SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development (1)

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EVOLVING ARCHITECTURE FOR HERRO (SPACE-BASED, TELEROBOTIC-ORIENTED) EXPLORATION OF THE MOON, NEOS, MARS AND VENUS

Abstract

This paper presents a highly evolvable architecture for extensive space-based human exploration of the Moon, Near Earth Objects (NEOs), Mars and Venus. The architecture is based on Human Exploration using Real-time Robotic Operations (HERRO), a space-based exploration strategy that refrains from sending humans to the surfaces of planets with large gravity wells. HERRO avoids the need for complex and expensive man-rated lander/ascent vehicles and surface systems. Additionally, the humans are close enough to the surface to eliminate the two-way communication latency that constrains typical robotic space missions, thus allowing real-time command and control of surface operations and experiments by the crew. In fact through use of state-of-the-art telecommunications and robotics, HERRO provides the cognitive and decision-making advantages of having humans at the site of study for only a fraction of the cost of conventional human surface missions.

The initial stage of the architecture focuses on exploration of the Moon from L-1, L-2 and different lunar orbits. It uses spacecraft elements that have already been developed (e.g., International Space Station (ISS) pressurized modules and expendable launch vehicles) and those currently under development (e.g., Multipurpose Crew Vehicle (MPCV) and the Space Launch System (SLS)). These elements are used in a "waystation" approach to provide an extended-duration outpost that can transfer between the various orbits to conduct telerobotic exploration at science sites widely scattered across the lunar surface, including the polar regions, far side and variable latitudes.

The next step of the architecture adds capability with a higher energy propulsive stage to enable human exploration of NEOs. There are several NEOs reachable within the duration and propulsive capabilities of this increment in capability.

The final stage of this evolutionary progression features the addition of a solar electric propulsion stage and a long-duration habitat to enable telerobotic exploration of Mars from orbit. This final step of the architecture could also be applied to exploration of Phobos and Diemos and the establishment of man-tended exploration outposts on the surface of these worlds. In a previous paper, we showed that the infrastructure developed for Mars missions could be extended to human missions to Venus orbit. From a

space transportation standpoint, the Venus mission is easier to achieve than the Mars mission. Although some modifications are required to accommodate operations closer to the sun, the Venus mission takes full advantage of the spacecraft and the in-space infrastructure used in the Mars campaign.