Introduction: Lunar dust proved to be a greater problem during the Apollo missions than was originally anticipated [1]. The highly angular, charged dust particles stuck to seals, radiators, and visors; clogged mechanisms; and abraded space suits [1]. As reported by Apollo 12 astronaut Pete Conrad “We must have had more than a hundred hours suited work with the same equipment, and the wear was not as bad on the training suits as it is on these flight suits in just the eight hours we were out.” [2]. Dust clinging to surfaces was also transported into habitable spaces leading to lung and eye irritation of the astronauts [1]. The Apollo astronauts were on the Lunar surface less than 24 hours and experienced many dust related problems [1]. With the Artemis program, we are planning longer stays on the surface, with more activities that have the potential to put the astronauts and equipment in contact with greater quantities of Lunar dust. The success of these missions will depend on our understanding of material interactions with Lunar dust and the development of ways to mitigate dust effects in cases where exposure to dust will lead to failure of components, unacceptable loss of power or thermal control, unacceptable loss of visibility, or health issues. Through the Lunar Surface Innovation Initiative (LSII), we are initiating a Patch Plate Materials Compatibility Assessment project. The overall goal of the three year project is to develop passive approaches to mitigate Lunar dust adhesion to surfaces for technologies that are currently at TRL levels 2-3 to bring them to TRL level 5 through ground-based assessment, culminating in a demonstration flight experiment on a Commercial Lunar Payload Services (CLPS) lander in 2022-2023. This paper discusses the detailed technical objectives and approach for this project.

Material Identification and Success Requirements: Key areas will be identified where dust is likely to be an issue, based on experience from Apollo missions, that could benefit from passive mitigation techniques. Some of these are solar cell cover glass, sensor lenses, display panels, visors, soft goods (space suit fabrics), and radiator surfaces. For each of the components identified, relevant parameters for success will be identified for assessing performance. Some of these are changes in transmittance, reflectance, solar absorptance, thermal emittance, thermal conductivity, electrical conductivity, wear, and resolution. For each component, relative parameters will be identified and performance limits determined to identify the dust coverage limit for acceptable performance. These measures will then be used to assess the performance of materials with, and without passive, mitigation.

Passive Mitigation Technologies: Passive Lunar dust mitigation technologies which have in the past shown some promise fall into the general categories of surface chemistry alteration, surface mechanical property alteration or a combination of both. Some of the passive mitigation technologies that will be further developed under this project will be low surface energy and low work function coatings, ceramic surfaces, surface chemistry modifiers, and laser ablation patterning. The passive mitigation technologies will be paired with component applications and performance limits in order to assess each technique for its effectiveness. In addition, some surfaces that will be tested can be used with active electrostatic techniques.

Ground Testing: Initial screening during the development phase will be performed at each Center where the technologies are being developed. Promising passive technologies will then be ground tested in the Lunar Dust Adhesion Belljar (LDAB) at NASA Glenn Research Center [3]. Pairs of materials with, and without, passive mitigation surfaces, can be exposed under vacuum to Lunar simulant that has been baked out and sifted onto the surfaces through a sieve shaker. Controlled nitrogen gas jets are used in vacuum to remove loosely adhering dust particles for comparison. Performance parameters will be measured prior to, and after, testing. Passive technologies may also be exposed to a ground based solar wind environment at NASA Goddard Space Flight Center for durability analysis.

Flight Testing: A flight experiment carrier similar to those used on the Materials International Space Station Experiment (MISSE) flights [4] will be developed to interface with a CLPS lander in order to evaluate the most promising passive technologies in comparison to surfaces without passive mitigation. An example of a MISSE flight tray containing space suit fabric materials is shown in Figure 1. Experiment sample trays will be designed and constructed to fit with the CLPS lander capabilities and requirements. A radiation hard 10 micron resolution optical microscope will be integrated into the flight experiment to measure the size...
range of the dust particles on experiment surfaces and a saltation sensor will be integrated into the experiment as well to determine the dust arrival rate at the experiment surface. Other methods of active characterization of the samples will depend on the capabilities of the CLPS lander.

![Figure 1. Space suit fabric material sample tray mounted on MISSE-7 [4]. Fabric samples are approximately 1.27 cm square.](image)

Performance data from ground tests and flight testing will be compared and used to advance the TRL of these technologies so they are available for use on future Lunar missions for dust mitigation.

**Summary:** The Patch Plate Materials Compatibility Assessment projects’ goal is to develop passive approaches to mitigate Lunar dust adhesion and bring them to TRL level 5 through ground-based assessment culminating in a demonstration flight experiment. Promising passive mitigation techniques focusing on alteration of the surface chemistry or surface mechanical properties will be paired with component materials that are most likely to need dust mitigation. Their performance will be assessed in both ground based systems and in the use environment on a CLPS lander. Performance data will be used to advance these passive technologies to a level where they can be used on future Lunar missions to improve performance in the harsh, dusty, Lunar environment.

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**References:**


