



Industry and Academia Workshop

Charts for Distribution



2025 Architecture Concept Review Updates

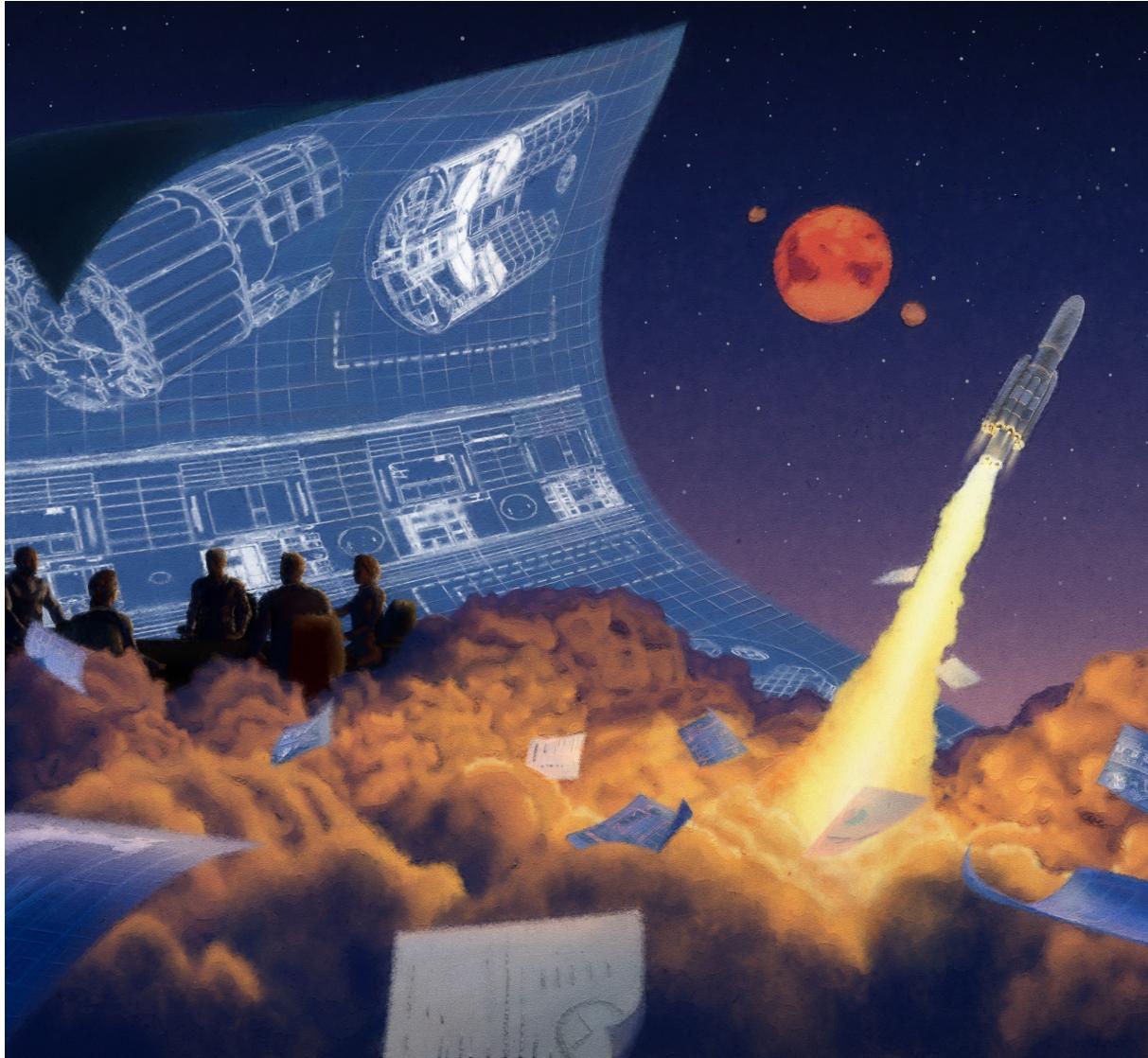
Nujoud Merancy
Deputy Associate Administrator
Strategy and Architecture Office
Exploration Systems Development



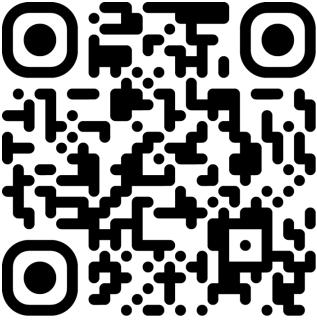
Welcome!

Workshops in Action

National Aeronautics and
Space Administration



- 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*)

Incorporating Your Feedback: Product Revitalization



The image is a cover for the 'Architecture Definition Document Revision C'. It features a background photograph of Earth from space, showing clouds and landmasses. A vertical rainbow gradient bar is positioned on the left side. In the top right corner is the NASA logo. The title 'NASA's Moon to Mars Architecture' is centered in large white text, with 'NASA's' in a smaller font above 'Moon to Mars Architecture'. The bottom right corner contains the document identifier 'Architecture Definition Document ESDMD-001 Revision C'.

Segments

Architecture Components

Segments

2.1.4 Humans to Mars



Header Image: Conceptual illustration of an isolated habitat being assembled on the surface of Mars. (Credit: NASA)

Human to Mars segments estimate human presence to Mars can improve future interests in space exploration. Since the initial days of spaceflight, the Red Planet has captivated humanity. The Moon to Mars Architecture will be a crucial study to truly live and work on a planet beyond humanity's own.

Building on previous segments, this segment will include the initial capabilities and infrastructure to support the first humans to Mars. This segment will include the initial capabilities and infrastructure to support the first humans to Mars. This segment will include the initial capabilities and infrastructure to support the first humans to Mars. This segment will include the initial capabilities and infrastructure to support the first humans to Mars. After landing humans on the Red Planet, NASA will prepare for progressively longer and more complex mission phases.

2.1.4.1 Science Objectives

The human to Mars segments will be the first humans to interact with the Red Planet to achieve the Mars-specific goals outlined in NASA's Moon to Mars Objectives. These objectives include cross-cutting science and operations goals, as well as Mars-specific infrastructure and transportation and habitation goals. These objectives will support the Mars architecture's decommission for the Moon architecture.

2.1.4.1.1 Science Objectives

NASA's Moon to Mars Objectives establish many science objectives that are applicable to both human and Mars exploration. These objectives provide opportunities for scientific and robotic investigations than those that are possible at the Moon, including investigating the origins of life and the existence of past or present life elsewhere in the solar system (LPS-4), which cannot be addressed on the Moon.

Moon to Mars Architecture Definition Document

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Unallocated Functions

Appendix B: Architecture Decomposition

Unallocated Functions by Use Case

B.8.2.2 Communication and Navigation, Negotiation, and Timing	
UC-A-204 L	Determination of position, navigation, and timing by crew and assets at distributed sites on the lunar surface
FN-C-204 L	Provide position, navigation, and timing services at distributed sites on the near side and opposite the Earth
Associated Data Document - Un-allocated Function by Use Case	
UC-A-205 L	Crew robotics utilization of position, navigation, and timing for accurate sample tracking on the lunar surface
FN-C-205 L	Provide position, navigation, and timing services at distributed sites on the near side and opposite the Earth
Associated Data Document - Un-allocated Function by Use Case	
UC-A-206 L	Determination of position, navigation, and timing by crew and assets at the Earth side of the Moon
FN-C-206 L	Provide position, navigation, and timing services at the far side and outside the eighth zone region on the lunar surface
Associated Data Document - Un-allocated Function by Use Case	
UC-A-207 L	Crew robotics utilization of position, navigation, and timing for accurate sample tracking at the far side on the lunar surface
FN-C-207 L	Provide position, navigation, and timing services at the far side and outside the eighth zone region on the lunar surface
Associated Data Document - Un-allocated Function by Use Case	
B.8.2.8 Data Systems and Management	
UC-D-201 L	Collect, store, and locally distribute large volumes of data on the lunar surface sufficient to perform real time analysis
FN-D-101 L	Collect, store, and locally distribute large volumes of data on the lunar surface sufficient to perform real time analysis
FN-D-102 L	Process large volumes of data locally on the lunar surface sufficient to perform real time analysis
FN-D-103 L	Process large volumes of data locally in cis-lunar space sufficient to perform real time analysis
FN-D-104 L	Process large volumes of data locally in cis-lunar space sufficient to perform real time analysis
Associated Data Document - Un-allocated Function by Use Case	

Moon to Mars Architecture Definition Document

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Sub-Architectures

Architecture Components

Sub-Architectures

Architecture Components	Sub-Architectures
 Autonomous Systems and Robotics	  Autonomous Systems and Robotics
This sub-architecture integrates the unique and complementary capabilities of humans and robotic systems to support the mission. It includes the ability to support mission planning, mission execution, mission planning, mission execution, science, and post-mission support across the architecture.	
Robotics are not only well suited to execute highly, repetitive, or hazardous tasks, but can also augment the abilities of humans. For example, a robot can be used to inspect a system or structure, while a human can use a crew to focus on highly-priority activities and improve safety without sacrificing operational effectiveness.	
Mobile robotics can also improve access to areas of scientific interest, asset handling, repairing, and maintenance, and can support the mission by performing tasks such as surveying, mapping, and sample collection, while also performing reconnaissance (e.g., scouting, surveying, mapping, collecting samples) in advance of crewed missions.	
 Communication, Navigation, and Timing (CANT)	  Communication, Navigation, and Timing (CANT)
This sub-architecture enables transmission and reception of raw and/or encoded signals across all exploration assets, it provides services to accurately and precisely determine location and orientation of assets, and it provides the ability to receive and process data from sensors and cameras distributed throughout the mission to Earth's Cooperative Universe.	
CANT sub-architecture considerations include service regions, delivery mechanisms, and user needs, as well as the need to support both low-latency and high-latency data. The need to support both high and low data rates, as well as maximizing interoperability of CANT services are key considerations in establishing an architecture that supports the mission.	
The CANT sub-architecture and concept of operations will mature in response to user needs. Services may mature from low-latency and high-latency to high-latency and low-latency, and from low data rates to high data rates. Increasing capacity and availability, additional cultural and lunar surface infrastructure, and the need to support both high and low data rates will drive the evolution of the CANT sub-architecture to support regional or global services. More accurate PNT information will empower precision navigation, tracking, planning, geolocation services, and temporal and spatial science.	

