SPACE LIFE SCIENCES SYMPOSIUM (A1)
Behavior, Performance and Psychosocial Issues in Space (1)

Author: Dr. Laurence R. Young
Massachusetts Institute of Technology (MIT), United States, lry@mit.edu

Dr. Kevin Duda
The Charles Stark Draper Laboratory, Inc., United States, kduda@draper.com
Dr. Charles Oman
Massachusetts Institute of Technology (MIT), United States, coman@mit.edu
Dr. Andrew Liu
Massachusetts Institute of Technology (MIT), United States, amliu@mit.edu
Mr. Alexander Stimpson
Massachusetts Institute of Technology (MIT), United States, ajstimps@mit.edu
Mr. Torin Clark
Massachusetts Institute of Technology (MIT), United States, torin@mit.edu

CRITICAL FACTORS AFFECTING LUNAR LANDING SUPERVISORY CONTROL PERFORMANCE

Abstract

INTRODUCTION: Landing on the moon requires the identification and selection of a lunar location that is level and free of hazards, along with a stable, controlled descent to the lunar surface. During crewed landings, astronauts must be able to interact with automated systems, perform tasks such as landing aimpoint re-designation, or make adjustments to the intended touchdown point through manual control of the vehicle flight path and attitude control. The design and implementation of manual flight control modes and information displays must account for vehicle dynamics, available control authority, out-the-window visibility, and human control capabilities. Furthermore, vestibular and visual sensorimotor performance may be degraded as a result of exposure to lunar gravity after short-term adaptation to weightlessness, glare due to high lunar latitude sun angles, surface reflectivity, as well as dust blowback from the descent engine are likely to interfere with supervisory control performance.

METHODS: Vehicle acceleration and rotation rate profiles of several candidate lunar descent trajectories from the braking burn through touchdown were analyzed for their potential to induce spatial disorientation. The visual environment of the moon (lunar surface characteristics, lighting angles) was analyzed in terms of its effects on perception of size and distance, identification of hazards and suitable landing sites, and geographic and terrain awareness during the descent from lunar orbit and approach to landing. The manual flight control modes, including control strategies and vehicle control authority, researched during Apollo, were reviewed for their applicability to Altair.

RESULTS: The candidate trajectories contain acceleration and rotation rate profiles that are likely to produce attitude perceptions that differ from actual vehicle state. The errors in attitude perception coupled with the deep shadows, featureless or fractal lunar terrain, low sun angles, and biases in the perception of object size and distance could result in reduced accuracy of pilot-in-the-loop control and safe lunar landing. Projected control authority of the Altair using Apollo Lunar Module flight control modes is likely to result in demanding vehicle control task, producing high pilot workload and poor Cooper-Harper handling quality ratings.

DISCUSSION: Advanced display countermeasures for enhancing situation and terrain awareness will be required, along with primary flight displays, to accurately represent the vehicle state for manual control to overcome performance limitations associated with lunar lighting, terrain characteristics, and

pilot perceptions., We further recommend that manual flight control modes be designed and evaluated with the available vehicle control authority to ensure that the pilot can accurately and precisely control the flight path and attitude while meeting NASA's human rating requirements for workload and control authority under both nominal and off-nominal scenarios.

This work was supported by the National Space Biomedical Research Institute through NASA NCC9-58.