

2025 Moon to Mars Architecture Workshops

Nujoud Merancy Deputy Associate Administrator *Strategy and Architecture* NASA – ESDMD - SAO



Welcome!

National Aeronautics and Space Administration



- Welcome to the 2025 Moon to Mars Architecture workshops for Industry and Academia
- Your input is critically important to the continued success of the architecture effort
- Feedback continues to inform the evolution of the architecture
- Participants include
 - ...almost 200 registrants
 - ...across industry and academia
 - ...representing nearly 100 organizations
 - ...small and large; new and established

We look forward to your participation



Moon to Mars Architecture

National Aeronautics and Space Administration



Beginning in 2022, NASA reset the strategic effort to enable human exploration of deep-space

- Objectives based architecting
- Enable flexibility and resilience
- Rooted in systems engineering fundamentals

All of Agency, All of Stakeholders

- Coordinated and collaborative
- Enhanced communication
- Commitment to transparency



NASA's Moon to Mars Strategy and Objectives Development



https://go.nasa.gov/4fXVGeY

Architecting from the Right

National Aeronautics and Space Administration





Rigorous systems engineering applied to identify the needs, understand relationships and identify gaps between systems to identify most effective and efficient solutions toward achieving long-term vision.

Architecture Segments

National Aeronautics and Space Administration





FUTURE SEGMENTS

Continued development and exploration at Mars and beyond for sustained exploration of the cosmos.

HUMANS TO MARS

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

SUSTAINED LUNAR EVOLUTION

Enabling capabilities, systems, and operations to support **regional and global utilization** (science, etc.), **economic opportunity**, and a steady cadence of human presence at the Moon.



FOUNDATIONAL EXPLORATION

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

HUMAN LUNAR RETURN

Initial capabilities, systems, and operations necessary to **re-establish human presence** and initial utilization (science, etc.) on and around the Moon. **Segment** | A portion of the architecture that integrates sub-architectures and progressively increases in complexity and objective satisfaction.

NASA's Moon to Mars Architecture

National Aeronautics and Space Administration



An Evolutionary Architecture Process:

Formulating an Exploration Strategy Based on Objectives



TRACEABILITY



Decomposition of Blueprint Objectives to executing Architecture elements

ARCHITECTURE FRAMEWORK

Organizational construct to ensure system/element relationships are understood and gaps can be identified

PROCESS & PRODUCTS



Clear communication and

review integration paths for

stakeholders

Architecture Products

National Aeronautics and Space Administration





NASA's Architecture Definition Document



Executive Overview

Architecture White Papers



NASA documents its roadmap for deep space exploration in the Architecture Definition Document.

The agency updates the document yearly and publishes it alongside other publicfacing products including white papers on relevant topics and an executive overview of the architecture.



Revision B Published **December 13**



NASA's Moon to Mars Architecture Website nasa.gov/architecture

2024 Feedback Key Takeaways

National Aeronautics and Space Administration



Industry and Academia Workshop

- Communication has improved.
- Stakeholders appreciated transparency regarding decisions and decision-making.
- Industry desires more clarity on the agency's investment priorities.
- Industry and academia would appreciate being involved earlier in the gap definition process.
- Enable more discussion opportunities at workshop.

International Partner Workshop

- Building community is integral to success.
- Partners want to engage their own domestic stakeholders and build support for space.
- Emerging space agencies desire more clarity on where they can engage in the architecture.
- Partners desire clear paths through preformulation to element initiation.

We've tailored our architecture products to meet desires expressed at last year's workshops. Your feedback and engagement is critically important to the continued success of the Moon to Mars Architecture.

Architecture Concept Review 2024 (ACR24)

National Aeronautics and Space Administration





At ACR24, agency leaders representing each of NASA's mission directorates, centers, and technical authorities provided concurrence on architecture updates:

- Revision B of NASA's Architecture Definition Document (ADD)
- Two new Moon to Mars Architecture elements
- Architecture-driven technology gaps definition and prioritization
- Initial Mars surface power technology decision
- Prioritization of 5 additional Mars architecture decisions
- 12 white papers

NASA published ACR24 products on December 13. This includes revision B of the ADD, the 12 white papers, and an executive overview of the architecture.

Moon to Mars Architecture Workshops

ADD Rev B Updates

- ADD Revision B updates add 50+ pages of new content including the two new appendices and the two new exploration elements
- The revision also reflects a refined and updated objective decomposition that seeks to improve clarity and embrace lessons learned
- Updated Definitions (Appendix D) reflected in the Objective Decomposition:
 - $\circ~\mbox{Refined}$ definition of utilization payload to include equipment
 - $\circ~$ Included an all-encompassing term of "Exploration Asset"
 - $\circ~$ Better defined the delineation between large and small cargo
 - Included call out to samples in addition to commodities and logistics items



National Aeronautics and Space Administration





10

Decomposition Updates

National Aeronautics and Space Administration



Characteristics and Needs

- $\circ\,$ Updated for better accuracy, clarity, and consistency
- o Implemented new numbering schema for better organization
- Rewrote for science objectives to improve clarity and consistency
- o Utilized model-based systems engineering (MBSE) environment