Architecture Components	Sub-Architectures
 Data Systems and Management	  Data Systems and Management
This sub-architecture includes capability that work together to manage, compute, store, sense, and process data. It includes the ability to support the Human, System, and Robotic sub-architectures and Robotic sub-architectures and can support the mission to Earth's Cooperative Universe.	
This sub-architecture encompasses the comprehensive themes that govern how the architecture manages, uses, and stores data as well as the nature of tools, models, processes, representations, and technologies used to support the mission. The sub-architecture also includes the ability to support the mission to Earth's Cooperative Universe and the ability to support the mission to Earth's Cooperative Universe that NASA can derive valuable insights can be derived from raw data.	
The sub-architecture includes the ability to support the mission to Earth's Cooperative Universe and conceptual data models using element-ground data visualizations, and relationships between elements, and addresses environmental storage, processing, and management of data. The sub-architecture also includes the ability to support the mission to Earth's Cooperative Universe and the ability to support the mission to Earth's Cooperative Universe architecture responsibilities including analysis data handling across communications and computational engines to support the mission to Earth's Cooperative Universe and the ability to support the mission to Earth's Cooperative Universe.	

Moon to Mars Architecture Definition Document

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Functional Mappings

Appendix B: Architecture Decomposition

Element Function Mappings

B.3.3 Exploration Ground Systems

B.3.3.1 Human Factor Themes

	 Human Factor Themes	 Exploration Ground Systems
 FH-G-101	Provide ground services on Earth	
 FH-G-102	Store and integrate system(s) on Earth	
 FH-G-103	Manage consumables and propellant	
 FH-G-104	Enable vehicle launching	
 FH-G-105	Enable multiple launch attempts for vehicle(s)	
 FH-G-201	Recover crew after Earth landing	
 FH-G-202	Recover cargo after Earth landing	

B.3.3.2 Functional Pipelines

	 Functional Pipelines	 Exploration Ground Systems
 FH-G-101	Provide ground services on Earth	
 FH-G-102	Store and integrate system(s) on Earth	
 FH-G-103	Manage consumables and propellant	
 FH-G-104	Enable vehicle launching	
 FH-G-105	Enable multiple launch attempts for vehicle(s)	
 FH-G-201	Recover crew after Earth landing	
 FH-G-202	Recover cargo after Earth landing	

Moon to Mars Architecture Definition Document

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Element One Pagers

Tech Gaps

Why Moon and Mars?

National Aeronautics and Space Administration



Historical Context



Crawl

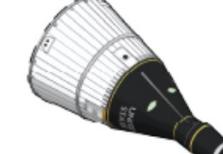
Project Mercury^[2] 1961 – 1963

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^[3] 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^[4] 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.

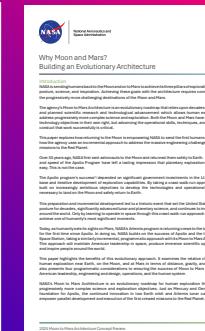
OBJECTIVES

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.

Programmatic Considerations

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

Read the White Paper



Building on Experience

Exploration Challenges by Destination

DISTANCE FROM EARTH



250 Miles



250,000 Miles



35,000,000 Miles

ONE-WAY JOURNEY



2 Hours



Days



Months

LIGHT-TIME DELAY



Negligible



Seconds



4-24 Minutes

GRAVITY



16.6% Earth Gravity
1% Earth Mass

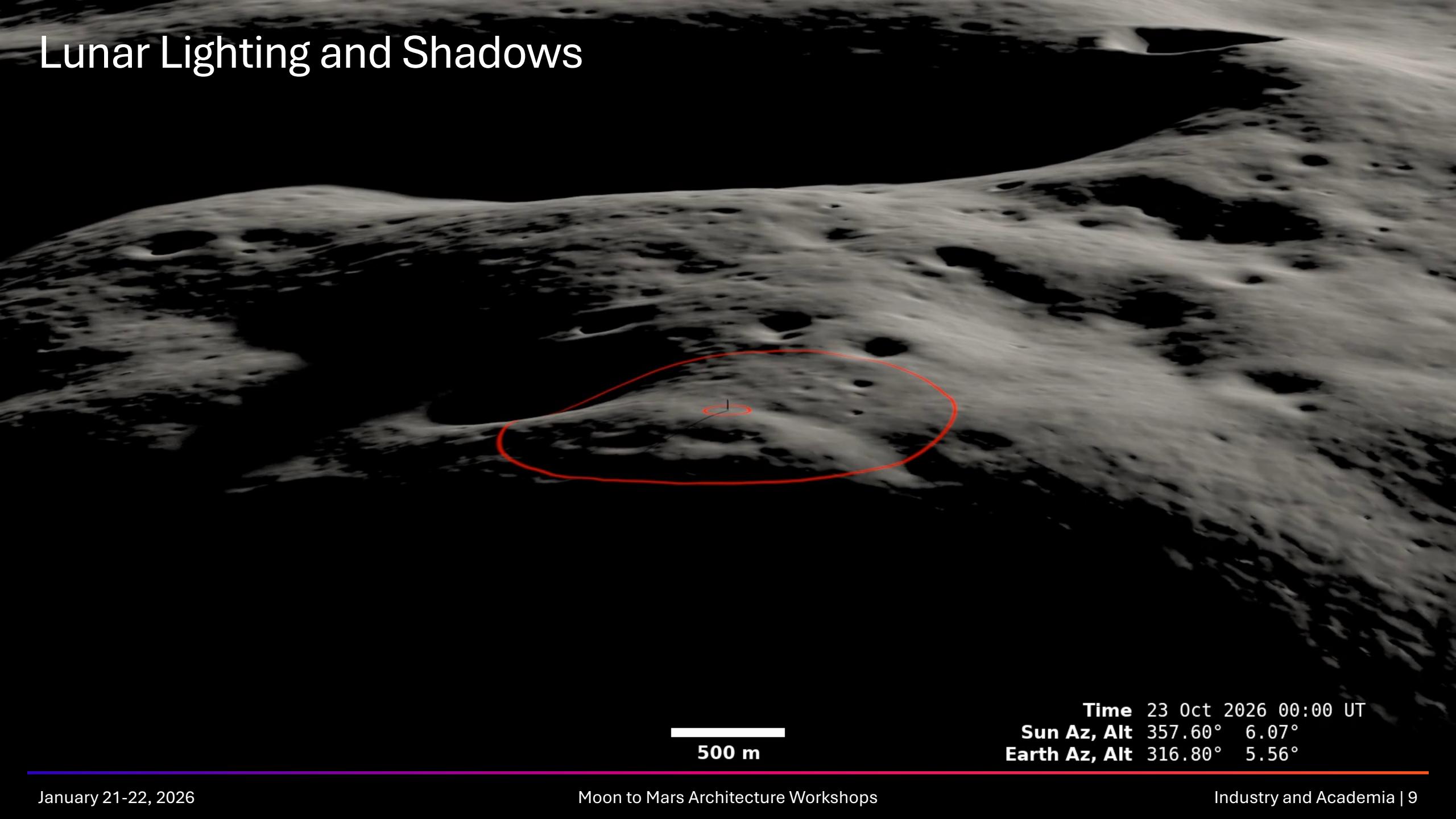


38% Earth Gravity
10% Earth Mass

The Lunar South Pole Region



Lunar Lighting and Shadows



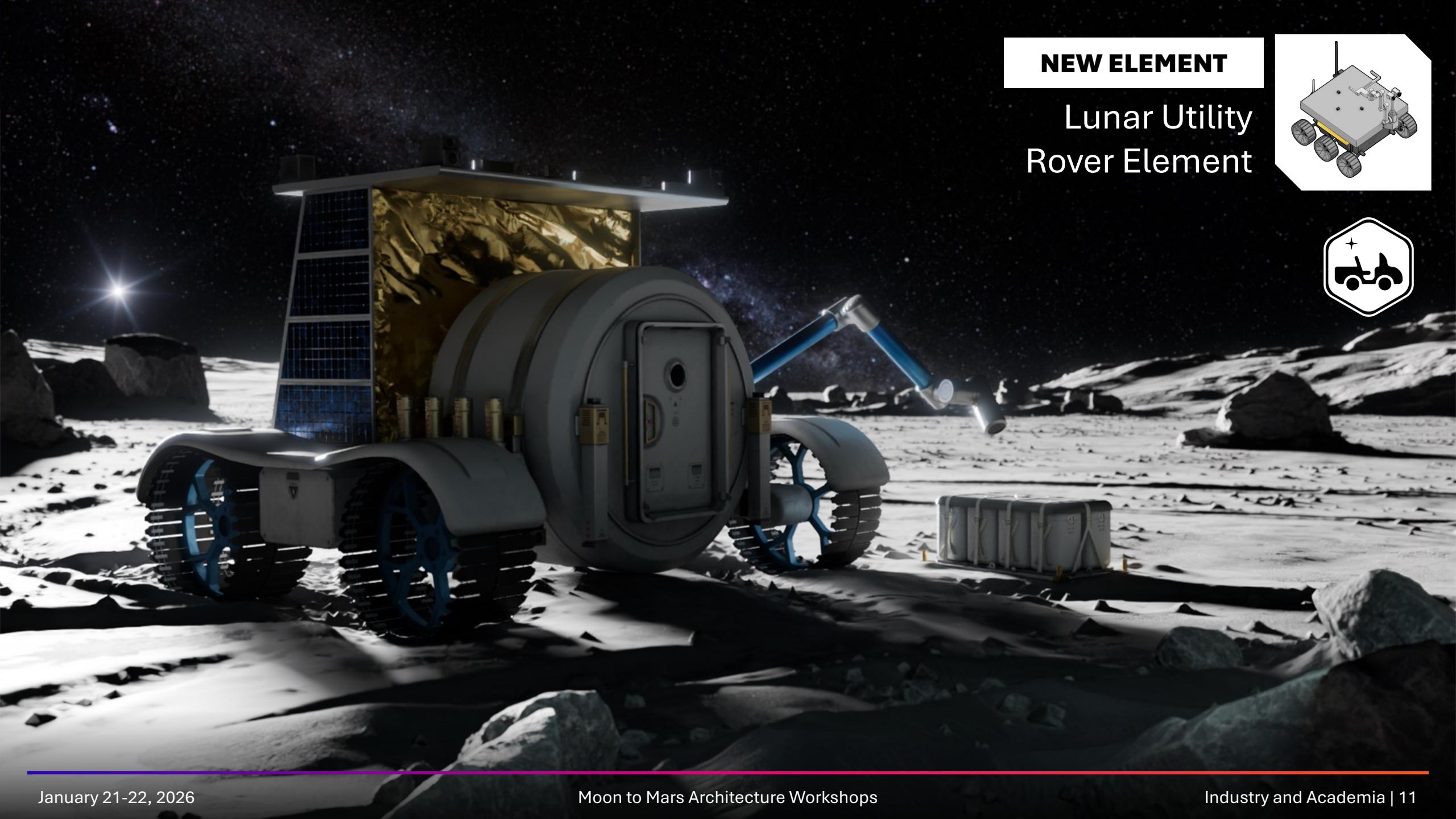
500 m

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

Roving the Lunar Highlands

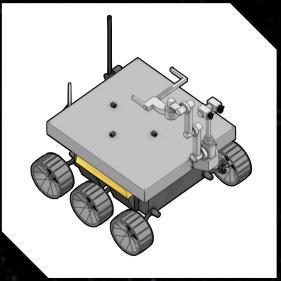
Apollo 16 - April 1972





NEW ELEMENT

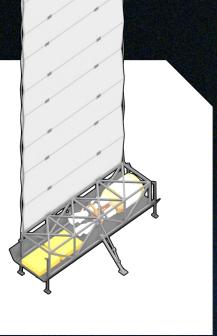
Lunar Utility
Rover Element





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

POWER OPPORTUNITY

HABITATION 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.



