SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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SENSORIMOTOR CONTROLS AND DISPLAYS FOR SAFE AND PRECISE LUNAR LANDING

Abstract

Introduction: Planetary landing requires the selection and identification of a location that is level and free of hazards, along with a stable, controlled descent to the surface using both automated systems and manual control. Spatial disorientation may occur upon reentering a gravitational field after vestibular adaptation to microgravity during transit. The workload of both selecting a suitable landing point and monitoring the state of the vehicle is also a concern. This research includes the development and evaluation of flight displays to enhance the pilot's situation awareness and reduce workload during landing.

Methods: Two experiments are reported: one examines the influence of sensory cues and simulated vehicle motions on spatial orientation, while the other investigates the effect of an energy contour display design on piloted landing performance. In Experiment 1, subjects reported perceived tilt and velocity onboard a motion based platform during simulated lunar landings. The subjects were given different sensory cues to determine orientation perceptions. In Experiment 2, impacts of a novel energy contour display on situation awareness and landing performance during simulated late-stage landing aimpoint redesignation tasks were investigated in a fixed-base simulator. Subjects monitored or manually controlled the vehicle to the surface, and selected alternate landing points during terminal descent based on the presence of varying energy contour information.

Results: Preliminary results for Experiment 1 indicate that there are particular motions during the landing trajectories which can result in significant orientation misperceptions. The simulated direction of engine thrust during descent causes tilt angles to be underestimated unless instrument display information is provided. The direction of horizontal velocity perceptions often varied significantly from the actual vehicle motion. Results for Experiment 2 were still being obtained at abstract submission, but will be reported at the IAC meeting.

Discussion: There is the potential for misperceptions of spatial orientation during landing on a planet with a gravity level less than 1-g, which could impact flight performance and safety. Additional effects of vestibular adaptation to microgravity, low light conditions, and dust blowback limit the pilots' ability to maintain proper spatial orientation and situation awareness. The development of advanced display concepts were evaluated to address these issues, and will likely be required for safe and precise planetary landing. This work was supported by the National Space Biomedical Research Institute through NASA NCC9-58.