MANUAL CREW OVERRIDE OF VEHICLE LANDINGS FOLLOWING G-TRANSITIONS

Hannah M. Weiss[1], Austin M. Bollinger[1], Kevin R. Duda[2], Douglas H. Wheelock[3], and Scott J. Wood[3]
[1] KBR, Houston, TX, [2] Draper Laboratory, Cambridge, MA, [3] NASA Johnson Space Center, Houston, TX

BACKGROUND

Manual control during exploration spaceflight consists of both planned automated supervisory control and unplanned crew override. This crew override capability is critical to enable overall mission success during landing contingencies. However, the introduction of manual override capabilities must be implemented to enable crews to mitigate risks introduced by human error. Adaptive changes in the sensorimotor system can manifest during g-transitions as spatial disorientation. While training and landing aids enable successful landing through disorientation, these adaptive changes may increase cognitive demand that needs to be accounted for in the manual control strategy. It is important to characterize these effects as soon as possible following the G-transition to develop appropriate countermeasures.

METHODS

The following study seeks to inform the risk associated with altered sensorimotor and vestibular function impacting critical mission tasks. We aim to characterize the effects of short and long-duration weightlessness on manual control following G-transitions using simulated lunar landing on a six-degree-of-freedom (6DOF) motion base, a fixed base simulation, and a supervisory control tablet task. The primary goal is to understand the impact of spaceflight on crew ability to perform manual crew override and supervisory control. This aim will be assessed by comparing pre- versus postflight simulation performance in crewmembers assigned to either short duration (< 30 day) or long duration (~6- month) missions to the International Space Station (ISS). We hypothesize there will be postflight increases in the percent time that pilots are outside of the acceptable range for recommended vehicle state parameters and the reaction time for secondary cognitive tasks. Ground-based control subjects, who are demographically matched to the crew considering age (± 5 years) and gender, will undergo the same testing schedule as the crew to examine the effects of flight phase independent of microgravity exposure. The second aim is to examine how adaptive changes in vestibular and cognitive function relate to changes in manual crew override proficiency. Crew performance for a sensorimotor perceptual test battery will evaluate motion perception tracking, roll nulling, and/or vection sensitivity using the 6DOF motion base. We hypothesize that a higher severity of vestibular alterations will be associated with increased percent time outside of guidance limits. Motion sickness severity and sleepiness will also be evaluated. To determine the impact of "just-in-time" training, the third aim seeks to compare performance during on-board lunar landing tasks conducted late in-flight to early postflight. We hypothesize that proficiency on the "just-in-time" laptop trainer late in mission will be positively correlated with early postflight proficiency on the same task. The final aim will establish assessments of performance, training protocols, and the learning progression in a ground-control cohort of first-time users.

RESULTS

The assessment of the learning progression associated with the piloting task on the motion base system with thirty ground subjects will be reported. Learning curves will be established across four distinct sessions and within session considering trial difficulty. The difficulty of the landing task can be modulated with the landing divert distance and cross or downrange difficulty. Results may include changes in performance across multiple trials of a multi-attribute lunar tablet supervisory control task. Preliminary investigations of eighteen subjects who completed vestibular threshold and motion perception tasks offer expected performance ranges for upcoming preflight crew evaluations. The results yielded an average roll threshold of 0.46 ± 0.30 deg/s and an average roll nulling root mean square error performance of 2.52 ± 0.52 deg/s.

RELEVANCE

This project will deliver an operational demonstration of crew monitoring capability following spaceflight and identify potential deficits that may require remediation. Comparison of individual vestibular and cognitive changes with crew performance will help better characterize the manual control risks associated with sensorimotor alterations. Ground testing will evaluate learning progression, refine training protocols, and serve as a control cohort for comparisons to crew performance.

ACKNOWLEDGEMENTS: The authors acknowledge contributions from Draper, the Dynamic Skills Trainer (DST) Lab, and the Software, Robotics, and Simulation Division toward the development of the lunar landing simulation platforms. This project is funded by the Human Health Countermeasures Element.