Interoperability Standards

National Aeronautics and
Space Administration



- 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

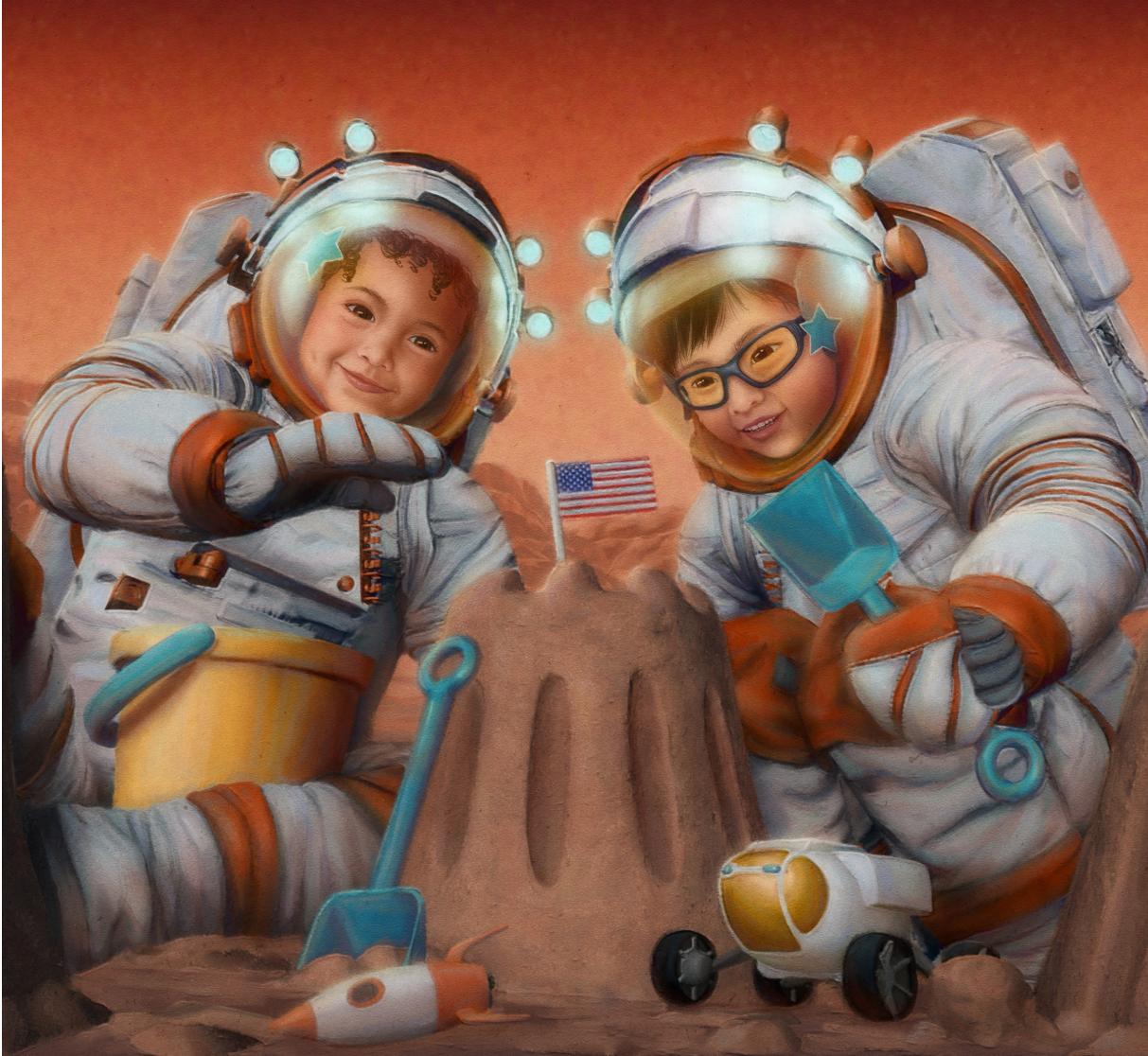


ADOPTED 2025



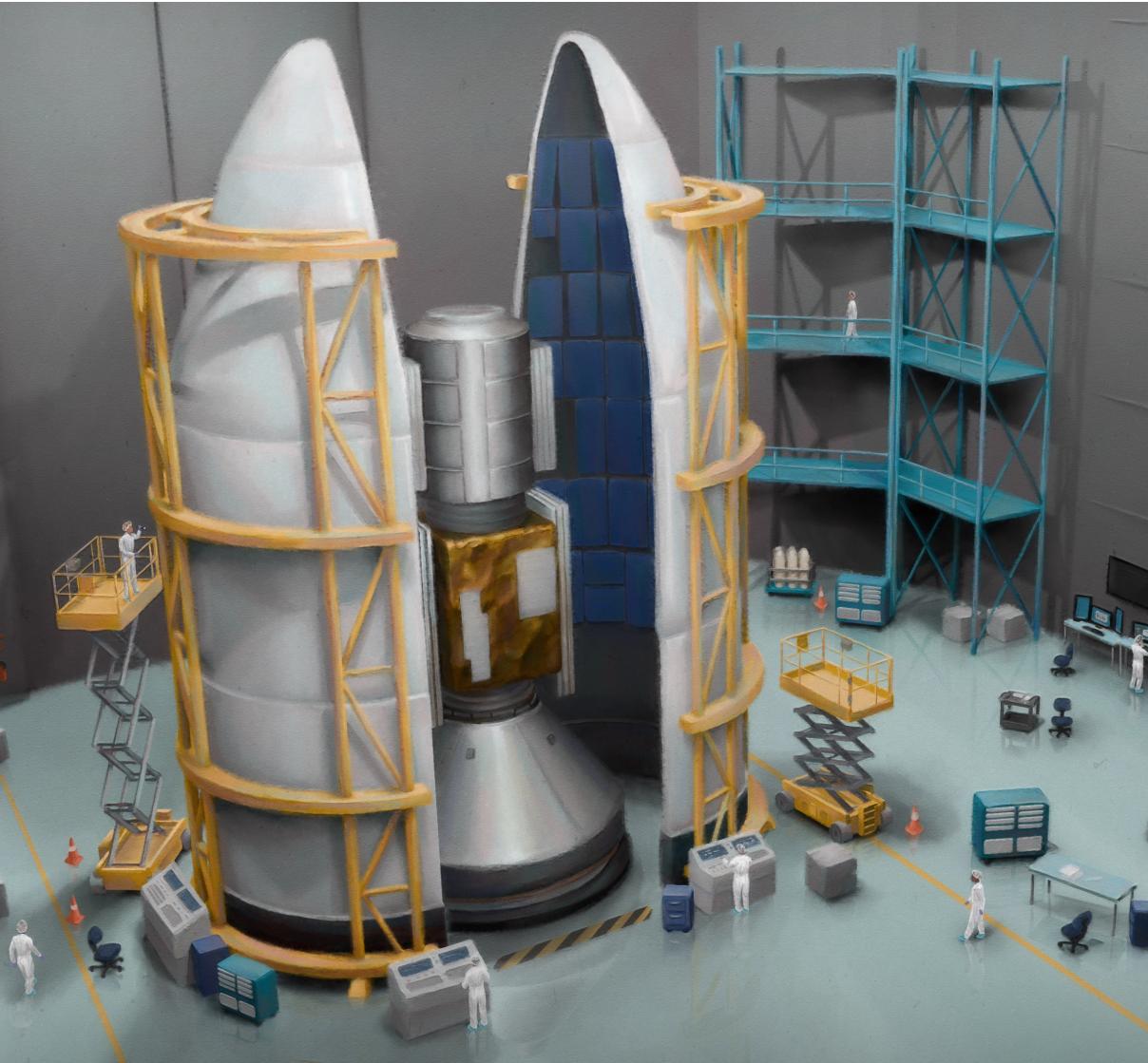
Tips for Workshop Engagement

National Aeronautics and
Space Administration



- 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/>

What's Out of Bounds?



- 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
- 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>

NASA Day of Remembrance

National Aeronautics and
Space Administration



Please Join Us in a Moment of Silence to Honor our Fallen Explorers



Industry and Academia Workshop

DAY TWO





Environmental Challenges

Panel Discussion

South Pole 2026



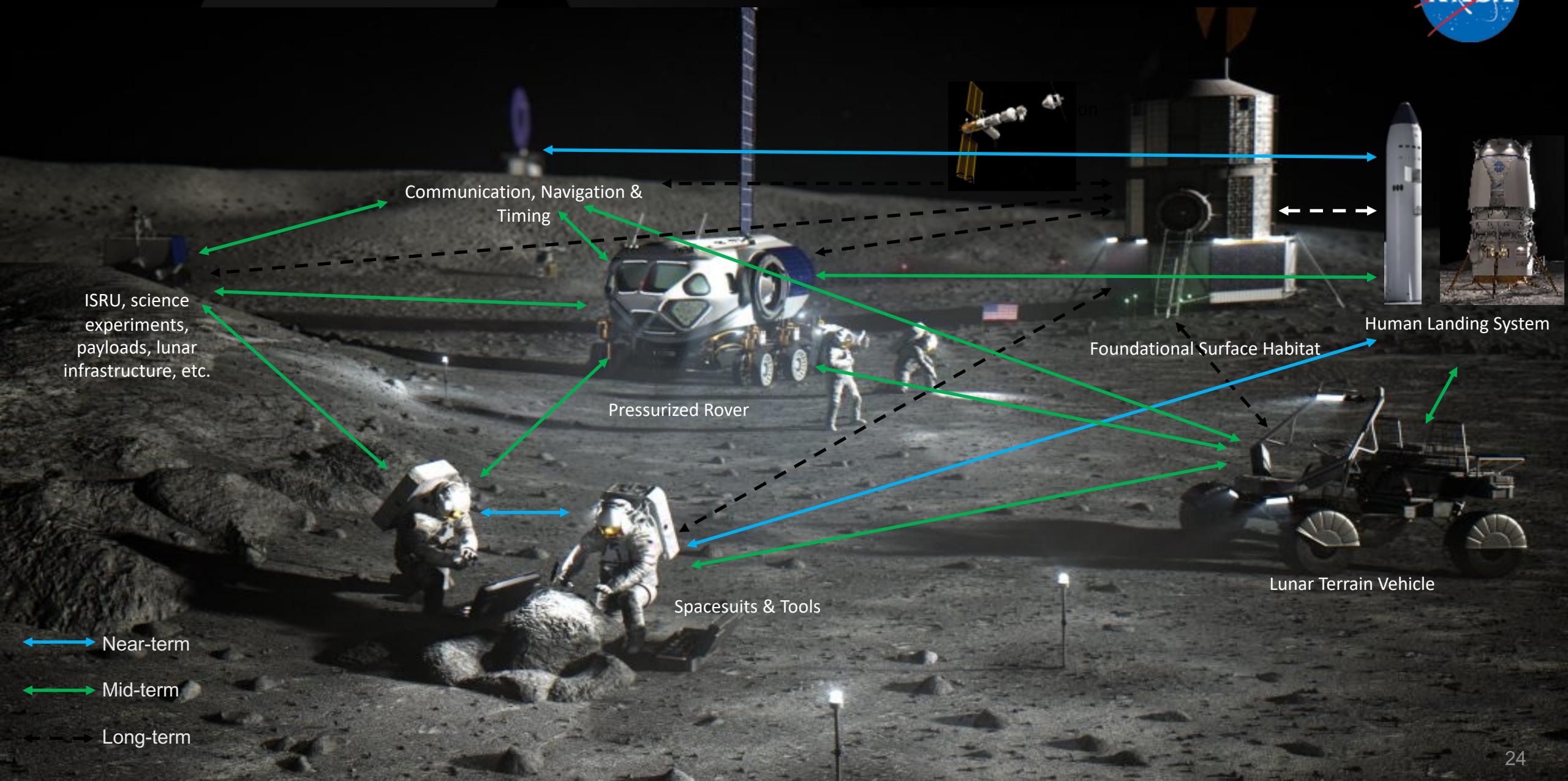
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Position 04h 14m 05s, 26° 20' 14"N
Subsolar 1.346°S 32.520°E
Sub-Earth 6.556°S 1.279°W
Pos. Angle 349.893°



