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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 2 (2B)

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GENERATION-II LUNAR ENTRY APPROACH PLATFORM FOR RESEARCH ON GROUND: A NOVEL CONCEPT FOR LOW COST, HIGH LONGEVITY AUTONOMOUS OPERATIONS ON THE MOON.

Abstract

Lunar exploration has been generating great interest, as it provides a compelling opportunity to demonstrate new technologies that could help build self-sustaining outposts in extraterrestrial environments, particularly Mars. Success in this challenge depends on developing sustainable and reusable architectures. Many of the diverse lunar missions currently in development have narrowly defined purposes and are consequently only capable of operating in limited areas on the lunar surface and executing specific predetermined tasks. The mass sent up for the mission therefore rarely serves more than a single purpose. The Space Engineering Research Center (SERC) at the University of Southern California has developed the Lunar Entry and Approach Platform for Research on Ground (LEAPFROG) with the primary goal of reinventing the function of a lunar lander such that it has the inherent capability to perform multiple tasks by changing the working configuration of its subsystems, maximizing the functional value of its mass. LEAPFROG is a low-cost testbed primarily for simulating lunar flight conditions on Earth. To address the challenge of reaching different landing sites on the Moon, the team developed a unique guidance, navigation, and control system that leverages the symbiotic relationship between thrust vector control of a central jet engine, and fixed attitude thrusters, allowing LEAPFROG to adapt to different thrust values and environmental conditions. The air-based propulsion provides a low-cost, low-risk, highly repeatable analog to a monopropellant rocket propulsion system, which will be used in the future, while maintaining the same control architecture. Since lunar landers with long mission timelines must be able to self-charge their onboard batteries, LEAPFROG is equipped with solar panels that deploy on-demand.

Its origami-based compact solar panel structure extends up to six times its folded configuration, providing the potential to supply power to multiple mission payloads. LEAPFROG's robotic arm can be utilized to manipulate tools and perform tasks like drilling, taking samples, etc. Unlike other robotic arms which are typically held down with flight locks when not in operation, this arm acts as a secondary structure that ensures the stability of fuel tanks during its non-operative mode. LEAPFROG is versatile and affordable. This platform is a robust canvas upon which researchers can rapidly develop and iterate on new technology for lunar missions, ushering us on our path to becoming an interplanetary species. This paper outlines the first and second phase designs of all subsystems, and details all results gathered by various testing of the components.