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EXPERIMENTAL INVESTIGATION OF CARBON NANOTUBE DUST MITIGATION SYSTEM FOR LUNAR HABITAT STRUCTURES

Abstract

NASA's Artemis program envisions to establish a sustainable presence on the Moon by the end of this decade. To enable this vision, one of the top priorities listed in the Artemis Plan is developing and demonstrating capabilities to retire technology hurdles in the area of dust mitigation to diminish dust hazards on lunar surface systems [1]. Lunar dust has proved to cause abrasion, thermal problems, wear and tear of materials exposed to the environments and health hazards, making it a major challenge for surface operations, as witnessed during the Apollo missions. It is therefore imperative that we overcome the dust hazards posed by the lunar environment and protect hardware deployed on the moon to enable sustainable missions.

This research study extends the utilization of the SPecially Integrated carbon nanotube Dust Ejection/Removal (SPIcDER) technology to lunar habitat structures. SPIcDER technology was originally developed for spacesuit dust cleaning and was shown to be compatible with state-of-the-art habitat concepts in a previous study [2]. The concept is extendable from spacesuits to flexible/inflatable/deployable habitat and lander surface systems due to their similar construction techniques: pressurized structures, outerlayer and thermal materials, irregular contours of flexible/thermal material and several layers of insulation. The usage of Carbon nano tube (CNT) flexible fibers as electrodes in the SPIcDER system makes it uniquely suited for flexible and deployable structures, where the surfaces have irregular contours and/or various curvatures. SPIcDER is modular and can be easily configured and optimized for various surface systems for dust protection.

Here we outline a plan for verification and test of SPIcDER which will advance its Technology Readiness Level (TRL) for implementation on lunar habitat structures for dust mitigation (due to restrictions imposed by COVID-19, our experiments have been delayed).The plan includes (i) Build and test an Engineering Development Prototype (EDP) embedded with SPIcDER, that has actuated parts and can morph into different geometries, (ii) Add flexible electrical insulation on CNTs for safety during operation and assess its effects, (iii) Evaluate SPIcDER dust cleaning performance in relevant vacuum conditions of lunar environment for the Artemis missions, (iv) Efficacy of dust cleaning with multiple lunar dust simulants and, (v) The application of SPIcDER to new outerlayer fabrics to demonstrate the versatility of the SPIcDER system.

Our proposed tests have all the necessary geometries as part of the EDP to demonstrate that SPIcDER can be customizable to the exterior and internal walls of a habitat or lander structures, spacesuit soft areas, gloves, thermal shields and blankets, and as a releasable soft cover for hardware deployed on the lunar surface.