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

01 Jan 2026 00:00 UT

Problem Description – Multilateral Interoperability





- International Standards
 - ([International Deep Space Interoperability Standards](#))
 - Avionics
 - Communications
 - Docking
 - ECLSS
 - Power
 - Rendezvous
 - Robotics
 - Thermal
 - Software
- Lunar Surface Specifications
 - (not yet publicly available)
 - Communication
 - C&DH
 - E3
 - Lighting
 - Navigation
 - Power
 - Software



Implementation Challenges

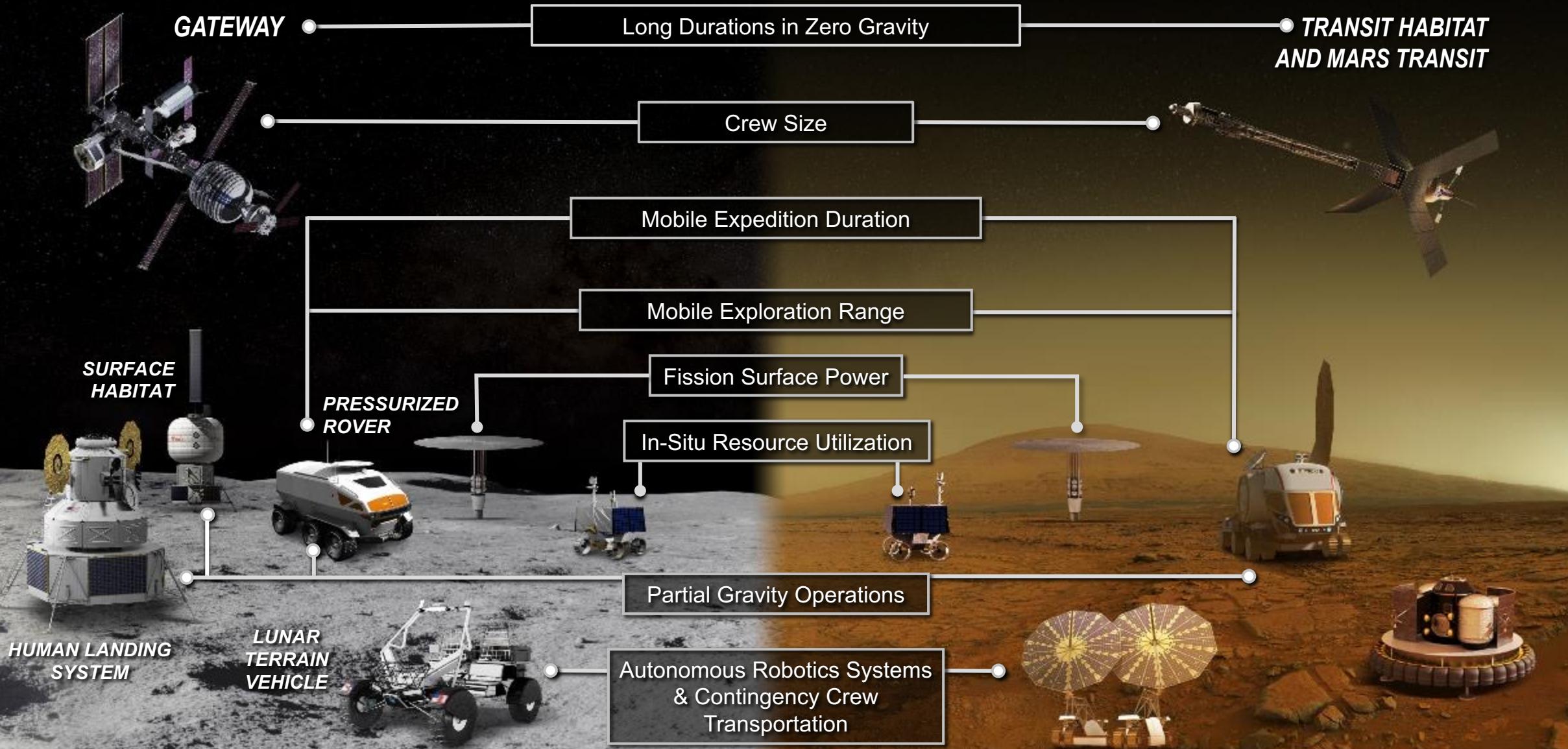
Panel Discussion



Artist render of Gateway's initial capabilities: NASA

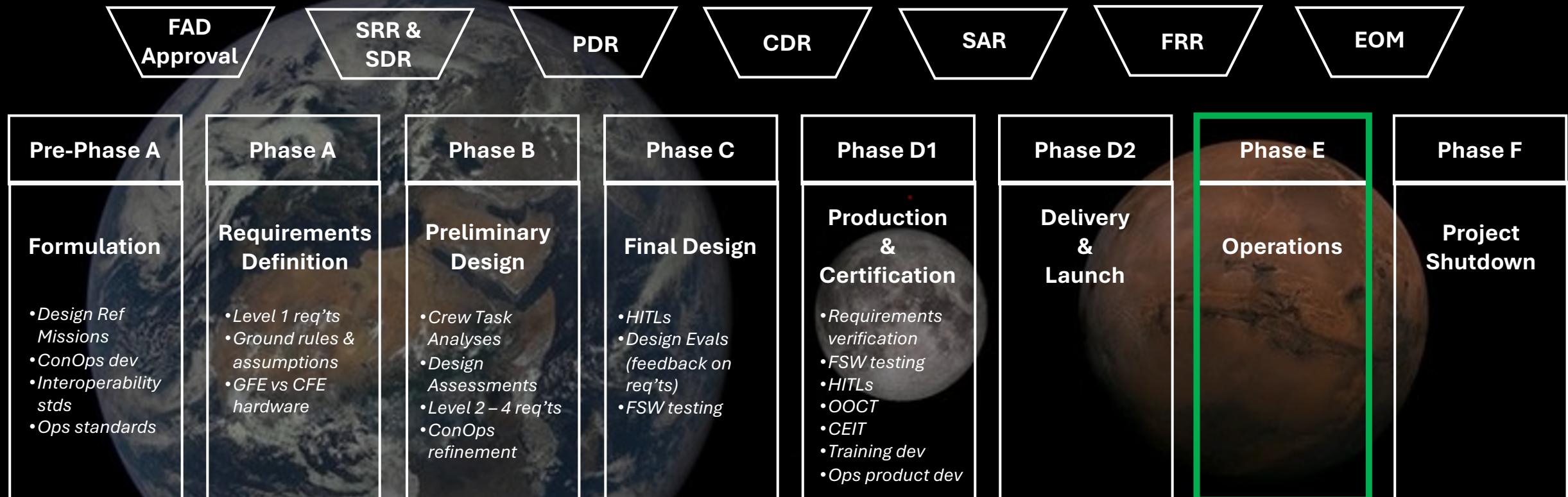
MOON AND MARS EXPLORATION

Scientific exploration and operations at the Moon will help prepare for the first human missions to Mars

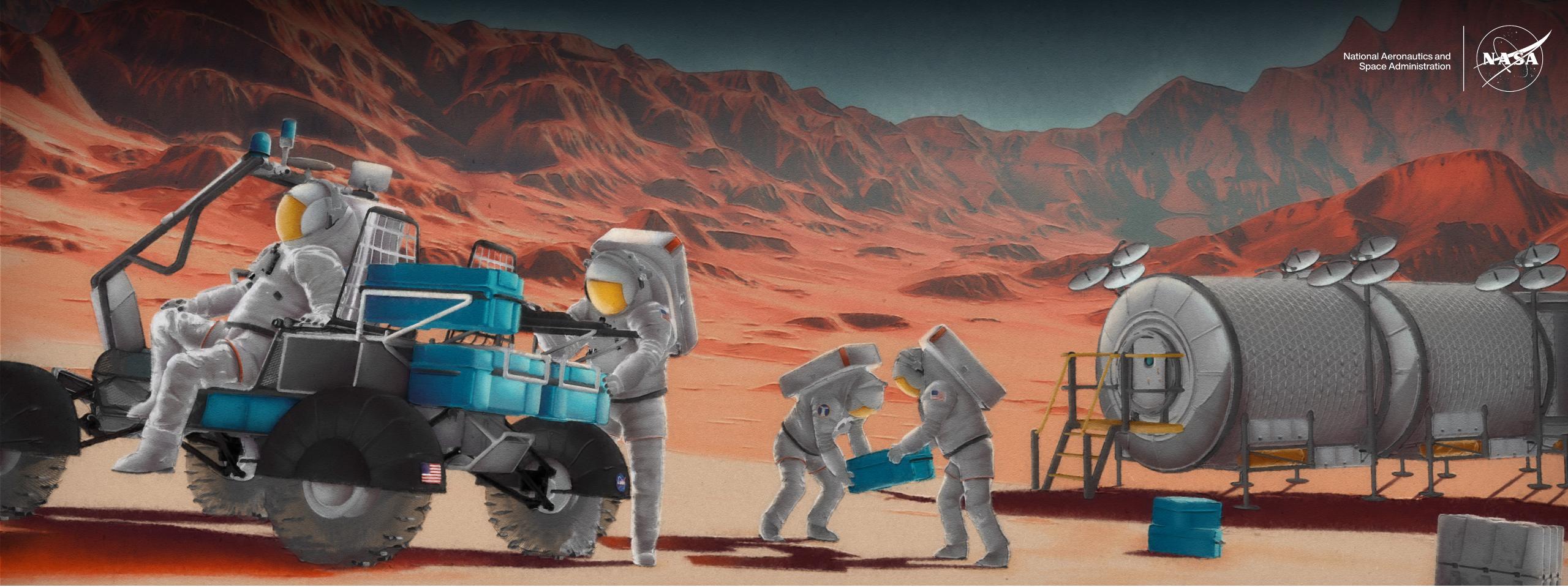


M2M Implementation Challenges - Operations

National Aeronautics and
Space Administration



Mitigation – Balanced Engagement Prior to “Mission”



