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PILOT-IN-THE-LOOP TECHNOLOGY FOR MOON LANDINGS

Abstract

In 2021, NASA increased the priority of technology to assist in emergency manual override during lunar and Mars landings to mission critical. During the Apollo 11 lunar landing, the automated landing control system was not used due to operational hazards and Armstrong landed under manual human-in-the-loop control. Switching from an automated flight control state to a manual control can be problematic, especially in high workload emergency situations. Examples from formation flight in high performance aircraft indicate full situational awareness (SA) is not acquired for about 20 seconds after formation maneuvers. Twenty seconds is too long for astronauts to assume manual control, gain full SA, and safely complete a lunar or Mars landing. During the Apollo 11 landing, Armstrong was guided by Aldrin's verbal instructions since his visual abilities were impaired by his perceived motion from engine-blasted moon dust. If the pilot was better maintained in the sensory SA loop during the entirety of the landing, switching to manual control would be near instantaneous. In addition, if a way to communicate the veridical velocity vector and altitude to correct for illusory vection during manual control was available, the landing would be significantly safer. The Aerospace Physiology Laboratory at ERAU is developing a multi-sensory cueing system that enables both of these solutions. Our inflight tests have shown that haptic cueing delivered to the torso can provide continuous, intuitive, non-visual, spatial orientation during inflight maneuvers to maintain SA. Coupled with advanced peripheral vision and 3-D audio cues, haptic technology would enable Artemis astronauts to attend to other critical events during landing without distraction while receiving intuitive cueing. Haptic cueing systems provide flight state information that will non-visually inform astronauts of critical information, including heading, attitude, altitude, or velocity. Our lab continues to assist the US Department of Defense to develop this technology for helicopter pilots for "brown-out" landings and is involved in simulator and inflight tests to optimize the haptic cueing. We will report on our ongoing 2022 inflight results and provide a detailed description of how the system will enhance human performance and safety of Artemis manual control lunar landings. Considerable technology transfer would arise from a lightweight comfortable haptic cueing garment that would assist pilots in degraded visual conditions, drivers, and elderly with impaired balance. The vibrotactile system we propose would also help with EVA's, surface exploration, the large number of landings expected with Artemis, and space for all accommodation.