initial Human to Mars Segment will target no fewer than four (4) crew to the surface, with consideration for the minimum to be up to six (6) crew for enhanced mission capability and/or provide risk reduction.*

- 2025 Architecture Concept Review Decision
- Documented in Revision C of the Architecture Definition Document
- Potential Future White Paper to Provide Detail

- Key architecture definition identified with high leveraged impact on architecture
- Assessment process involved cross-agency stakeholders, technical experts, and technical authorities
- Decision primarily driven by crew operation and risks, and the need for new paradigm



# Three Key Findings



## Key Findings #1:

Mars Mission needs a Different Paradigm: Mars distance induced communication delay and/or blackout forces **a paradigm shift** away from the smaller crewed missions of LEO / Lunar heritage



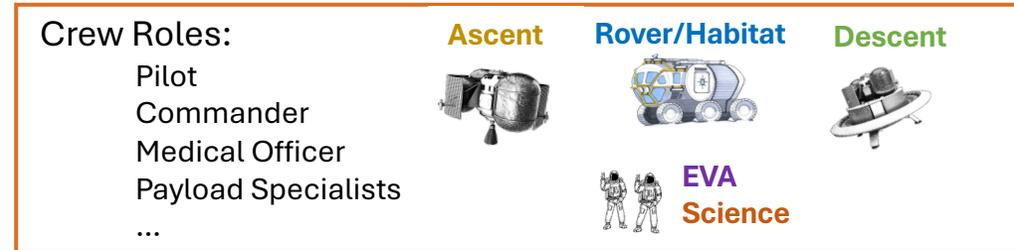
## Key Findings #2:

Surface EVA is a primary driver for crew size (Buddy Rule, EVA Cadence, etc.)



## Key Findings #3:

Crew expertise, tasking, and training, are all key drivers for crew time, and crew time will be extremely precious for Mars surface missions



# Key Finding to Number of Crew Recommendation



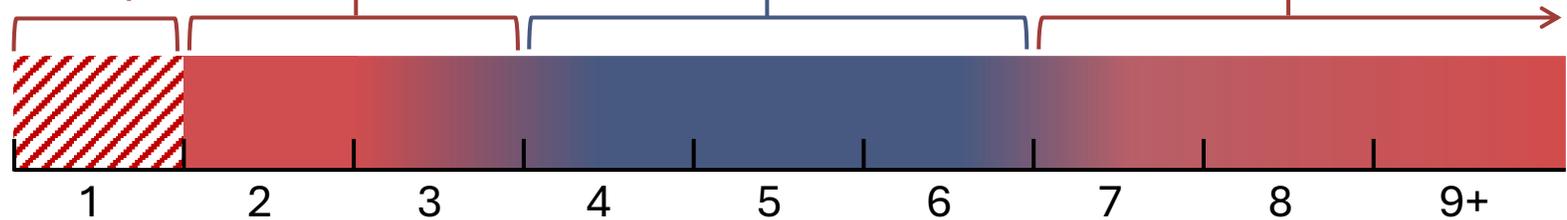
2 or 3 crew are technically feasible but not recommended due higher risk, especially for extravehicular activity operations.

4 to 6 crew balances opportunity, risk, and complexity, while offering appropriate scalability and flexibility for Earth-independent operations with robotic/autonomous system support

1 crewmember cannot meet operational needs

7 + crew present significant architecture feasibility challenges for initial missions

Number of Crew



RISKS

CONSIDERATIONS

Each additional crewmember...

- increases available crew time, but growing architectural complexity could diminish available crew time
- reduces risk by spreading workload and expertise coverage and protecting against contingencies

Every crew will need adequate Earth-independent systems, robotic capabilities, and concepts of operations to account for communications delays preventing real time support from Earth.