Mars Key Definition: Number of Crew to Surface Decisions

**Patrick Chai, David Baumann,
Eddie Terrell**
NASA

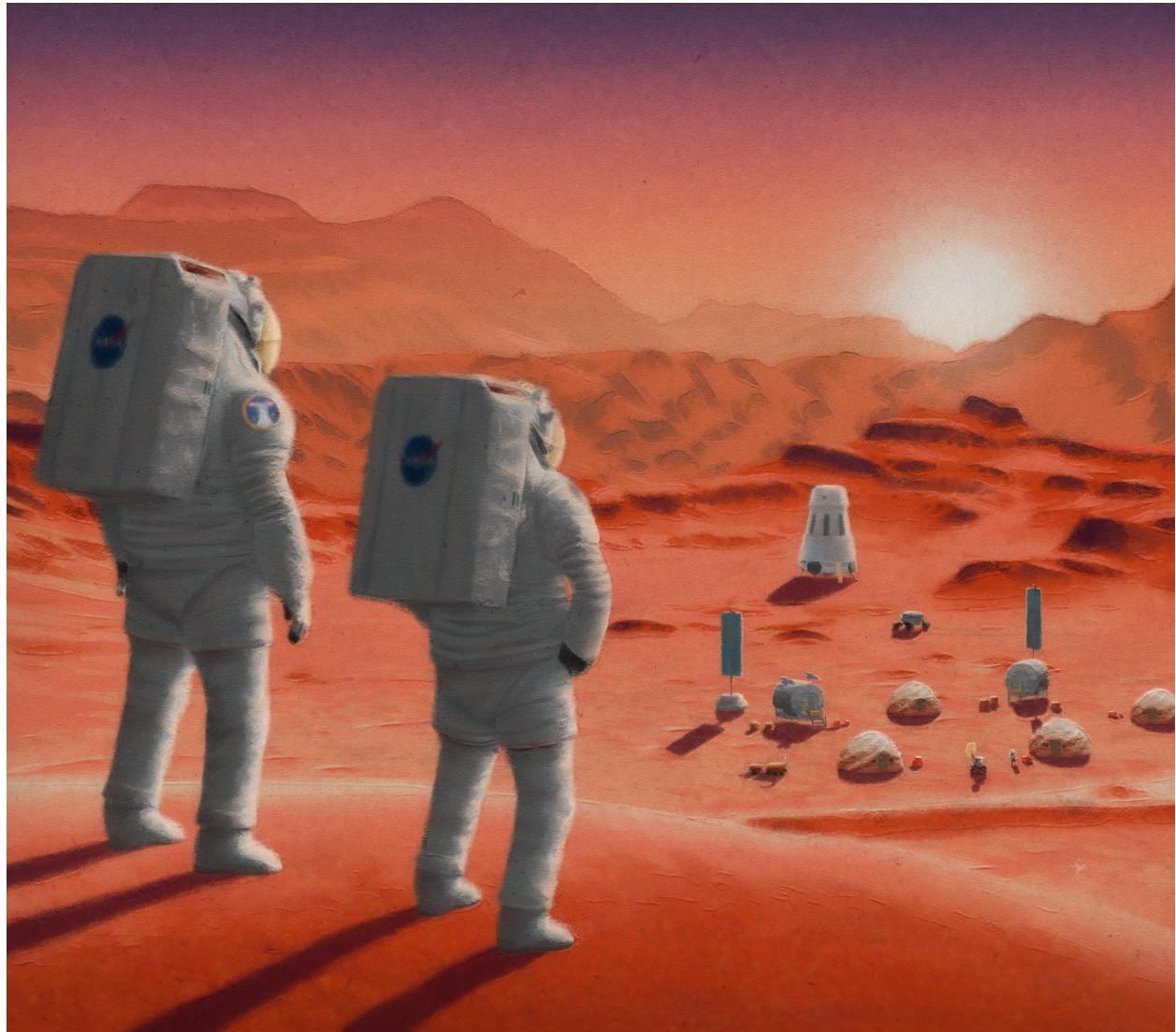


The Moon to Mars Initial Human to Mars Segment will target no fewer than four (4) crew to the surface, with consideration for the minimum to be up to six (6) crew for enhanced mission capability and/or provide risk reduction.

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

Background

- 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



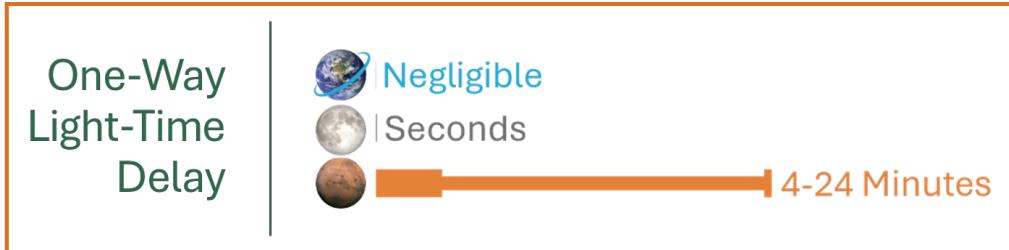
Three Key Findings

National Aeronautics and Space Administration



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



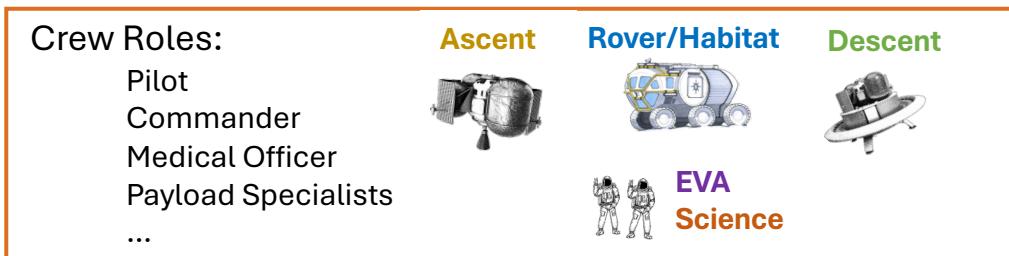
Key Findings #2:

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



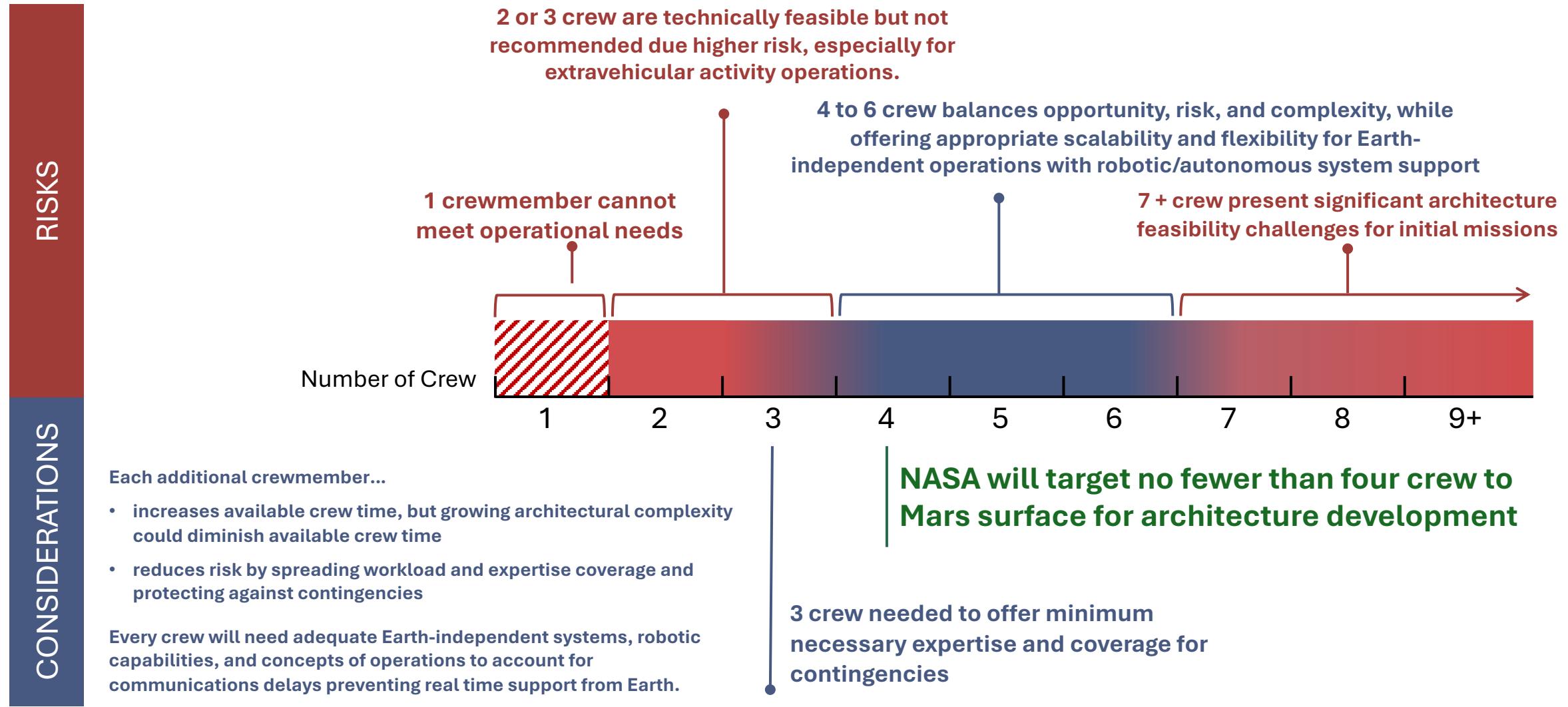
Key Findings #3:

