

Mars Exploration (3)
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CRADLE: AN ANALOGOUS TWIN TEST-BED TO MIRROR AND VALIDATE HUMAN-ROBOTIC
PLANETARY OPERATIONS ON MARS

Abstract

Earth transcendence requires humans to extend their robotic and physical presence to the rest of the solar system. LEO has been a proving ground for developing long duration human exploratory technologies for two decades. The Moon is essential for building and testing surface-based technologies as we push outward. Its proximity makes it a safe zone while preparing missions to Mars. Sub-surface water ice and mineral rich regolith make Mars a vital destination for deploying sustainable, off-world infrastructure. Resource rich asteroids for industries on Earth and in space necessitate autonomous and semi-autonomous robotic infrastructure supporting crewed planetary missions. Earth based twin analogues are vital to Mars operational elements to improve the overall mission efficiencies and success. Situated in Lucerne valley California, CRADLE (California Research Analog for DeepSpace and Lunar Environments) is a high-fidelity twin environ and “end-to-end” mission simulation facility developed under a public-private partnership. CRADLE provides an environment for human-in-loop simulation, as well as testing for planetary operations involving hardware such as rovers, robots, and landing/ascent vehicles. Coupled with human-rated pressurized modules, CRADLE helps to identify and address unforeseen challenges and address existing ones so these solutions may be implemented in the Mars twin scenario. These experiences involve human-machine interactions, such as using assistive autonomous and semi-autonomous tools/systems for human psychology, medical and scientific operations; surface based interplanetary communications systems and robotic infrastructure assembly. Emphasis is placed on achieving sustainability by simulating ISRU based operations on Mars. The crew analog will include manipulating ISRU systems manually and tele-robotically. Mission planners and mission controllers have an analog platform for real-time mission support in an avatar like scenario. Simulating scenarios using AR/VR will help the crew to immerse in the environment psychologically and visually. The location of CRADLE provides proximity to engineering support from Southern California’s numerous aerospace and robotic manufacturers in autonomous and semi-autonomous technologies for planetary surface science and operations. Finding mechanisms to integrate humans and robots in high-fidelity scenarios will decrease the crew’s workload within the norms of muscle-fatigue envelopes for reduced gravity human operations. CRADLE leverages the local industry and critical exploration technologies while presenting a suite of opportunities essential for public readiness and private access to human spaceflight. The end-to-end services establishes CRADLE as a critical twin facility to augment design, testing and validation of technologies. Through such twin simulations CRADLE will improve mission safety, execution and value.