NASA’s Moon to Mars Architecture Workshop

What: Mars Forward Capabilities at the Moon

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WHEN WILL WE ACHIEVE LUNAR OBJECTIVES?
- Multi-decadal campaign
- Support annual cadence of crewed missions
- Development of permanent infrastructure
- Expansion of economic sphere to the Moon

WHO DOES THIS APPROACH INCLUDE?
- NASA
- U.S Government
- Industry
- International Partners
- Academia
- Public

WHAT FOUNDATIONAL CAPABILITIES ARE NEEDED
- Long-duration microgravity systems
- Partial gravity destination platforms
- Low Earth Orbit assets and infrastructure

WHERE SHOULD SYSTEMS BE?
- Ensure access to the Lunar South Pole
- Capability for non-polar expeditions

HOW WILL WE GET THERE AND RETURN?
- Lunar Microgravity staging in NRHO
- Earth ↔ NRHO ↔ Lunar surface
- Surface Mobility

WHY EXPLORE?
- SCIENCE -
  Understand the universe
  Direct observations

- INSPIRATION -
  “Artemis Generation”
  Overcome challenges
  Succeed with hard work

- NATIONAL POSTURE -
  Enrich lives on Earth
  Technology development
  International partnerships

NASA ARCHITECTURE WORKSHOP – JUNE 2023
Driving M2M Objectives:

**OP-1**: Conduct human research and technology demonstrations on the surface of Earth, low Earth orbit platforms, cis-lunar platforms, and on the surface of the moon, to evaluate the effects of extended mission durations on the performance of crew and systems, reduce risk, and shorten the timeframe for system testing and readiness prior to the initial human Mars exploration campaign.

**OP-7**: Validate readiness of systems and operations to support crew health and performance for the initial human Mars exploration campaign.
Key Mars Forward Capabilities that would Benefit from Risk Reduction Activities at the Moon

- Human Adaptation and Accommodation in a Long-Duration Deep Space Environment
- Deep Space Delivery and Aggregation
- Long Duration & Dormancy
- Autonomous Operations
- Surface Landing & Ascent
- Acclimation to Partial Gravity
- Crewed Surface Operations and Surface Mobility
- Nuclear Operations
- Interoperability Standards & Capability Modularity
Lunar Missions as Preparation for Mars: Human Lunar Return (HLR)

Mars Forward Elements:
• SLS/Orion and other commercial launch systems to transport crew & cargo to deep space
• HLS ascent as a demonstration for Mars ascent
• HLS autonomous terminal descent and landing including plume ejecta dynamics
• xEVAS suit is feed forward to a partial gravity Mars EVA suit
• Gateway systems such as solar electric propulsion, autonomous systems, and habitation feed forward to Mars transit and habitation
• VIPER is feed forward for Mars ice core drilling
Lunar Missions as Preparation for Mars: Foundational Exploration

Notional Mars Forward Elements:

- Unpressurized mobility to transport cargo, elements, logistics and crew both prior to and during crew missions
- Pressurized mobility for crew exploration of the planetary surface
- Cargo transportation to deliver large elements and cargo to the surface
- Surface habitation (mobile or perhaps stationary) to support the crew while on the surface
- Power generation, storage, and distribution on the surface
- High bandwidth communication and position, navigation and timing systems
Summary

While the environmental and operational strategies will differ, every mission to the Moon can help inform design and operational strategies for future Mars missions by:

- Providing key information and approaches necessary to support humans at greater duration and distance in deep space
- Demonstrating key operational capabilities and techniques
- Evaluating advanced exploration and surface exploration techniques
- Reducing the risk of advanced technologies and system concepts

Access the white paper with this QR code or at [www.nasa.gov/MoonToMarsArchitecture](http://www.nasa.gov/MoonToMarsArchitecture)