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

National Aeronautics and
Space Administration



Crew Health and Operation Perspective

National Aeronautics and
Space Administration



- 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
 - 10:15am



Other Key Architecture Definitions

National Aeronautics and
Space Administration



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



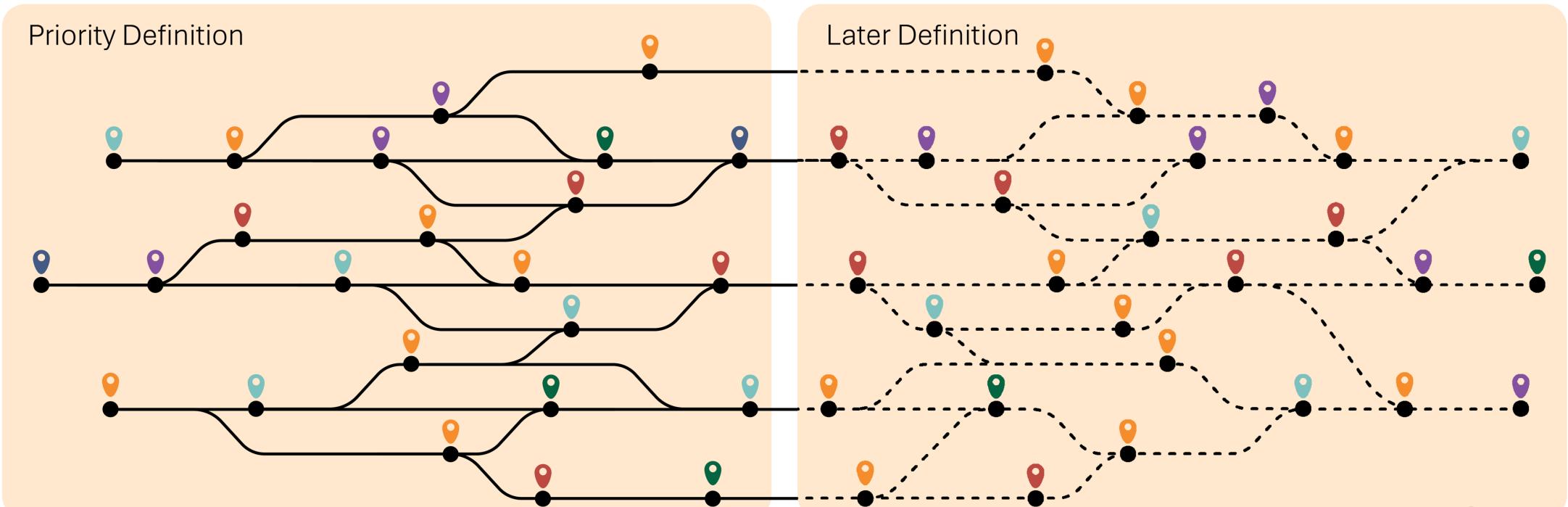
Established an architecture level methodology to evaluate crew risk across the vast architecture trade space.





