

**RESEARCH OBJECTIVES FOR HUMAN MISSIONS IN THE PROVING GROUND OF CIS-LUNAR SPACE.** P. B. Niles<sup>1</sup>, D. B. Eppler<sup>1</sup>, K. J. Kennedy<sup>2</sup>, R. Lewis<sup>3</sup>, J. F. Spann<sup>4</sup>, and T. A. Sullivan<sup>2</sup>, <sup>1</sup>Exploration Integration Science Directorate, NASA Johnson Space Center, Houston, TX 77058; ([paul.b.niles@nasa.gov](mailto:paul.b.niles@nasa.gov)), <sup>2</sup>Human Health and Performance Directorate, NASA Johnson Space Center, Houston, TX 77058, <sup>3</sup>Exploration Systems Projects, NASA Goddard Space Flight Center, Greenbelt, MD 20771, <sup>4</sup>Marshall Space Flight Center, Huntsville, AL 35812.

**Introduction:** Beginning in as early as 2023, crewed missions beyond low Earth orbit will begin enabled by the new capabilities of the SLS and Orion vehicles. This will initiate the “Proving Ground” phase of human exploration with Mars as an ultimate destination (Fig 1) (1). The primary goal of the Proving Ground is to demonstrate the capability of suitably long duration spaceflight without need of continuous support from Earth, i.e. become Earth Independent.

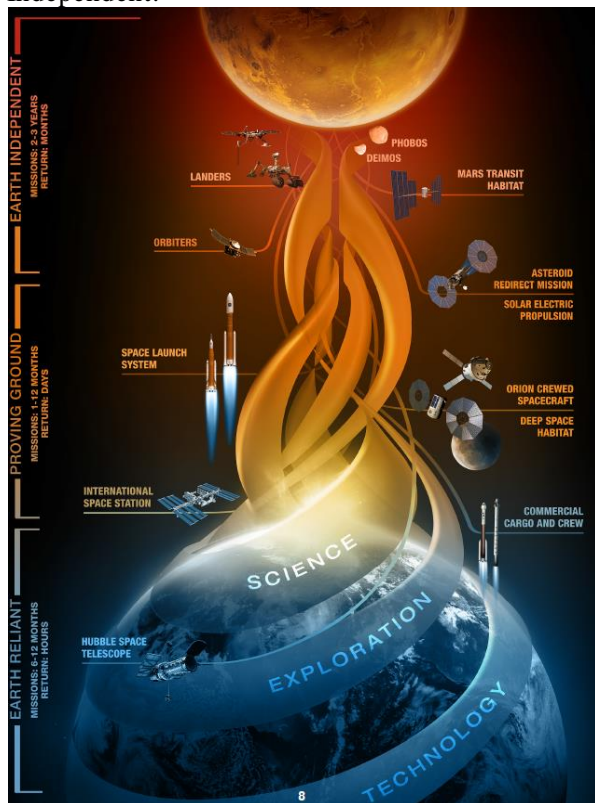


Fig 1. Human Exploration in the 2020’s and beyond(1)

A major component of the Proving Ground phase is to conduct research activities aimed at accomplishing major objectives selected from a wide variety of disciplines including but not limited to: Astronomy, Heliophysics, Fundamental Physics, Planetary Science, Earth Science, Human Systems, Fundamental Space Biology, Microgravity, and In

Situ Resource Utilization. Mapping and prioritizing the most important objectives from these disciplines will provide a strong foundation for establishing the architecture to be utilized in the Proving Ground.

**Possible Architectures:** Activities and objectives will be accomplished during the Proving Ground phase using a deep space habitat (Fig 1). This habitat will potentially be accompanied by a power/propulsion bus capable of moving the habitat to accomplish different objectives within cis-lunar space. This architecture can also potentially support staging of robotic and tele-robotic assets as well as sample-return.

Table 1. (1)

Proving Ground Objectives		
Category	Title	Objective
Transportation	Crew Transportation	Provide ability to transport at least four crew to cislunar space.
Transportation	Heavy Launch Capability	Provide beyond LEO launch capabilities to include crew, co-manifested payloads, and large cargo.
Transportation	In-Space Propulsion	Provide in-space propulsion capabilities to send crew and cargo on Mars-class mission durations and distances.
Transportation	Deep Space Navigation and Communication	Provide and validate cislunar and Mars system navigation and communication.
Working in Space	Science	Enable science community objectives.
Working in Space	Deep Space Operations	Provide deep-space operations capabilities: <ul style="list-style-type: none"> <li>• Extravehicular activity (EVA)</li> <li>• Staging</li> <li>• Logistics</li> <li>• Human-robotic integration</li> <li>• Autonomous operations</li> </ul>
Working in Space	In-Situ Resource Utilization	Understand the nature and distribution of volatiles and extraction techniques, and decide on their potential use in the human exploration architecture.
Staying Healthy	Deep Space Habitation	Provide beyond LEO habitation systems sufficient to support at least four crew on Mars-class mission durations and dormancy.
Staying Healthy	Crew Health	Validate crew health, performance, and mitigation protocols for Mars-class missions.

As mission durations increase from 20 days to 300 days, increasingly ambitious objectives may be undertaken including rendezvous with an asteroid or other near-Earth object.

Research activities can occur inside the habitat, outside the habitat, via externally mounted instruments, or using free flying satellites/landers.

**Research Objectives:** Primary mission objectives are listed in Table 1. In order to help define details of the mission architecture, including the means by which the architecture can be supported, more specific research objectives are needed.

In support of the ongoing studies conducted by NASA's Future Capabilities Team, we are tasked with collecting research objectives for the Proving Ground activities. The objectives could include but are certainly not limited to: demonstrating crew well being and performance over long duration missions, characterizing lunar volatiles, Earth monitoring, near Earth object search and identification, support of a far-side radio telescope, and measuring impact of deep space environment on biological systems. The Future Capabilities Team is actively soliciting input into the Research objectives for the Proving Ground and we hope to solicit discussion and input during the meeting.

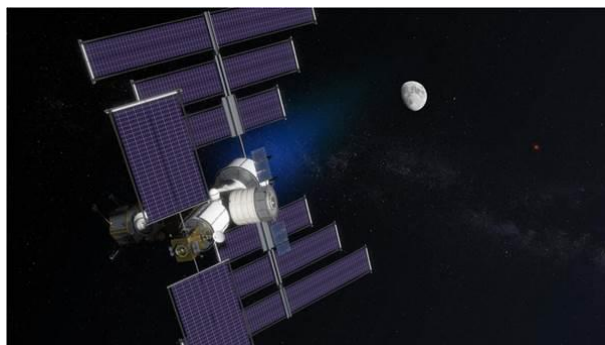


Figure 2. Artistic concept of a possible crewed deep space habitat with power and propulsion capability.

#### References:

1. NASA, NASA's Journey to Mars: Pioneering Next Steps in Space Exploration. 34 ( October 8, 2015).