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# CRADLE- CALIFORNIA RESEARCH ANALOG FOR DEEPSPACE AND LUNAR ENVIRONMENTS

**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 analogues are vital simulation elements, providing flight-like scenarios which improve mission success and reduce risk. Situated in Lucerne valley California, CRADLE (California Research Analog for DeepSpace and Lunar Environments) is a high-fidelity testbed 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 including flight hardware such as rovers, robots, and landing/ascent vehicles. Coupled with human-rated technologies, and pressurized modules, CRADLE expands the range of human tele-robotic operations, helping to identify and address unforeseen challenges before embarking on actual missions. These experiences may involve human-machine interactions such as, 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. Mission planners and mission controllers have an analog platform for real-time mission support in a twin-like scenario. 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 and asteroid surface science and operations. Finding mechanisms to integrate humans and robots in high-fidelity scenarios will decrease crew's workload within the norms of muscle-fatigue envelopes for reduced gravity human operations. In turn these efficiencies will increase the frequency of science results. A trade study comparing various habitat construction techniques is presented to address customers simulation preferences. Through the simulation of both technical, operational and even legal scenarios CRADLE will improve mission safety, execution and value. 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 simulation facility to augment design, testing and validation of technologies in accordance to human factors requirements.