DESIGN AND TESTING OF A DEVICE FOR MOON DUST DEPOSITION ON TEST ARTICLES/SYSTEMS –

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Introduction

NASA has been charged with returning humans to the moon in the next decade

One of the chief challenges of long term habitation and research on the lunar surface will be the lunar regloith

Illustration of NASA astronauts on the lunar South Pole. Credit: NASA

Introduction

- According to NASA regolith is made up of “rock chips, mineral fragments, impact and volcanic glasses and a peculiar component only found on the Moon called “agglutinates””

- Its abrasive, sharp, and holds heat, meaning it can cut soft material, clog machinery, grind precision mechanisms and make electronics over heat

Introduction

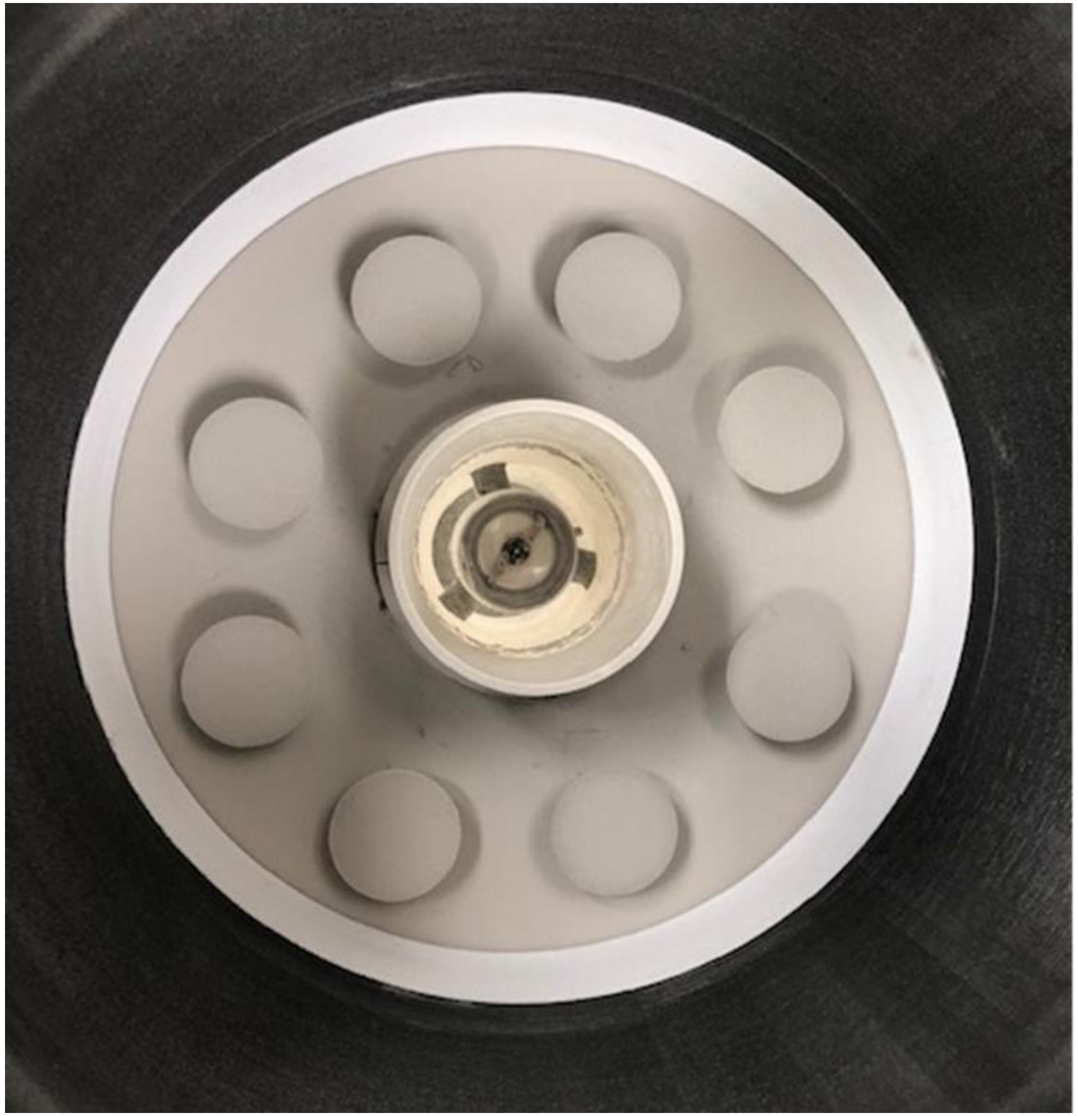
One specific area of concern is passive thermal systems such as radiators

