

DEVELOPING AN EARTH-FIXED VISUAL REFERENCE TO AID STABILITY, READAPTATION, AND EGRESS AFTER A WATER LANDING

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INTRODUCTION

Water landings present the worst possible sensory conditions for crews trying to orient and stabilize themselves immediately after long-duration spaceflight. Of the three sensory feedback systems involved in maintaining stability (i.e., proprioceptive, vestibular, and visual), none will provide reliable orientation information under the current water landing scenarios. The proprioceptive and vestibular systems are affected during spaceflight by disuse and adaptation to microgravity. Vision may not suffer the same degradation, but the visual environment within the enclosed space of a capsule, or interior room of a recovery ship, is disorienting when subject to wave-induced motion. The result is an increased risk of fall-related injury. In a prior study, 70% (21 of 30) of nonimpaired subjects reported that the presence of an Earth-fixed horizontal line helped them stabilize when their visually enclosed environment was exposed to wave motion. In addition to aiding stability, sensory re-adaptation occurs when inputs from the three sensory systems are synchronized with one another and aligned with Earth's gravity. The earlier an Earth-fixed visual reference can be introduced the sooner the readaptation process can begin. The goal of this project is to identify the optimal features of a device that visually presents gravitational reference cues to support stability and readaptation.

METHODS

The capsule sensory-condition simulator is a three-sided enclosure atop a six degree-of-freedom motion platform. A sum-of-sines equation is used to drive the motion platform, producing the simulated wave motion. The equation was derived using the frequency range present in inertial measurement unit (IMU) data collected during open-water Orion mock-up testing. The enclosure creates the nature of a floating visual environment where the walls move in relation to the standing surface. To more accurately represent the condition of postflight crewmembers, galvanic vestibular stimulation (GVS) is applied to disrupt normal vestibular function and standing on a compliant surface attenuates proprioceptive feedback. An instrumented handhold allows the subjects to stabilize themselves and serves as the primary dependent variable. Subjects are instructed to minimize handhold use so the higher forces applied to the handhold correspond to greater instability.

Various forms of a visual reference have been explored. Passive systems, such as mechanical gimbals and weighted plumb bobs were eliminated from consideration because of the inertia-induced oscillations that the wave-motion causes. Laser lines presented as horizontal, vertical, or the combination of both are being used to provide the Earth-fixed visual reference. These are presented in the central visual field or periphery from laser sources that are mounted either from within or outside the visual enclosure.

RESULTS

Data collection for this study is currently in progress.

CONCLUSIONS

This study will determine whether a visual reference system can help improve stability during challenging sensory conditions and define the optimal characteristics for such a system.