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ARTEMIS'S HALO AS A USE CASE FOR DESIGNING AGAINST HUMAN ERROR IN DEEP SPACE

Abstract

If to err is to be human, then introducing humans into a complex system is to accept the risk of non-perfect performance. However, errors in a highly volatile environment like deep space, can have unacceptable adverse consequences on crew health or mission success. Due to the severity of such consequences, the Northrop Grumman Human Systems Integration (HSI) team considers human error to be a significant design factor in developing the Habitation and Logistics Outpost (HALO), the first module of the orbiting Lunar Gateway supporting long-term astronaut missions to the Moon's surface. Sustained human presence in cislunar space, beyond fast acting assistance from Earth, necessitates unprecedented astronaut reliance on immediate resources and embedded design safety features to minimize error impacts. HSI's design and development process of the HALO module is therefore a unique use case for mitigating human error in spacecraft design and must account for mission profile constraints not present in historical spacecraft operations in low Earth orbit such as radiation, increased transfer time, and uncrewed periods.

To effectively address human error in deep space, the HSI team executes multiple human factors engineering analyses throughout development and iteratively collaborates with HALO subsystems. Resulting recommendations and design solutions must be de-conflicted with various restrictions such as limits of hardware configurations, impacts to vendor schedules, subsystem scope, program requirements, and balancing flight certified designs with novel technologies. A human-centered task analysis is used to identify and analyze all crew tasks expected during HALO's lifespan. Human error analysis is applied to the task analysis to identify types of errors made during crew activities, assess the impacts of those errors on crew health and mission success, and propose design controls that reduce or eliminate the error. Human-in-the-Loop (HITL) tests are then used to verify the efficacy of human error controls and to understand crew approaches to differing tasks.

By considering human error during HALO development, engineers reduce potential error impacts on crew health and mission success by embedding safety features into crew interfaces. Resulting products foster trust with end-users, reduce frustration and time lost on-orbit using ad hoc workarounds, and limit costs associated with repairing human-error induced damage. Such methodology will become increasingly important to mission success as the global space community seeks to venture further into our solar system. This paper will outline best practices, methodologies and human factors principles utilized in identifying and mitigating sources of human error for cislunar space environments.