**NASA will target no fewer than four crew to Mars surface for architecture development**

3 crew needed to offer minimum necessary expertise and coverage for contingencies

- Crew workload is a significant driver for mission success and crew safety
  - Orbiting crew around Mars will affect surface crew size
  - Even number of crew preferable over odd number
  - Caution on over-reliance of the promise of automation/AI to make up for smaller crew sizes
- 
- Day 2 Topics:
    - Human Systems Challenges Breakout
      - 11:45am



INITIAL HUMAN MARS  
SEGMENT TARGET STATE

**The Initial Human to Mars Segment will be scoped to consist of more than one crew landing.**

Additional assessment needed to evaluate the following options:

- Multiple short-duration missions to a single site
- Multiple short-duration missions to multiple sites
- Multiple long-duration missions to a single site

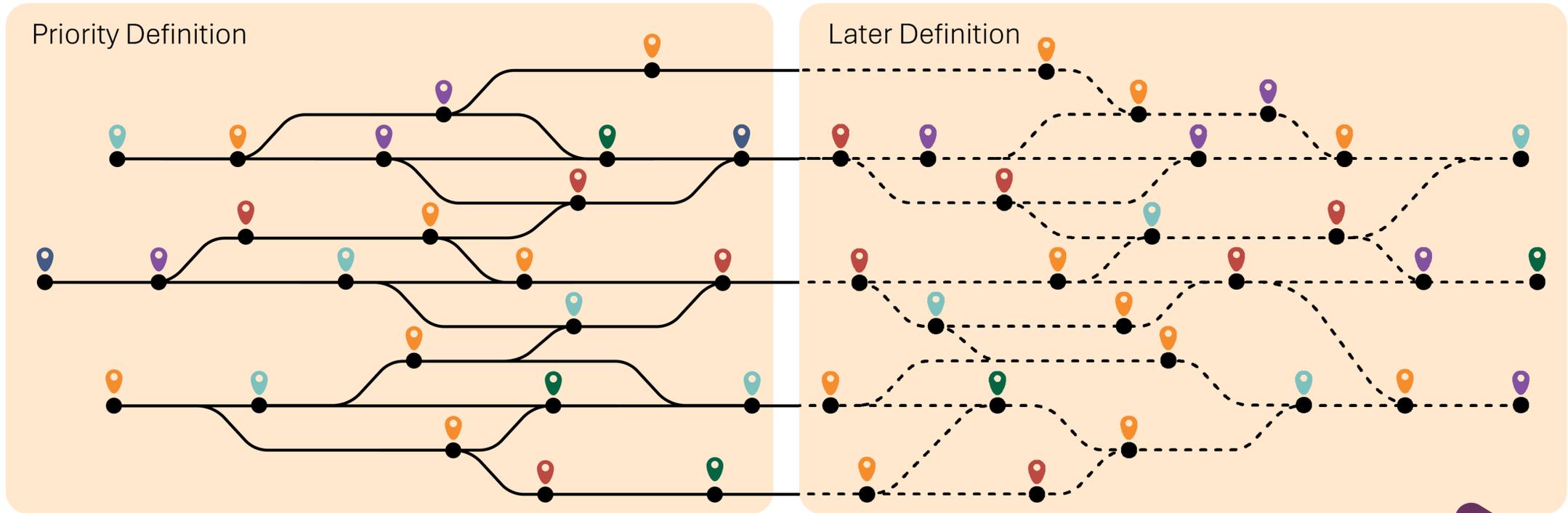
MARS LOSS OF CREW  
RISK POSTURE

**Established an architecture level methodology to evaluate crew risk across the vast architecture trade space.**



## Notional Definition Flow

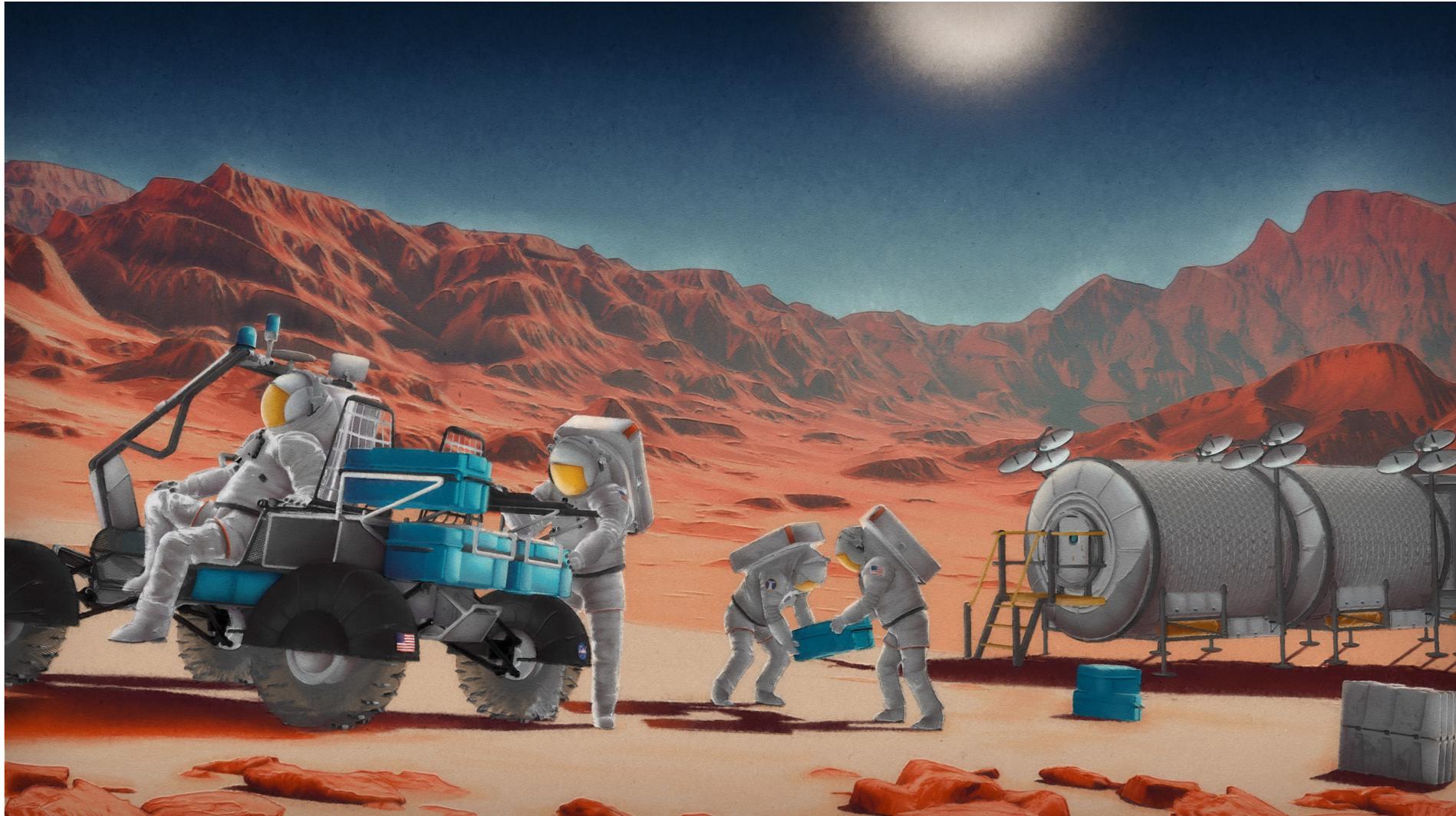
📍 = Definition Task



## Timeline to Exploration Destination

Completed Definition Tasks | 📍📍📍📍📍📍

WHY We Go | WHERE We Go | WHO Is Involved | WHAT We Do There | WHEN We Go | HOW We Go | Definition Color Key



