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Quality and Safety, always a beginning! (1)

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THE ARCHITECTURE OF A SAFE LOW COST EARTH BASED LUNAR LANDING TEST BED FOR THE VALIDATION OF EXPERIMENTAL FLIGHT AND NEW TECHNOLOGIES

Abstract

A propulsive landing on the surface of an extraterrestrial body requires a robust vehicle with a guidance, navigation and control (GNC) system that is reliable, efficient and repeatable. Developing algorithms for these systems involves the creation of a mathematical model to simulate reality, and the testing of physical hardware to validate the results produced by the simulations. Unique design considerations for the structures are required for off-nominal flight in 1G to avoid damage yet still allow the vehicle to re-fly quickly. The validation of experimental control algorithms requires the development of necessary infrastructure to iterate through a virtual to physical testing process, which is both time and cost intensive. The University of Southern California's (USC) Space Engineering Research Center (SERC) in collaboration with the University of California at Berkeley (UCB) and the University of California at San Diego (UCSD) has developed such an infrastructure for an earth-based lunar landing test bed capable of validating experimental GNC algorithms with measures designed into both the hardware and software of the vehicle to mitigate failures in the event of off nominal flight conditions, allowing for innovative landing solutions to be repeatedly tested at a higher rate. The Lunar Entry Approach Platform For Research On the Ground (LEAPFROG) is a flight vehicle funded under a NASA Artemis STEM Competition Pilot award with the goal of supporting a nation-wide competition among universities. Powered by a central 300 N thrust turbine jet engine, the vehicle includes a cold gas attitude control system (ACS) to maintain stability, and a gimbal controlled by linear actuators to achieve thrust vector control (TVC) responsible for translation of the vehicle. Structurally, a number of innovations are built in for safety and reliability, including a composite based chassis and roll cage designed using Ansys Composite PrepPost (ACP) to support and protect the critical hardware, as well as a mechanical fuse allowing the frame and legs to avoid excessive loading in the event of a free fall. Additionally, the software architecture monitors competition teams' inputs during flight that can override the controls and land the vehicle safely in the event of a policy violation. This paper will expand on the design and analyses of the features implemented in the structural and software designs that ensure a safe validation of innovative GNC algorithms on this lunar landing platform for use worldwide as a low-cost testbed for advanced technology testing.