Lunar regolith buildup on radiative surfaces can become insulative and lower emissivity

Introduction

This research describes a system that was developed to research the effects of the buildup of lunar regolith on radiative surfaces

The system needed to consistently and predicably lay down uniform layers of regolith simulant across the 8 coupons

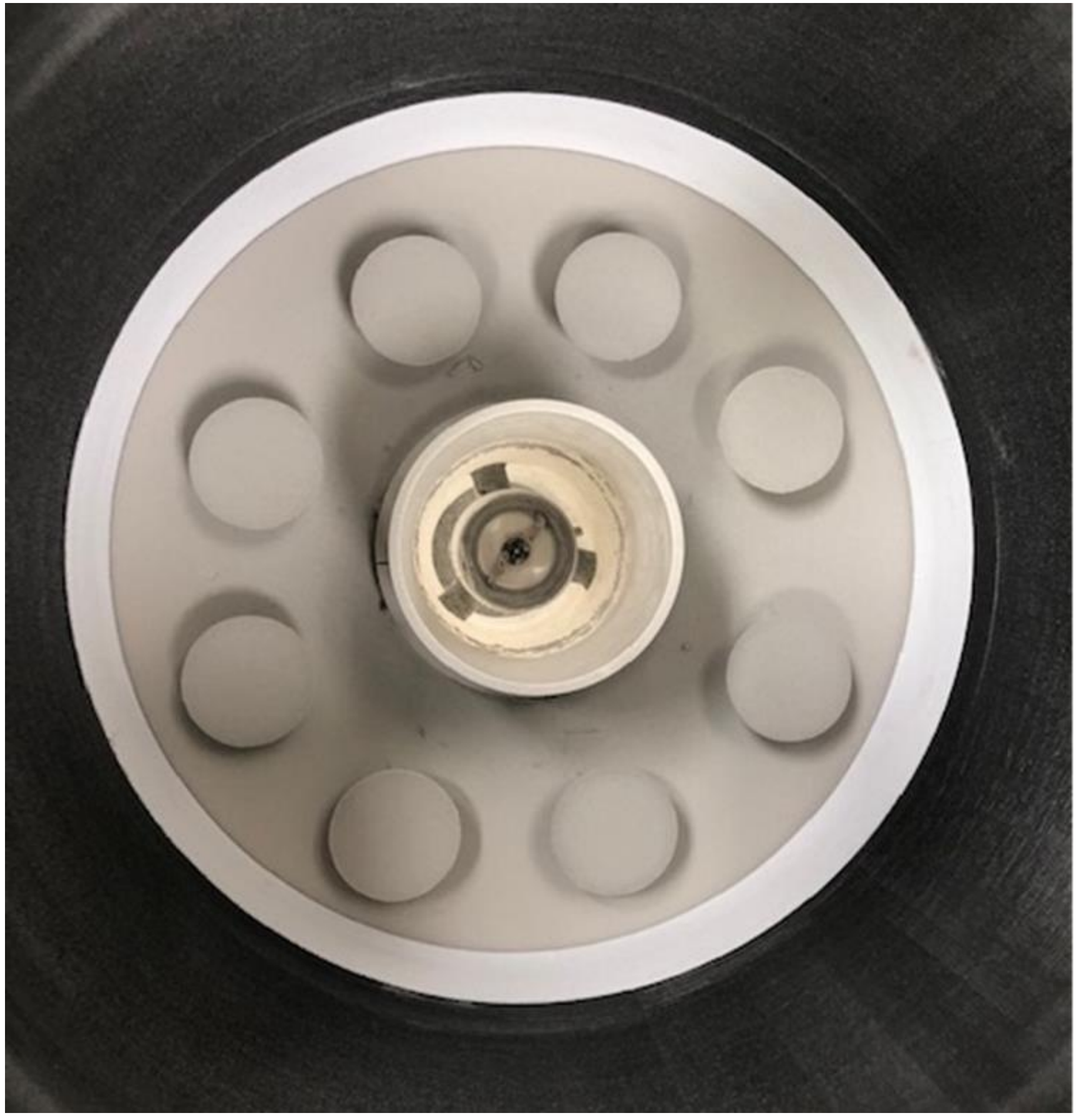


Previous work

This design was based on one used previously in Hollingsworth et. al, done in 2006

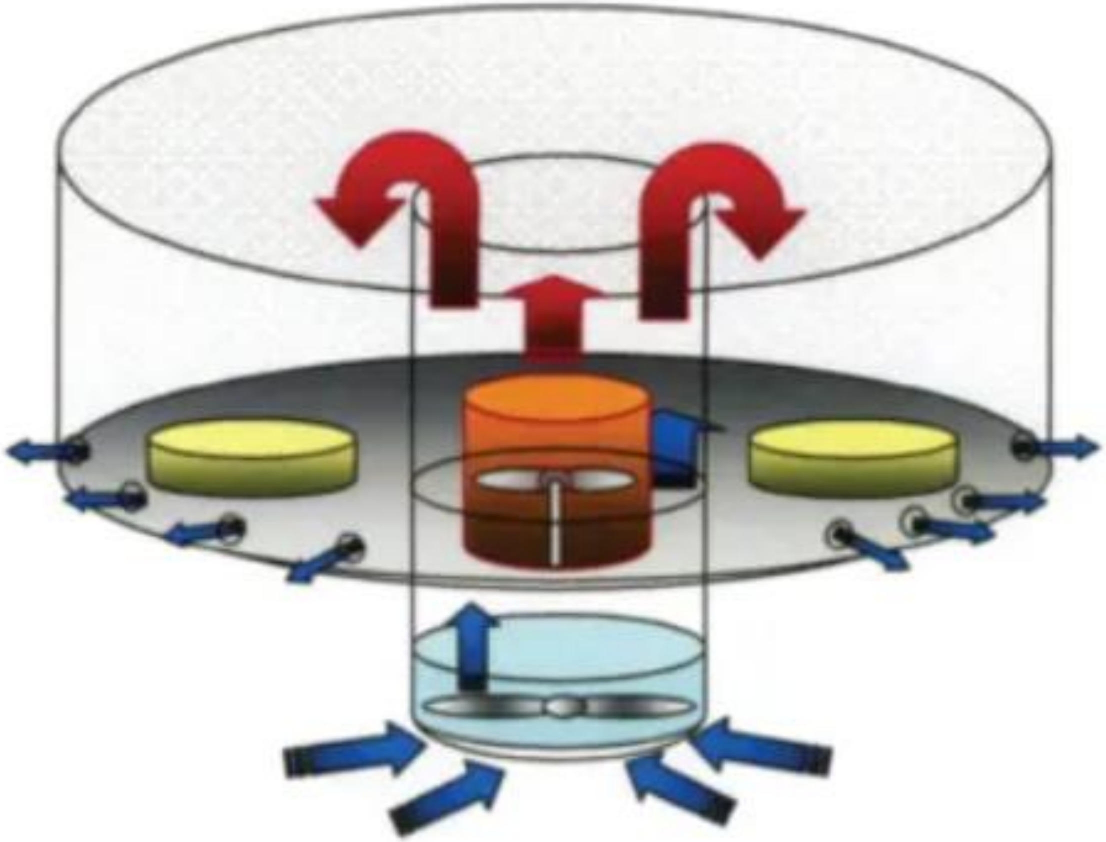
This device was used to study mars regolith exclusively the first time, now will be repurposed for a variety of lunar simulants