Architecture  
White Papers





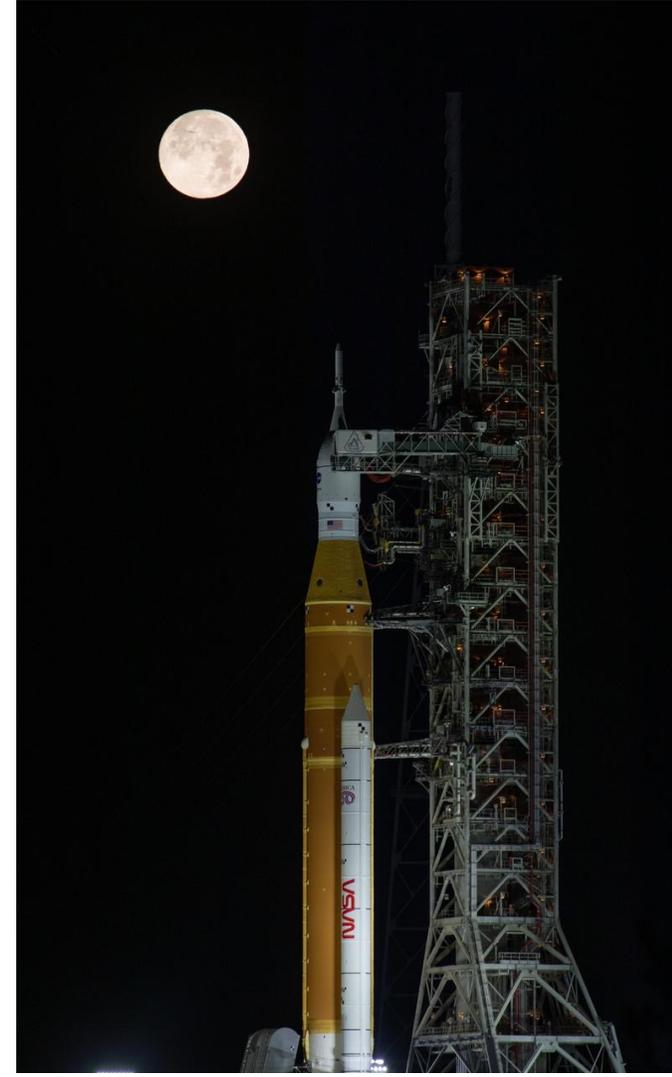
FIRESIDE CHAT

# Moon to Mars Program Office Update: What's New? What's Next?



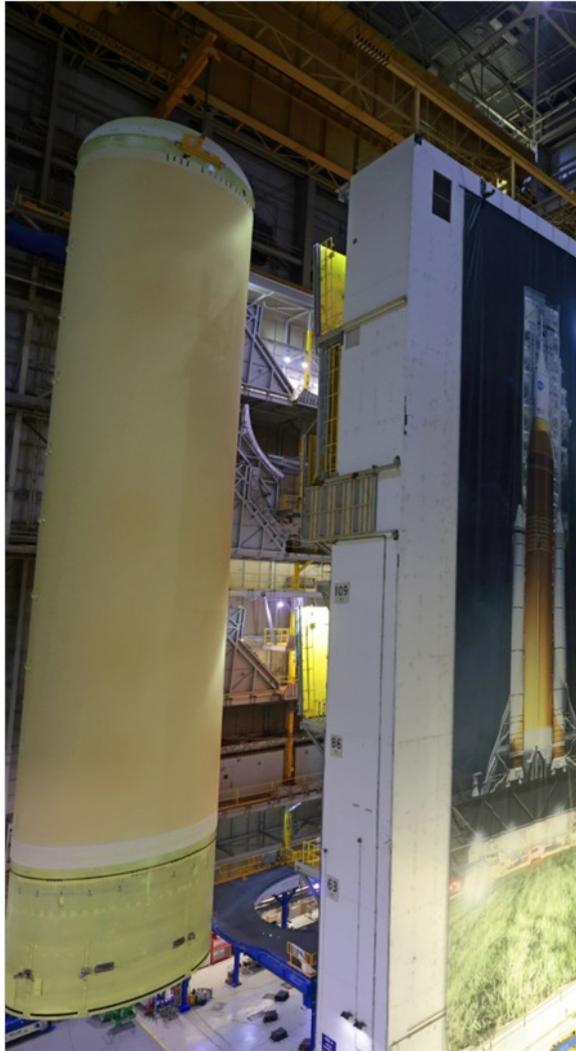
# Artemis II

National Aeronautics and  
Space Administration



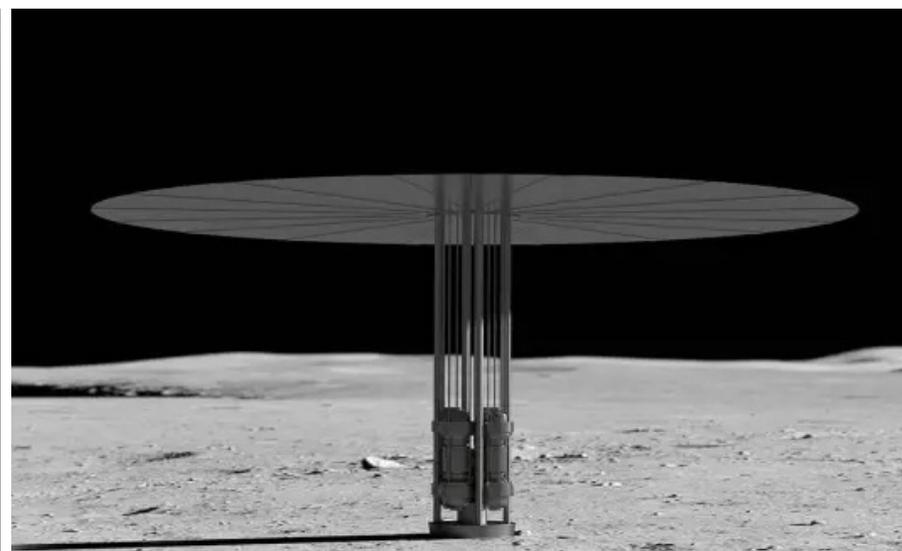
