Concept of Operations for a Prospective "Proving Ground" in the Lunar Vicinity

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NASA is studying conceptual architectures for a "Proving Ground" near the Moon or in high lunar orbit to conduct human space exploration missions that bridge the gap between today's operations with the International Space Station (ISS) and future human exploration of Mars beginning in the 2030s. This paper describes the framework of a concept of operations ("Conops") for candidate activities in the Proving Ground.

The Conops discusses broad goals that the Proving Ground might address, such as participation from commercial entities, support for human landings on the Moon, use of mature technologies, and growth of capability through a steady cadence of increasingly ambitious piloted missions. Additional Proving Ground objectives are outlined in a companion paper.

Key elements in the Conops include the Orion spacecraft (with mission kits for docking and other specialized operations) and the Space Launch System (SLS) heavy-lift rocket. Potential additions include a new space suit, commercial launch vehicles and logistics carriers, Solar Electric Propulsion (SEP) stages to move elements between different orbits and eventually take them on excursions to deep space, a core module with multiple docking ports, a habitation block, and robotic and piloted lunar landers. The landers might include reusable ascent modules which could remain docked to in-space elements between lunar sorties. A module providing advanced regenerative life support functions could launch to the ISS, and later move to the Proving Ground. The architecture will include infrastructure for launch preparation, communication, mission control, and range safety.

The Conops describes notional missions chosen to guide the design of the architecture and its elements. One such mission might be the delivery of a ~10-t Transit Habitat element, co-manifested with Orion on a Block 1B SLS launcher, to the Proving Ground. In another mission, the architecture might participate in direct human exploration of an asteroidal boulder brought to high lunar orbit by the Asteroid Redirect Mission. The Proving Ground stack could serve as a staging point and tele-operation center for robotic and piloted Moon landings. With the addition of a SEP stage, the architecture could support months-long excursions within and beyond the Earth's sphere of influence, possibly culminating in a year-long mission to land humans on a near-Earth asteroid. In the last case, after returning to near-lunar space, two of the asteroid explorers could join two crewmembers freshly arrived from Earth for a Moon landing, helping to quantify the risk of landing deconditioned crews on Mars. In a conceptual mission particularly stressing to system design, Proving Ground elements could transit to Mars orbit. Other possible design-driving operations include relocation of the stack with no crew on board, the unpiloted journey of the advanced life support module from ISS to the lunar vicinity, excursions to other destinations in near-Earth space, and additional support for Mars exploration in conjunction with the Evolvable Mars Campaign.

The Proving Ground Conops concludes with a discussion of aborts and contingency operations.