Lunar Habitation Science Opportunities and Constraints

James E. Johnson, james.e.johnson@nasa.gov | Paul D. Kessler, paul.d.kessler@nasa.gov | Allison Quesenbery, allison.m.quesenbery@nasa.gov

Habitation Concepts & Supported Functions

NASA and its international and commercial partners are assessing new habitation concepts for Artemis missions to the Moon and Mars. The functional needs of such habitats will increase as missions progress across the Human Lunar Return (HLR), Foundational Exploration (FE) and Sustained Lunar Evolution (SLE) architectural segments. These increasing needs will be met with scalable increases in volume, power, and larger crew sizes over longer mission durations which will provide numerous scientific and exploration opportunities.

Key habitation functions supporting science and utilization as listed in NASA's Architecture Definition Document (ADD) Revision A.

Function ID	Functional Description
FN-060-L	Provide intravehicular activity facilities, utilization accommodation, and resources (e.g., power, data, and physical interfaces) on the lunar surface.
FN-152-L	Transfer equipment from extravehicular to intravehicular environment.
FN-113-L	Operate habitation system(s) in dormancy/remote mode between crewed missions on the lunar surface.

Intravehicular Facilities

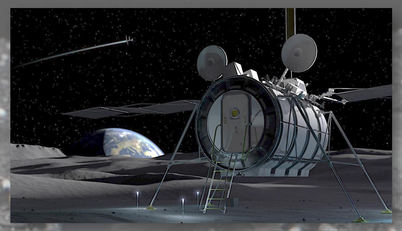
- Dedicated pressurized volume for experiments and scientific supply storage
- Power, data, thermal control, communications capabilities of varying scale
- Larger and/or aggregated habitation may support freezers, glove boxes, and other such facilities

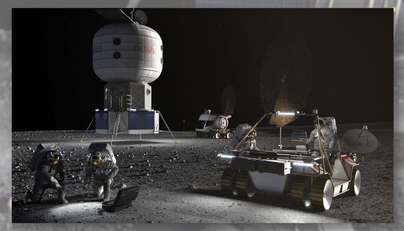
Equipment Transfer

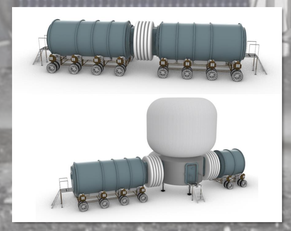
- Airlock and/or depressurizable cabins allow crewed transfer of scientific packages between pressurized and ambient lunar environment
- Future robotic systems may enable transfer between interior and exterior environments without crew

Dormancy/Remote Operations

- Initial missions may experience up to 3 years between crewed occupancy
- Provision of long-duration platform for pressurized science and utilization
- Additional power, data, and communications resources to support science during uncrewed operations







Notional lunar surface habitation concepts being assessed for Artemis Moon to Mars segments.

Lunar Habitation Science Opportunities

The primary opportunity afforded by lunar surface habitation is a pressurized environment, periodic crew interaction, and power, data, and communications services. Initial habitation elements will be limited in the volumetric allocation and services they can provide, although these capabilities are expected to increase over time as a sustained lunar presence is achieved.

Initial habitation opportunities expected to scale over time

Internal Utilization Volume

- Up to 0.5m^3
- 8.2 psia, 34% O2

Power for Utilization

- Internal & external
- 1000-4000 W
- Limited night power

Other Services

- Supply water
- Reconfigurable workspaces

Lunar Habitation Science Constraints

Despite scalable habitation concepts, some constraints need to be considered by proposed experiments given the challenges of early habitation in HLR and FE segments. Science and utilization payloads will be significantly limited by initial volume and mass allocations, exacerbated by minimal logistical and infrastructure delivery capabilities during early missions. Constraints will likely be negotiated based on science and utilization priorities while increased habitation functionality is gradually realized.

Constraining considerations for initial lunar surface habitation

Autonomy & Remote Operations

- Crewed mission frequency of once per year during FE and initial dormancy periods of 1-3 years will limit crew interaction
- Payloads will need to function with maximum autonomy during uncrewed and dormancy periods

Power Limitations

- Initial elements will be self-sufficient and limited in power
- Lunar night operations may require power down of non-essential payloads
- Lunar night power allocations may be limited to 100's of Watts or less

Limited Volume/Mass

- Initial habitation elements will not have sufficient volume for large freezers, gloveboxes, etc.
- Utilization payload volume may be discontinuous to maximize volumetric efficiency of smaller habitats
- Limited logistical resupply will drive some utilization self-sufficiency

Reliability

- Limited crew time and logistical constraints will drive high-reliability payloads
- Payloads will need to be recoverable from faults via ground commanding, or autonomy

Summary

As NASA returns to the lunar surface, scalable habitation concepts will provide science and utilization opportunities that may be unique from other lunar surface elements, particularly relating to operations in a pressurized volume with crew. While initial experiments may face volumetric, power, and operational constraints, integrating habitation and science payload concept development efforts will maximize scientific return as a sustained lunar presence is enabled.

www.nasa.gov/moontomarsarchitecture/