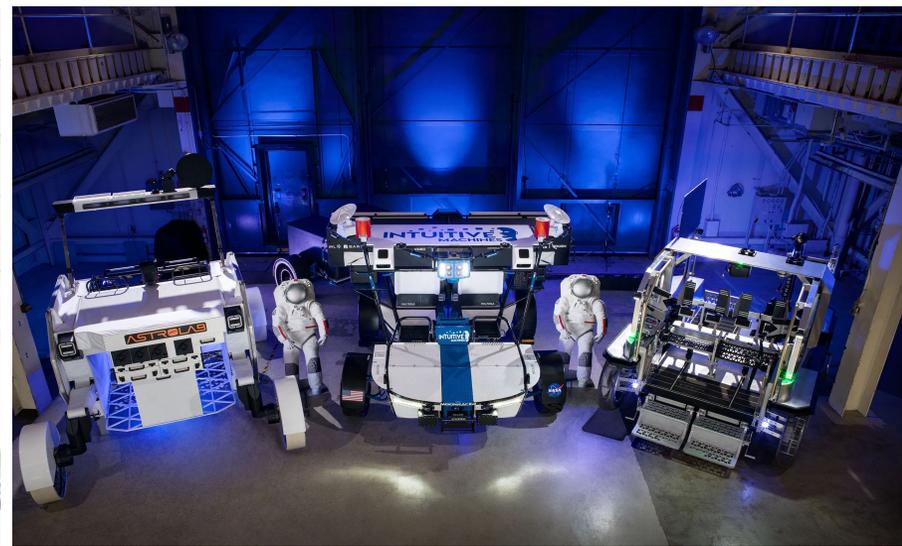
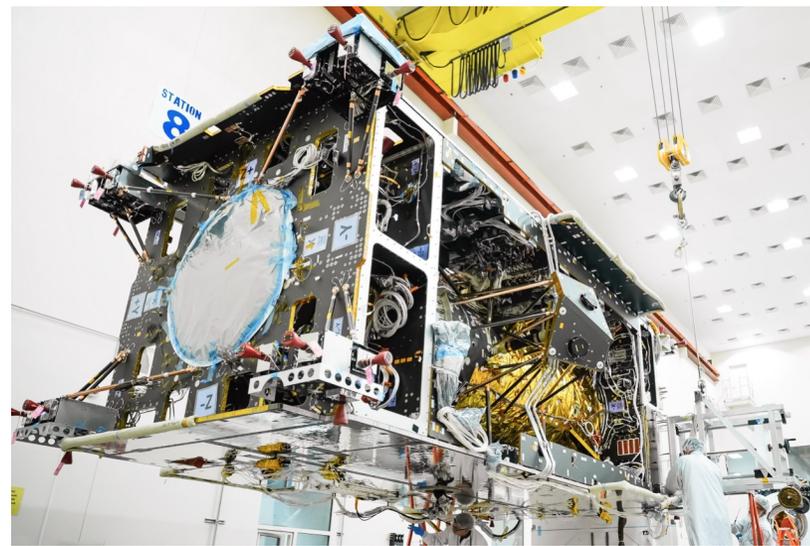
# Artemis III

National Aeronautics and  
Space Administration



# Artemis IV+

National Aeronautics and  
Space Administration



# Problem Description – Multilateral Infrastructure & Interoperability

