Patch Plate Materials Compatibility Assessment

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Lunar Dust Issues During Apollo

"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" –Commander Charles (Pete) Conrad, Jr. –Apollo 12 –from the Apollo 12 Technical Crew Debriefing, December 1, 1969

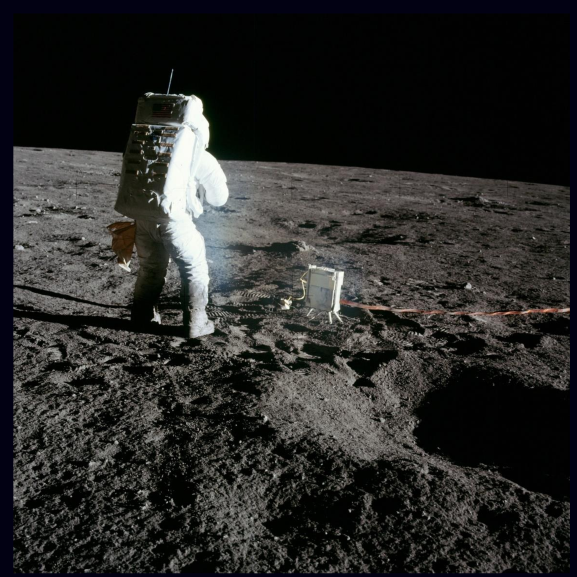
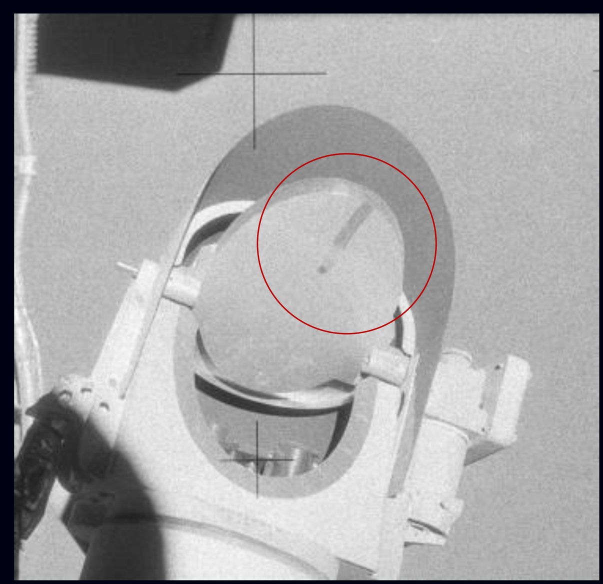




Image on the left is of Commander Charles (Pete) Conrad Jr.'s suit on the lunar surface during an Apollo 12 EVA, showing dust accumulation on gloves, lower legs and boots, center image is a photo of Alan Bean taken by Pete Conrad, the blue haze in the center was on multiple images and attributed to dust on the camera lens, image on the right is of the TV mirror on Surveyor III after Pete Conrad wiped the surface with a gloved finger (area in circle). *-Photos courtesy of NASA Apollo 12 Image Library*

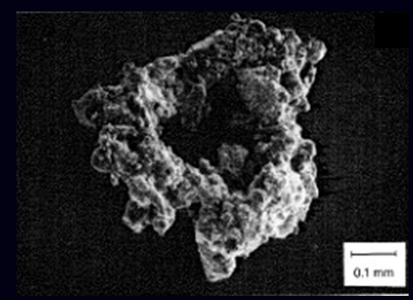


Image on the left (NASA S87-38112) is a scanning electron photomicrograph of lunar soil agglutinate

Lunar dust is highly angular, and charged by the solar wind. As a result, it is difficult to remove from surfaces and very abrasive. Dust clinging to surfaces during the Apollo missions and transported into habitable spaces led to lung and eye irritation of the astronauts.[1]

With the Artemis program, we are planning longer stays on the lunar 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.

[1]Gaier, J.R. "The Effects of Lunar Dust on EVA Systems During the Apollo Missions", NASA TM-2005-213610/Rev1, (2005)

Goal of the Patch Plate Materials Compatibility Assessment Project

To develop passive approaches to mitigate lunar dust adhesion to surfaces and 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.

Objectives of the Patch Plate Materials Compatibility Assessment Project

Target Applications and Success Requirements

Components that could benefit from passive lunar dust mitigation:

- Solar cell cover glass
- Sensor lenses
- Display panels
- Visors
- Soft goods (spacesuit fabrics)
- Radiator surfaces

Examples of Key Performance Parameters to assess performance:

Example Key Performance Parameters

Performance Parameter	State of the Art	Threshold Value	Project Goal
Change in solar absorptance after exposure to lunar dust in a vertical orientation (thermal control paints)	20%	<10%	<5%
Change in transmittance after inclination (coverglass, windows…)	20%	<8%	<5%
Particle (~25 micrometer) retention after inclination (polymeric materials)	85%	50%	30%
Thermal protection surface degradation factor (α/e, metallic materials and radiator surfaces)[a]	300%	100%	50%
Wear rate (mm^3/Nm, ceramic materials)[b]	0.25 (Al 6061)	0.10	0.05