Notional Definition Flow

📍 = Definition Task



Timeline to Exploration Destination

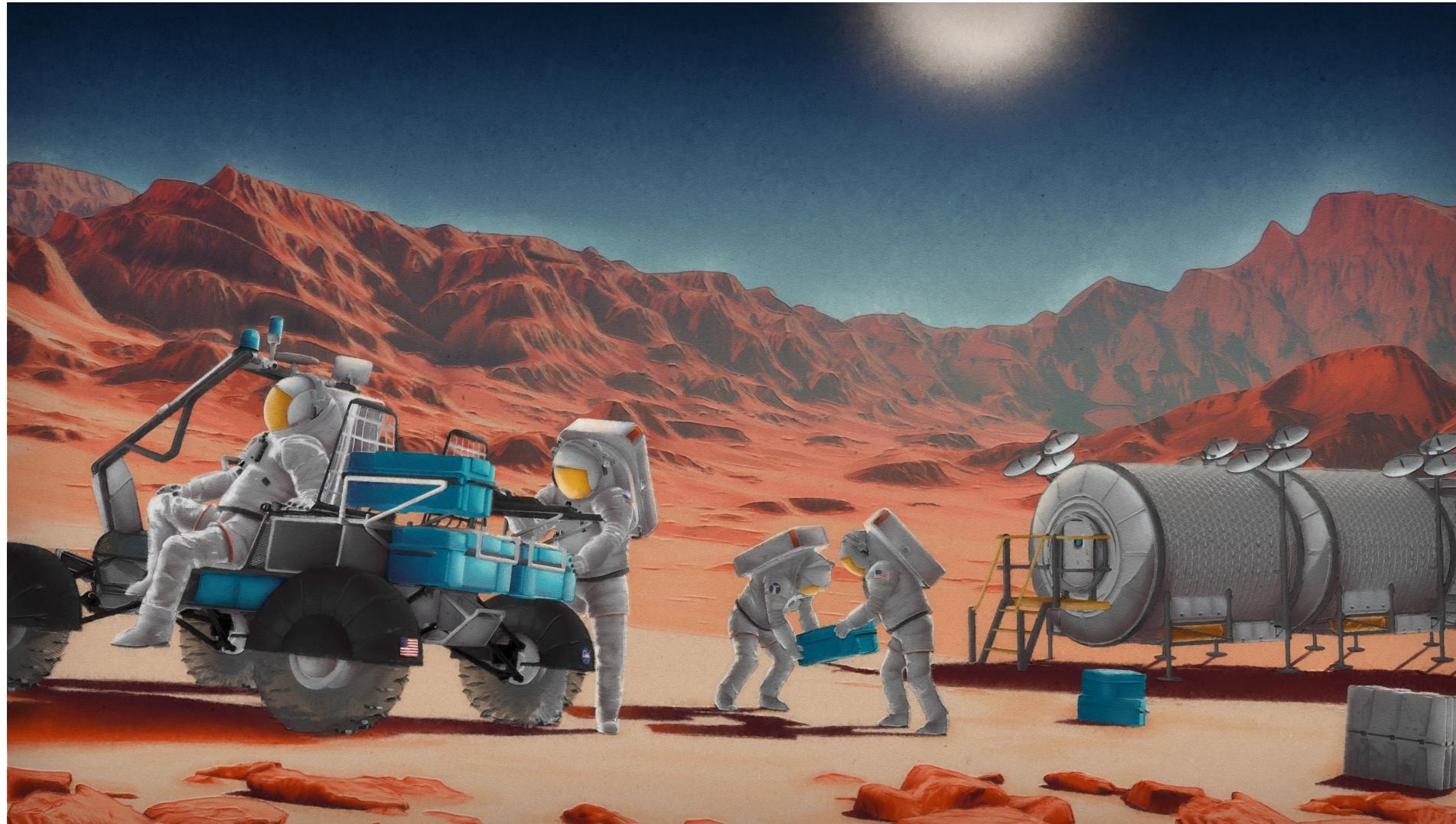
Completed
Definition Tasks



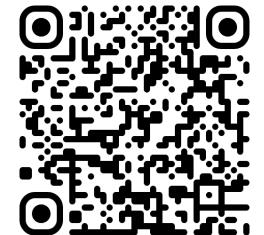
Definition
Color Key

Summary

National Aeronautics and
Space Administration



Architecture
White Papers





Architecture-Driven Data Gaps

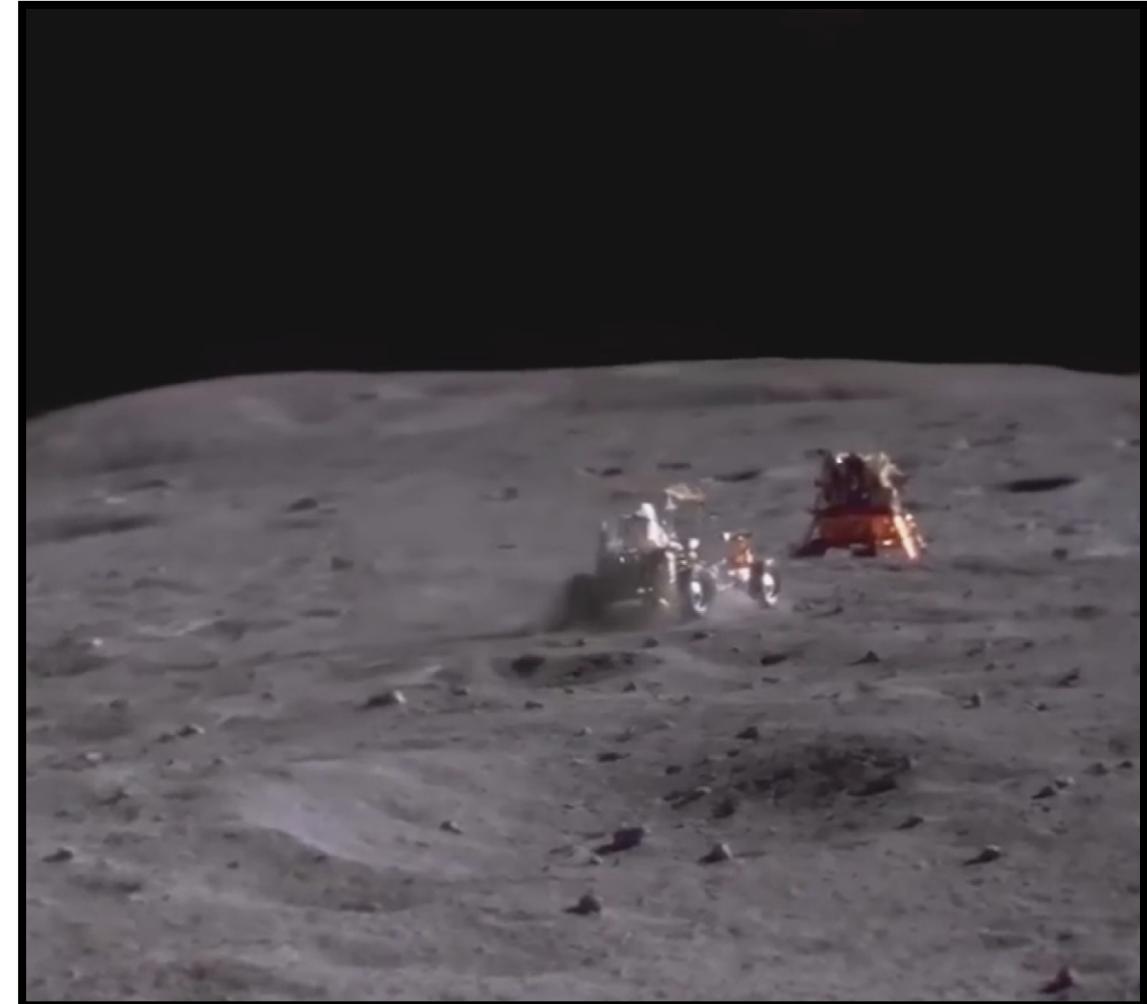
Audrey Morris-Eckart
Deputy Manager

Science, Technology Utilization & Integration
Strategy and Architecture Office

Data Gaps Purpose



- 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**

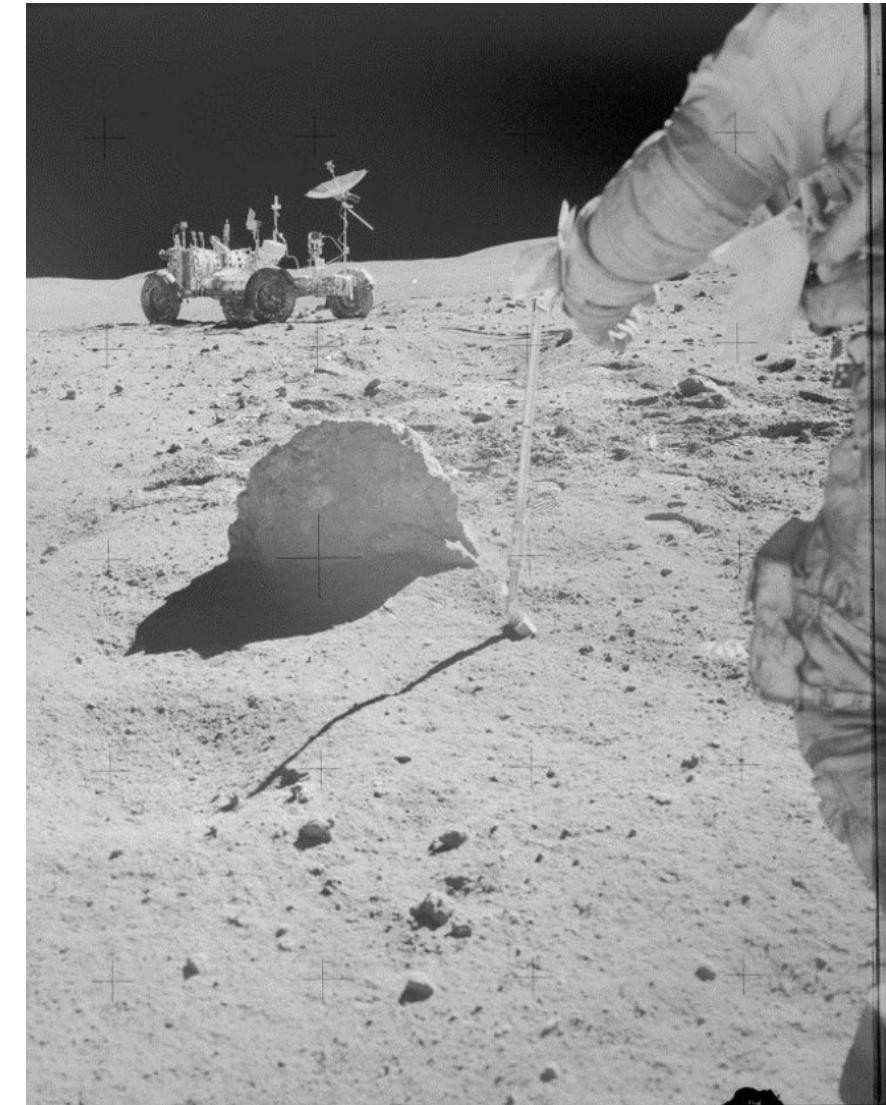


Data Gaps Caveats

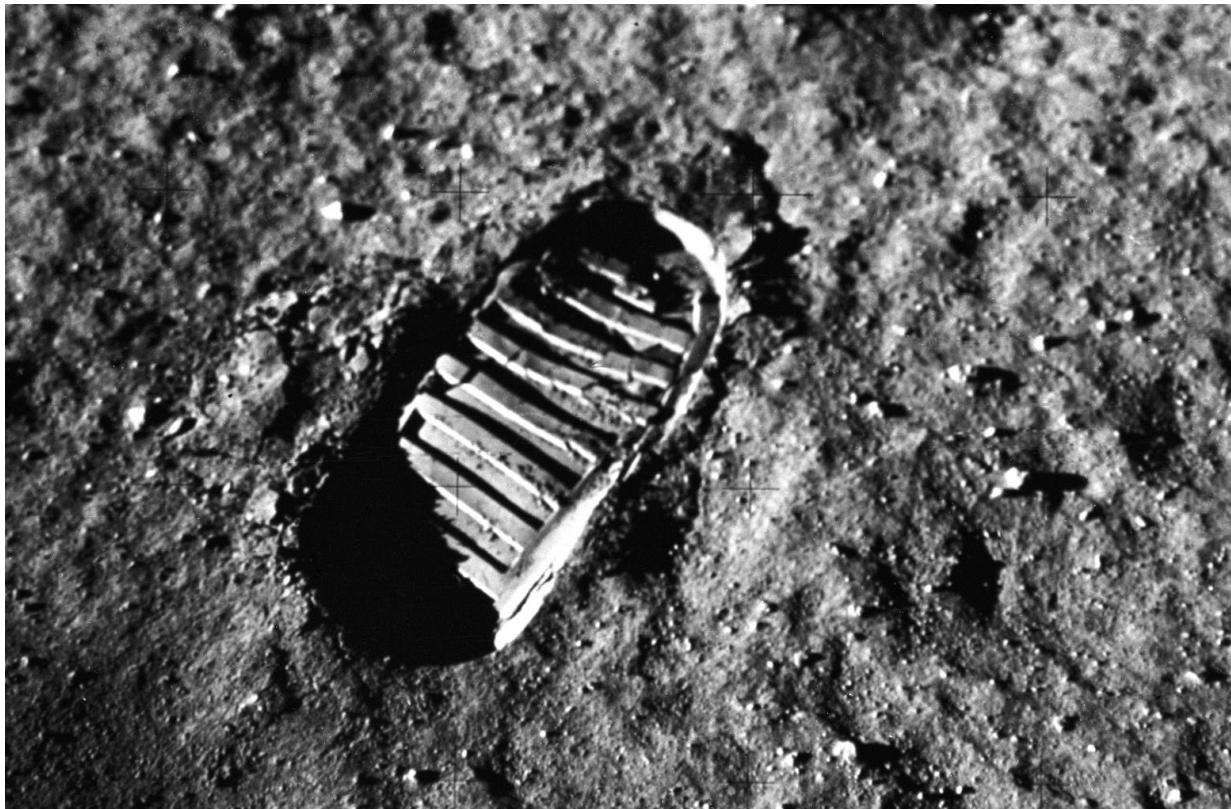
National Aeronautics and
Space Administration



- 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



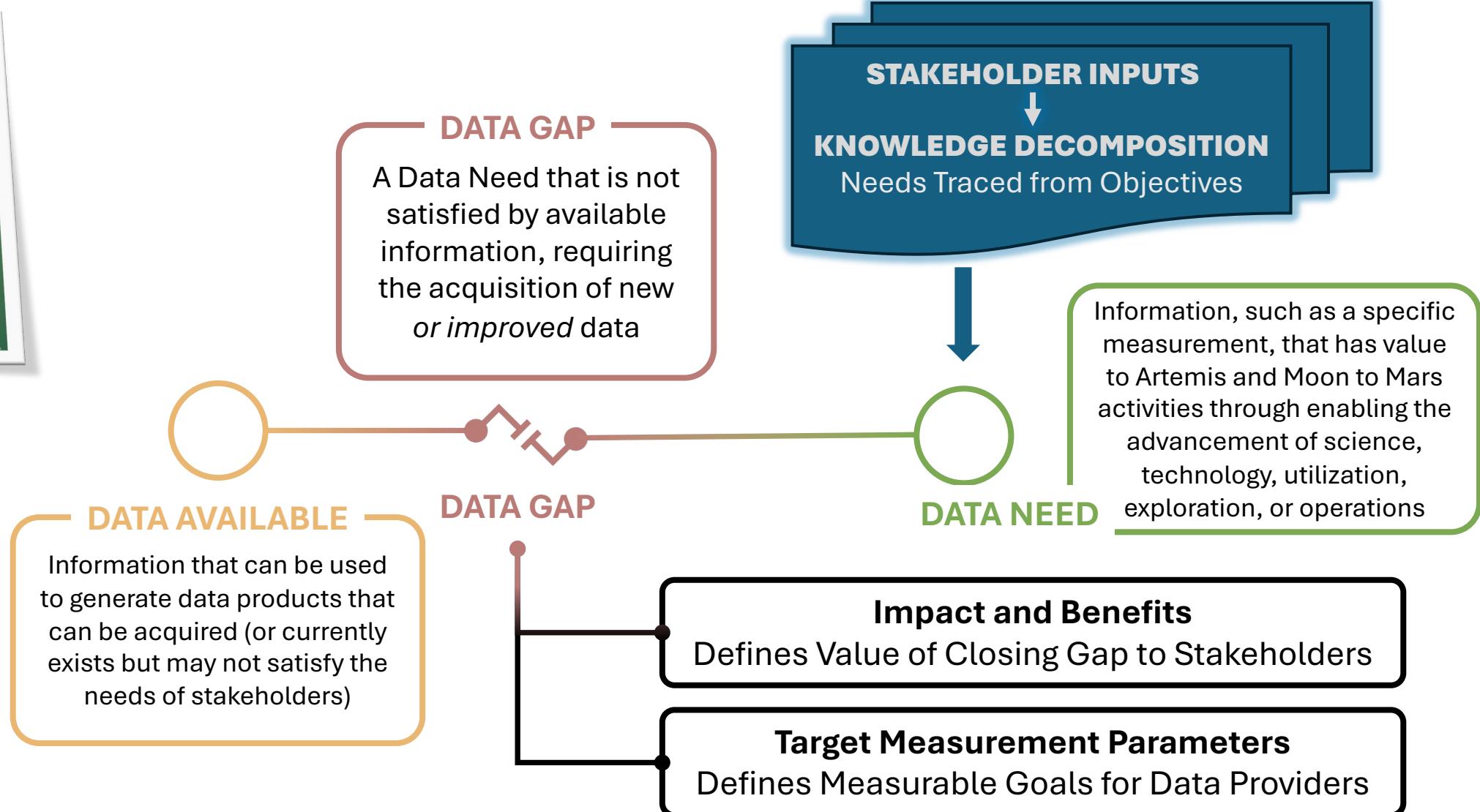
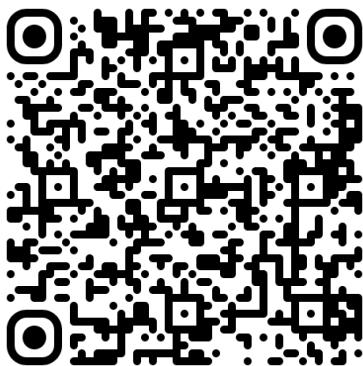
Technology Gap Replaced with Data Gaps