As passed to us the summer we began the study, several pieces of the original apparatus was broken, and needed to be replaced



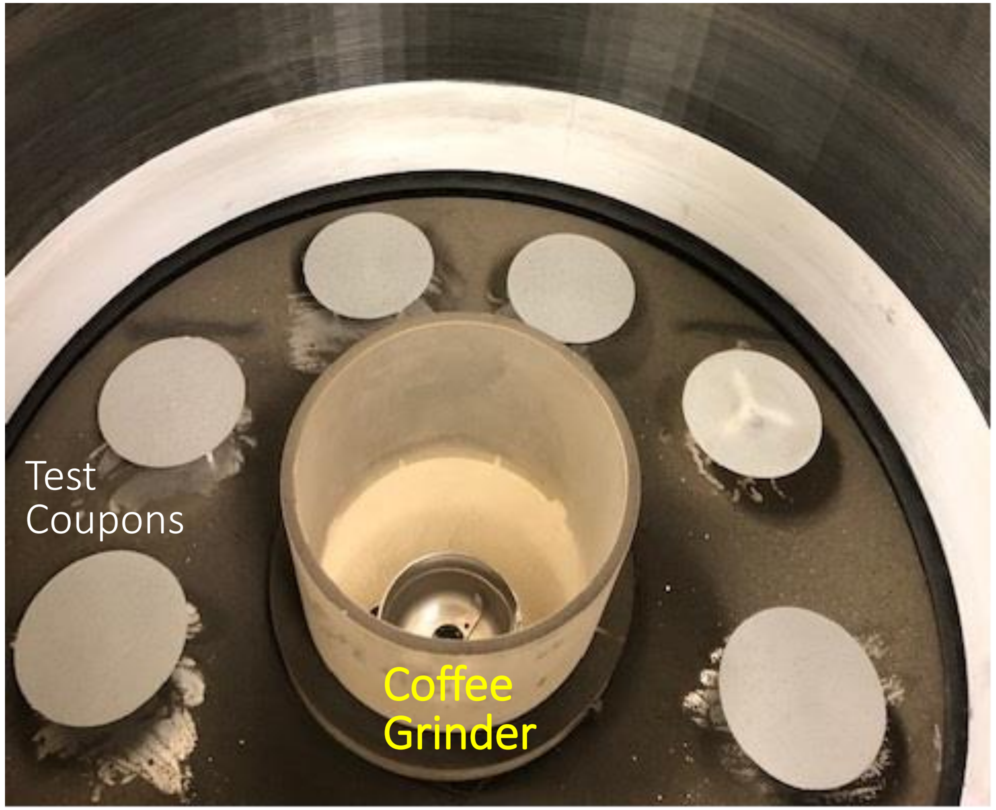
Design

A coffee grinder in a tube, extruding up into a chamber. The coffee grinder is filled with regolith simulant and blown up into the chamber lid where a cone is suspended upside down and creates a cloud of material dispersed though out the chamber. The 2” round test coupons on the chamber floor are covered in the simulant as it settles in the chamber. A ring of vent holes are around the base of the chamber to help air flow



Schematic depiction of the dusting apparatus is shown from a published NASA Tech Brief[2].