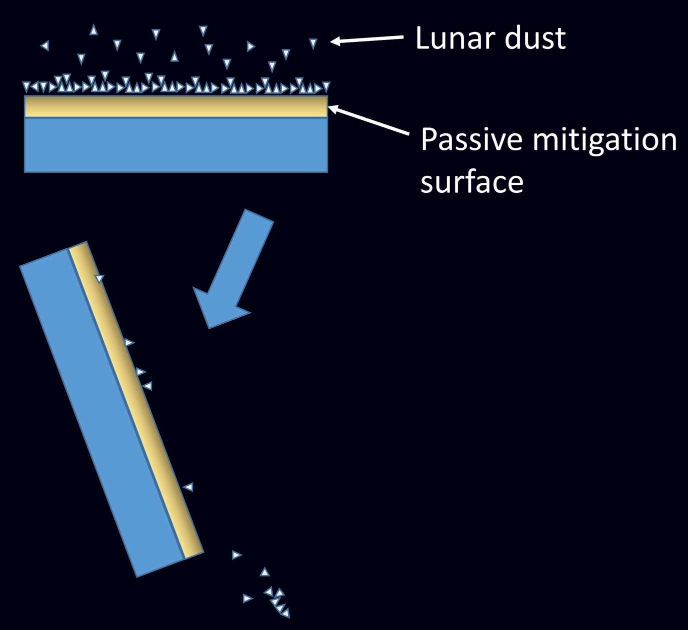
[a]Gaier, J. et al. The Effect of Simulated Lunar Dust on the Absorptivity, Emissivity, and Operating Temperature on AZ-93 and Ag/FEP Thermal Control Surfaces, 2008, NASA-TM 2008-215492.

[b]Chinnusamy, S. et al. Experimental Investigation on the Effect of Ceramic Coating on the Wear Resistance of Al6061 Substrate, J. Mater. Res. Technol. 2019, 8(6), 6125-6133

Apply Passive Mitigation Technologies

Candidate passive lunar dust mitigation technologies that can be used alone or with other active removal techniques:

- Low surface energy materials
- Work function matching coatings
- Ceramic surfaces
- Surface chemistry modifiers
- Laser ablation patterning

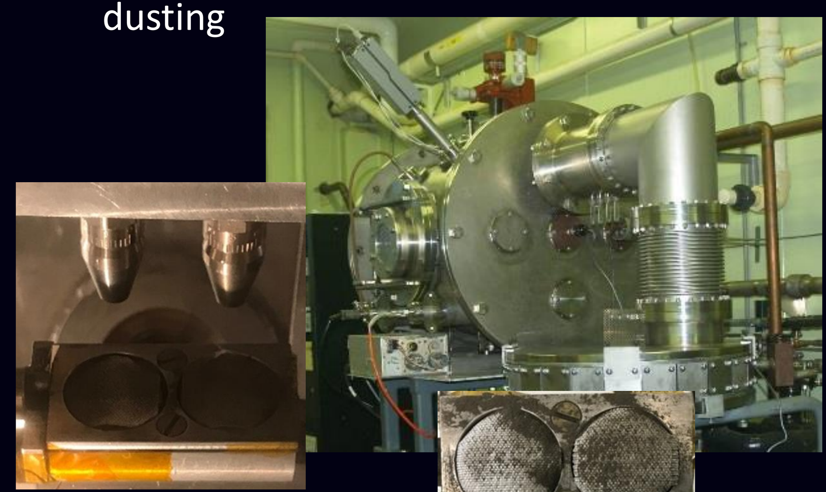


Test in Relevant Ground Based Environments

Test for ability to shed lunar dust in relevant ground vacuum environment using lunar dust simulant.

Lunar Dust Adhesion Belljar at NASA Glenn Research Center is shown below.
Capabilities:

- Heating and stirring of lunar dust simulant in vacuum ~1e-6 Torr
- Baked out simulant sifted onto surfaces with a sieve shaker
- Controlled nitrogen gas jets to remove loosely adhering dust in vacuum after dusting



Sample pair under nitrogen jets after dusting, prior to nitrogen jet

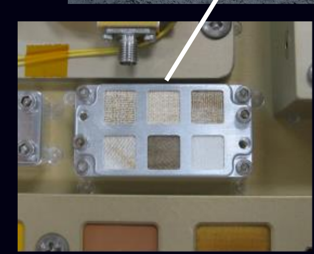
Sample pair after exposure to nitrogen jet

Demonstrate Through Flight Experiment

Flight experiment carrier developed to interface with CLPS lander with:

- Mounting for samples
- Active characterization
- 10 micron res. optical microscope
- Saltation sensor

Example drawing of CLPS lander with experiment mounted on the side



Example of sample holder from Materials International Space Station Experiment-Gaier, J.R. et al., "Post Flight Characterization of Samples for the MISSE-7 Spacesuit Fabric Exposure Experiment", NASA TM-2012-217651, (2012)

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