Breakout Session: Human Lunar Return (HLR)

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Why Explore – the Starting Point of HLR

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

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 MOON TO MARS ARCHITECTURE WORKSHOP – JUNE 2023
Architecture Framework

A group of tightly-coupled systems, functions, and capabilities that perform together to accomplish architecture objectives.

Ex: Transportation Systems: Contain common functions (e.g., RPOD) & need to ensure end-to-end allocation for crew transport from Earth to destinations to safe return.

A portion of the architecture, identified by one or more notional missions or integrated use cases, illustrating the interaction, relationships, and connections of the sub-architectures through progressively increasing operational complexity and objective satisfaction.

Ex: Human Lunar Return integrated use case is similar to current notional Artemis IV operations.
**Segments and Sub-architectures**

**Segment:** A portion of the architecture, identified by one or more notional missions or integrated use cases, illustrating the interaction, relationships, and connections of the sub-architectures through progressively increasing operational complexity and objective satisfaction.

**Sub-architecture:** A group of tightly-coupled systems, functions, and capabilities that perform together to accomplish architecture objectives.
Objectives that drive the HLR segment include achieving science, inspiration, and national posture goals around and on the surface of the Moon

### Science

<table>
<thead>
<tr>
<th>Examples:</th>
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<tbody>
<tr>
<td>Exploring the lunar south polar region to understand chronology, composition, and structure of this region</td>
<td>LPS-1</td>
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<tr>
<td>Understanding volatile composition and the environment of shallow permanently shadowed regions near the lunar south pole</td>
<td>LPS-2</td>
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<tr>
<td>Assessing the history of the Sun as preserved in lunar regolith</td>
<td>LPS-3</td>
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<tr>
<td>Characterizing space weather dynamics to enable future forecasting capabilities</td>
<td>HS-2</td>
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<tr>
<td>Characterizing plant, model organism/systems, and human physiological responses in partial-gravity environments</td>
<td>HS-1</td>
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### Transportation & Habitation

<table>
<thead>
<tr>
<th>Examples:</th>
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<tbody>
<tr>
<td>Systematically and progressively test areas such as crewed transportation to cis-lunar space</td>
<td>TH-1, TH-2</td>
</tr>
<tr>
<td>Rendezvous and docking, uncrewed Human Landing System demonstration, initial human landing</td>
<td>TH-2</td>
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### Operations

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<tr>
<th>Examples:</th>
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<tbody>
<tr>
<td>Supporting ground infrastructure</td>
<td>OP-4</td>
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<tr>
<td>Deep-space communications and tracking systems</td>
<td>OP-2</td>
</tr>
<tr>
<td>Crewed transportation to and from cis-lunar space, initial Gateway deployment</td>
<td>OP-6</td>
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Human Lunar Return (HLR)

- Includes inaugural Artemis missions to enable returning humans to the Moon
- Demonstrates both crewed and uncrewed lunar systems, including the support to initial utilization (science, etc.) capabilities
- Demonstrates initial systems to validate system performance and to establish a core capability for follow-on campaign segments
- Comprises a variety of other efforts in work to support data-gathering and risk-reduction activities to help inform future decisions
  - E.g., the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE), Commercial Lunar Payload Services (CLPS), and Volatiles Investigating Polar Exploration Rover (VIPER)
HLR: Use Cases & Functions

- HLR Use Cases and Functions were driven by what is needed to re-establish human presence and initial utilization (science, etc.) on and around the Moon.

- ~40 Use Cases and ~50 Functions have been mapped to HLR.

- Mapping of the elements may not fully satisfy the use case, function, or associated objective or that completion is achieved.
Human Lunar Return Segment

EXPLORATION GROUND SYSTEMS

ORION SPACECRAFT

SPACE LAUNCH SYSTEM

GATEWAY

DEEP SPACE LOGISTICS

xEVA Systems

HUMAN LANDING SYSTEM

COMM, POSITIONING, NAV, TIMING (CPNT)

COMMERCIAL LUNAR PAYLOAD SERVICES
3.1.3.1 Crewed Initial Lunar Surface Reference Mission

- Transporting crew and systems from Earth to cislunar space
- Staging crewed lunar surface missions from cislunar space
- Assembling integrated assets in cislunar space
- Transporting crew and systems between cislunar space and the lunar surface
- Returning crew and systems from cislunar space to Earth
- Crew operations on the lunar surface
- Frequent crew EVA on the surface
- Crew conducting utilization activities on the surface.
- Additional science, utilization, crew health and performance, and operations are also envisioned

3.1.3.2 Crewed Gateway and Lunar Surface Reference Mission

- Crew conducts utilization activities in cislunar space
- Enable ground personnel and science teams to directly engage with crew on the surface and in lunar orbit - augmenting the crew’s effectiveness at conducting science activities
- Enables crew and/or robotic emplacement and set-up of science instrumentation in lunar orbit with long-term remote operation
- Autonomous/semi-autonomous mission operations in cislunar space
Discussion Questions (1/2)

• Is the depth of detail for HLR sufficient?
• As more Artemis missions are flown as part of HLR, what level of detail do you expect to see in the ADD for flown vs. upcoming missions?
• Is there information that might be beneficial to include in future segment chapters or updates to HLR content?
• What questions did you have about HLR that were not answered in the ADD?
• Do Use Cases and Functions have enough context?

• Are there any Functions and/or Use Cases that should be included in HLR segment that were not?