• Lunar Use Cases and Functions

- Refined to better align syntax and remove overlapping or redundant functions
- Added "bucketing" or classes of capabilities to better align assets with functions
- Updates reflect two years of lessons learned and stakeholder feedback

Mars Use Cases and Functions

- Added for the Transportation & Habitation, Mars Infrastructure, and Operations Objectives
- $\circ~\mbox{Followed}$ similar syntax and nomenclature of lunar objective decomposition

Asset Mapping Tables

- Split utilization payloads into equipment, science/research payloads, and technology demonstrations
- Clarified interpretation of asset mappings as a contribution to the architecture by an asset

New Element: Initial Surface Habitat

National Aeronautics and Space Administration





Architecture Elements Approved at ACR24 Initial Surface Habitat

Enables expanded exploration capabilities up to 4 surface crew, establishes opportunities for Marsforward precursor missions, and increased exploration capabilities and science during missions

Primary Functions Met by Element

Enable a pressurized, habitable environment on the lunar surface for short durations (days to weeks)

Operate habitation system(s) in uncrewed mode between crewed missions on the lunar surface

Provide power for deployed external surface utilization payload(s) and/or equipment for long durations (months to years+)

Provide intravehicular activity facilities, utilization accommodation, and resources, operable during crewed and uncrewed increments on the lunar surface

+15 additional functions.

FN#

FN-H-101

FN-H-201

FN-P-402 L

FN-U-201 L

New Element: Lunar Surface Cargo Lander

National Aeronautics and Space Administration





Architecture Elements Approved at ACR24 Lunar Surface Cargo Lander

Dedicated cargo lander to deliver logistics, utilization, small exploration assets, and other cargo to the Moon; payload capacity on the order of 2 tons

Primary Functions Met by Element

- Transport a moderate amount of cargo (1000s of kg) from Earth to south pole region sites on the lunar surface
- Transport a moderate amount of cargo (1000s of kg) from Earth to distributed sites outside of the south pole region on the lunar surface
- Provide precision landing for cargo transport to the lunar surface

Enable landing on the lunar surface under all lighting conditions

FN#

FN-T-202 L

FN-T-204 L

=N-T-402

FN-T-403 L

New ADD Appendixes

National Aeronautics and Space Administration



Architecture-Driven Technology Gaps

APPENDIX C

- With a broad array of needs competing for technology development resources, the agency must judiciously target priority technologies that enable NASA to achieve its exploration goals
- NASA has applied rigorous systems engineering processes to develop and prioritize architecture-driven technology gaps to inform technology development investments
- The resulting list is included in Appendix C of Revision B of the Architecture Definition Document and will be updated annually

To learn more, read the associated white paper and participate in the workshop white paper poster session and/or briefing. www.nasa.gov/architecture



Key Moon to Mars Architecture Decisions

APPENDIX B

- In laying out an architecture decision roadmap, it is critically important to understand how key drivers relate to each other and how an architecture can change depending on the order in which decisions are made
- NASA has applied rigorous systems engineering principles in laying out an architecture decision roadmap that clearly identifies a logical order in which decisions may be made based on their precedence relationships
- NASA documents these decisions in Appendix B of the Architecture Definition Document and will update yearly as new decisions are identified or made
- As part of the 2024 Architecture Concept Review, NASA added five additional decisions to its initial list of seven priority Mars decisions. Additionally, NASA made it's first Mars decision, selecting nuclear fission and the primary surface power generation technology for initial crewed missions to Mars.

February 2025

Moon to Mars Architecture Workshops

15

2024 White Papers







Human Exploration and Operations Mission Directorate

Next Space Technologies for Exploration Partnerships -2

(NextSTEP-2) Broad Agency Announcement (BAA) Appendix R: Lunar Logistics and Mobility Studies

NNH16ZCQ001K-Appendix-R-1

Draft Originally Issued: August 16, 2024 Issue Date: September 20, 2024

> Amendment 004 Issued: October 21, 2024

Proposals Due: October 25, 2024, by 12:00 PM Eastern Tim

300 E ST SW Washington, D.C. 20546-0001

Logistics and Mobility: BAA App R

National Aeronautics and Space Administration



- The request sought **proposals from industry** that might advance lunar cargo and mobility capabilities. Proposed areas of study included:
 - Logistics Carriers
 - Logistics Handling and Offloading
 - Logistics Transfer
 - Staging, Storage and Tracking
 - o Trash Management
 - Surface Cargo Transportation and Mobility Systems
 - Integrated Strategy

Opportunities for collaboration with industry for early studies and trades will continue



What's Different this Year?

National Aeronautics and Space Administration



We want to hear from YOU!

- We've retooled the workshops to promote more engagement and interaction between all present
- We've added non-NASA panelists to broaden the perspectives highlighted in discussions
- We're focused on finding avenues to collaborate that close architecture and technology gaps