System



Vent Ring

System

The chamber is a 2’ diameter by 2.5’ tall barrel

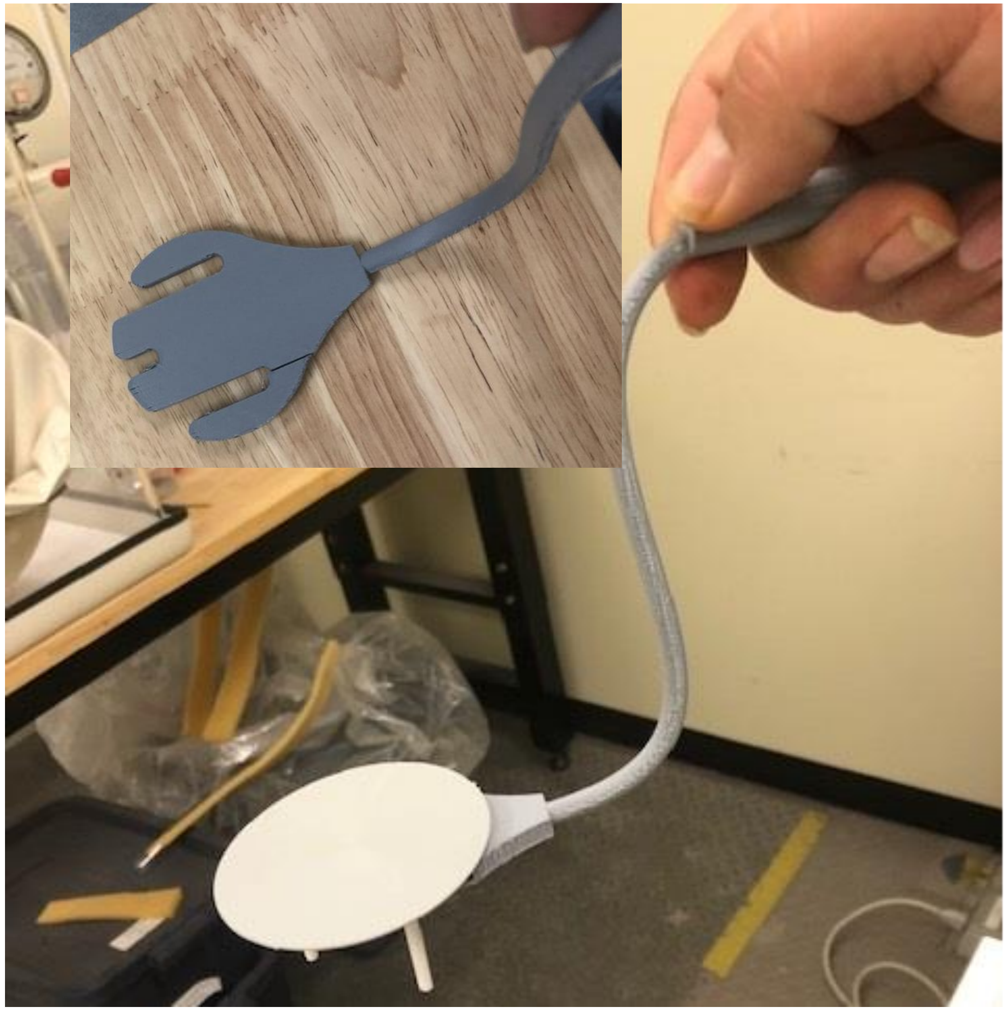
The barrel, cone and vent ring are all 3D printed in PLA

The lid and central tube are clear acrylic

System

Test coupons were 2” diameter plastic circles glued to the top of pizza box tables

