POTENTIAL EXPLORATION MISSION OBJECTIVES FOR CREW ON ORION. David A. Kring[1,2], [1]USRA Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston TX 77058 (kring@lpi.usra.edu), [2]NASA Solar System Exploration Research Virtual Institute.

Introduction: The Orion crew vehicle and Space Launch System (SLS) provide new capabilities for exploring deep space. A series of Exploration Missions (EMs) with those vehicles are being planned for the cis-lunar region to validate spacecraft performance and evaluate crew health performance. Those efforts will be important contributions to the Global Exploration Roadmap (GER) [1], which includes extended duration crew missions and humans to the lunar surface.

Initial Mission Capabilities: In the initial EMs, I suggest Orion be outfitted with a high-definition camera to image the Moon during 100 km altitude passes over the lunar surface (Fig. 1), an additional camera to detect impact flashes on the farside and/or in the nighttime hemisphere to complement ground-based measurements of the nearside, radiation detectors for measurements external to and within the Orion crew capsule to test crew exposure models, a receiver to make modern measurements of radio noise on the lunar farside for comparison with an RAE-2 occultation of Earth in 1973, and a communication asset that can be deployed into orbit for future farside relay.

Human-assisted Robotic Sample Return: More complex missions that follow can integrate humans in orbit with robotic assets on the lunar surface. The feasibility and productivity of an Orion L2-farside sample return mission involving a 30 km traverse [2] and an astrophysical mission that deploys a radio antenna [3] have previously been studied. Those scenarios will be enhanced if Orion has sufficient bandwidth to accommodate high data rates, including high-definition video from the lunar surface. Once an orbiting facility at the Earth-Moon L2 position is available, then longer duration farside sample return missions as envisioned by the HERACLES concept [4,5] can be implemented. That activity has the capacity to traverse 100 to 300 km and return to Earth 30 to 60 kg of material needed for geologic and in situ resource studies.

Destinations: Historically, two dozen successful missions have explored the lunar nearside surface. None have landed on the farside, so that vast region of unexplored territory is an obvious target of interest. A global landing site study [6] found that the Schrödinger basin, within the South Pole-Aitken basin, on the lunar farside, has the greatest potential for scientific return. Multi-element missions can subsequently target other farside destinations within the South Pole-Aitken basin, either robotically or with humans using Lunar Electric Rovers (LERs) or Space Exploration Vehicles (SEVs). Crew on the surface would greatly accelerate scientific discovery while also testing methods for in situ resource utilization (ISRU) and sustainable exploration. Robotic assets, such as the LERs, could be used to survey additional areas (e.g., for resource volatiles), in between those crew landings.

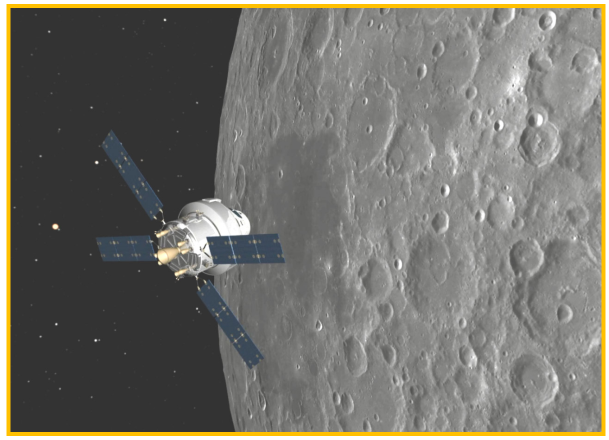

Fig. 1. Concept illustration of the NASA Orion crew vehicle and ESA service module passing over the lunar surface en route to a halo orbit about the Earth-Moon L2 position. Alternative orbits include distant retrograde orbits (DROs) or near-rectilinear orbits (NROs).

Demonstrating Capabilities & Retiring Risk: Human-assisted robotic missions will revalidate our ability to land on and traverse the lunar surface, ascend to and rendezvous in lunar orbit, and return samples to Earth, all of which are essential capabilities to be developed for the GER. In addition, the installation of an orbiting facility and assembly of robotic elements at L2 will validate deep space assembly operations (a Mars-forward capability), while developing the capability for crew to tele-operate surface assets (a Mars-forward technology) and demonstrating a series of crew health performance capabilities (e.g., deconditioning countermeasures, space radiation protection and monitoring, habitation systems) needed for exploration beyond the cis-lunar environment. The eventual deployment of crew on the surface will validate a capability for long-duration activities in relatively low gravity geologic settings while encumbered with pressurized suits, vehicles, and habitats (which are elements of any Mars-forward architecture).

References: [1] International Space Exploration Coordination Group (2013) *The Global Exploration Roadmap*, NASA NP-2013-06-945-HQ, 42p. [2] Potts N. J. et al. (2015) *Adv. Space Res.*, *55*, 1241–1254. [3] Burns J. O. et al. (2013) *Adv. Space Res.*, *52*, 306–320. [4] Landgraf M. et al. (2015) *LEAG Mtg*., Abstract #2039. [5] Steenstra E. S. et al. (2016) *Adv. Space Res.*, *58*, 1050–1065. [6] Kring D. A. and Durda D. D., eds. (2012) *A Global Lunar Landing Site Study to Provide the Scientific Context for Exploration of the Moon*, LPI Contrib. 1694, 688p.