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

National Aeronautics and Space Administration



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

National Aeronautics and Space Administration



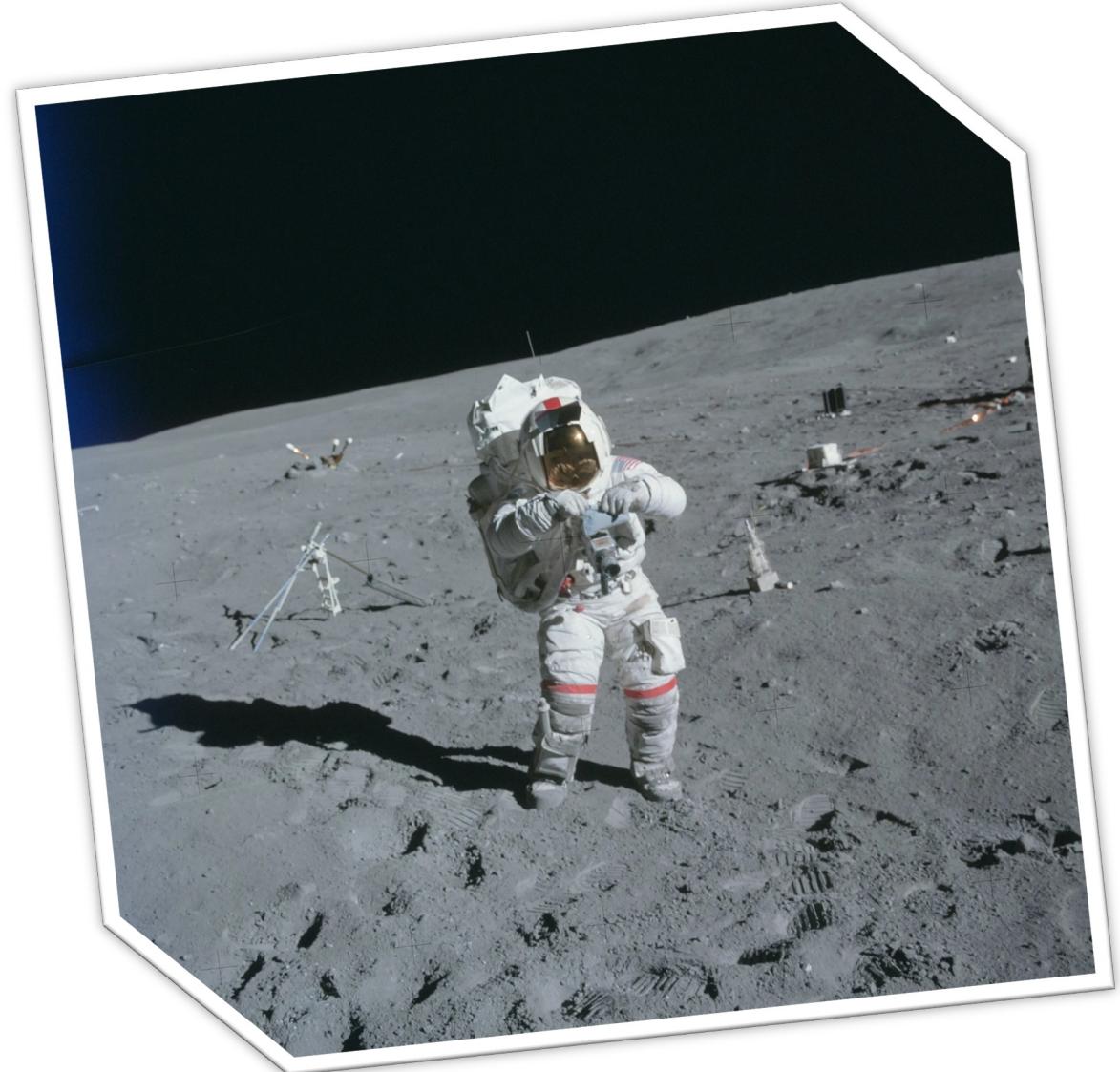
- Section 3.3 Initial Architecture-Driven Data Gaps
 - Summarizes the methodology and purpose
- Appendix E
 - List of Data Gaps and defines attribute details for each gap
 - ADD Rev C Includes 25 initial Data Gaps
- Built from rigorous systems engineering principles which were also used to define technology 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.	Objective	Data Type
DN-017 L	SE-07 LM, LI-05 L, TH-03 L	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.	Lunar Surface Induced Environment Characterization	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.		



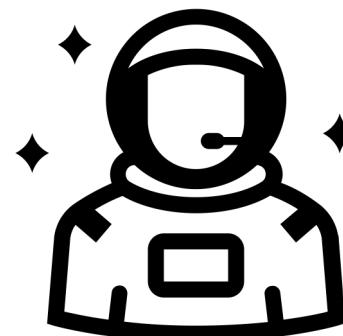
Data gained will help

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



Data Gaps

Roundtable



**Audrey
Morris-Eckart**
NASA

**Debra
Needham**
NASA

**Kristen
John**
NASA

**Kristina
Gibbs**
NASA-SSERVI

**Tim
Crain**
Intuitive Machines

Initial Lunar Data Gaps List in Rev C of ADD, Appendix E



ID	Data Type	Lunar Data Gap Title
DN-001 L	Orbit-to-Surface Imagery	Sustained, site-specific sub-meter scale imaging of lunar south pole exploration zones and sites
DN-002 L	Remote Sensing	Comprehensive, high-fidelity digital elevation map (DEM) coverage of lunar south pole exploration zones and sites
DN-003 L	Remote Sensing	High-resolution, time-resolved thermal mapping of lunar south pole exploration regions and sites
DN-004 L	Orbit-to-Surface Monitoring	Collection of imagery over lunar surface exploration sites to monitor impacts of human exploration
DN-005 L	Surface-to-Surface Imagery	Optical images from lunar surface at the lunar south pole
DN-006 L	Remote Sensing	Orbital observations of water ice deposits in the south polar region
DN-007 L	In Situ Measurement	In situ measurements of the horizontal and vertical distribution, abundance, and physical makeup of shallow bulk water ice
DN-008 L	In Situ Measurement/Sample Return	Geotechnical properties of highland regolith at the lunar south pole
DN-009 L	In Situ Measurement	Electrostatic properties of highland regolith at the lunar south pole
DN-010 L	In Situ Measurement/Sample Return	South polar lunar regolith elemental and mineral composition
DN-011 L	In Situ Measurement	In situ lunar surface plasma environment characterization
DN-012 L	In Situ Monitoring	In situ lunar surface radiation environment measurements and space weather monitoring
DN-013 L	In Situ Measurement	In situ measurements of the composition, distribution, and abundance of volatiles in the near-surface lunar south pole
DN-014 L	In Situ Measurement	High-resolution lunar rock size distribution and morphology at the lunar south pole
DN-015 L	In Situ Measurement	Flux and size measurements of lunar meteoroid ejecta
DN-016 L	In Situ Measurement	Lunar surface seismic activity characterization and monitoring
DN-017 L	In Situ Measurement	In situ measurement of particle velocity during lunar plume surface interaction (PSI) phenomena
DN-018 L	In Situ Measurement	In situ measurement of landing site alteration imaging at small scale on the lunar surface
DN-019 L	In Situ Measurement	In situ measurement of lunar regolith (dust) particle flux and charge

High priority, but not in priority order

Initial Mars Data Gaps List in Rev C of ADD, Appendix E

National Aeronautics and
Space Administration



ID	Data Type	Mars Data Gap Title
DN-001 M	In Situ Measurement	Geotechnical properties of Mars regolith, rocks, and bedrock at diverse geographic locations
DN-002 M	In Situ Measurement	Surface and subsurface water content at surface exploration sites
DN-003 M	In Situ Measurement	Localized and predictive Mars surface weather characterization
DN-004 M	In Situ Measurement	Human-scale EDL atmospheric entry environment characterization
DN-005 M	In Situ Measurement	In situ measurement of particle velocity during Martian plume surface interaction (PSI) phenomena
DN-006 M	In Situ Measurement	In situ measurement of landing site alteration imaging at small scale on Mars



Sample Return

Panel Discussion

4.8 UNSUPPORTED CREWED SURFACE LANDING ACTIVITIES

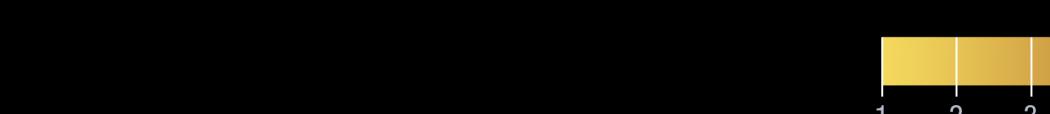
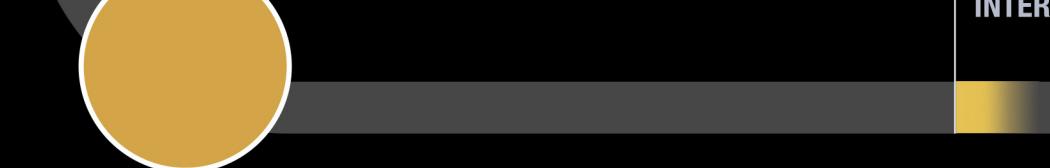
4.8.1 Preparation & Beginning of First EVA
4.8.4 Sample Collection
4.8.5 Documentation Activities Throughout Collection
4.8.6 End of an EVA



4.9.9 Considerations During Long-Term EVAs & Cross Missions
4.9.8 Tools Storage b/w Long-term EVAs & Cross Missions
4.9.7 Cold Stowage of Empty Containers b/w EVAs & Cross Missions



4.10.4 Uncrewed Sample Transfer, Storage, & Stowage b/w long-term EVAs & Cross Missions



4.9 EXPANDED & EXTENDED LUNAR EXPLORATION

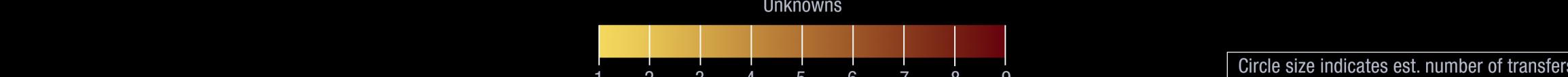
4.8.7 Sample Storage b/w Crewed EVAs
4.8.8 Tool Storage b/w Crewed EVAs
4.8.9 End of an EVA



4.9.1.1 Ambient Sample Storage w/in Vehicle/Habitat
4.9.1.2 Ambient Sample Storage w/in Habitat
4.9.2 Cold Sample Collection
4.9.2.1 Freezer Capabilities (Initial, Active, Passive)



4.9.2.2 Thermal Transfers
4.9.4 Cold Sample Storage w/in Habitat
4.9.3 Cold Sample Storage w/in Vehicles



4.11 TOOLS, SUIT, & VEHICLES INTERACTION