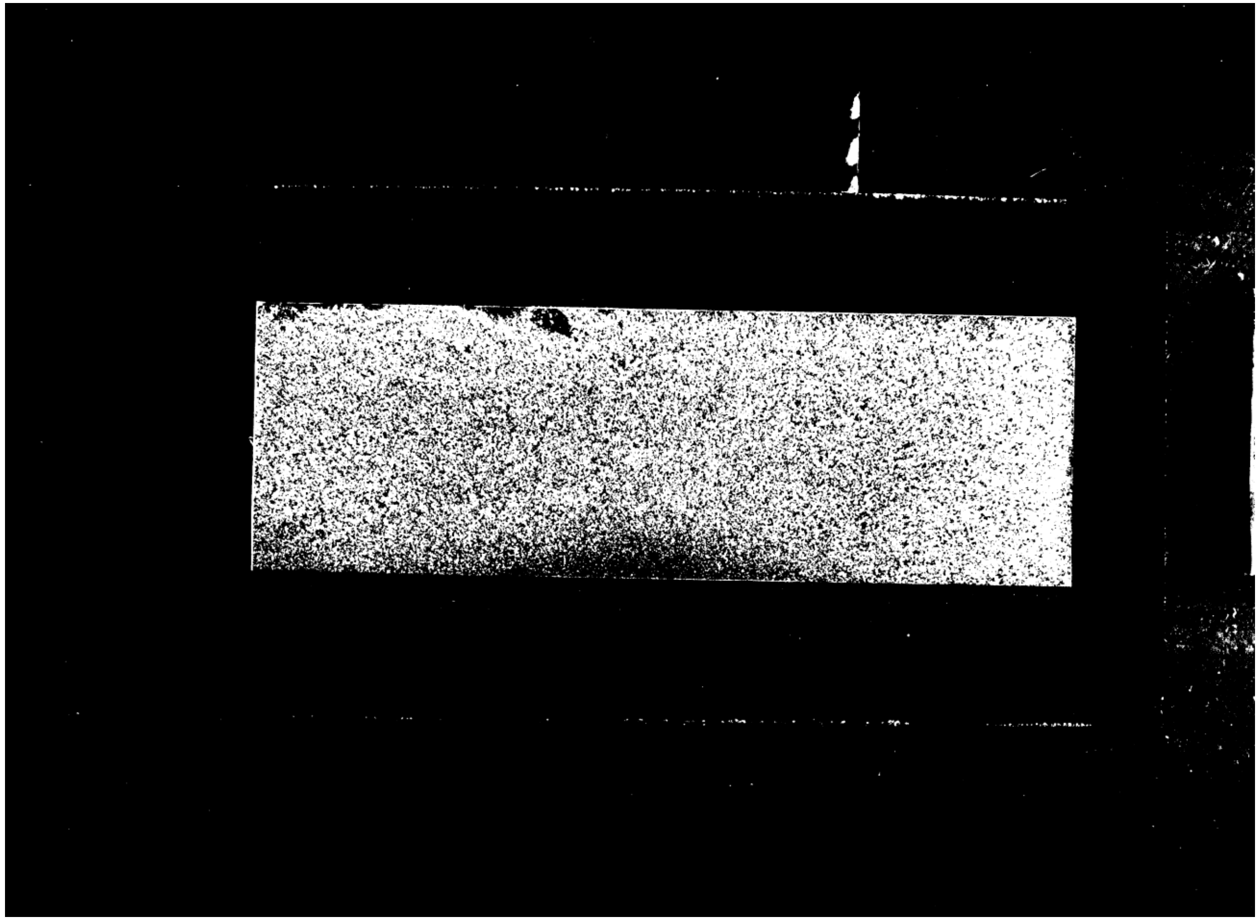
The tables were extremely light, and the dust layers are very thin, with testing, interns tended to tip tables over while transporting them to the balance. A 3D printed “Sporkatula” was developed to make handling more consistent



Digital Imaging

Using a XIMEA XiC camera with a resolution of 12 megapixels, a custom LED lighting arrangement, and a custom 3D-printed acrylic enclosure

The pictures are then processed using Python and OpenCV and passed through a Contrast Limited Adaptive Histogram Equalization (CLAHE) routine

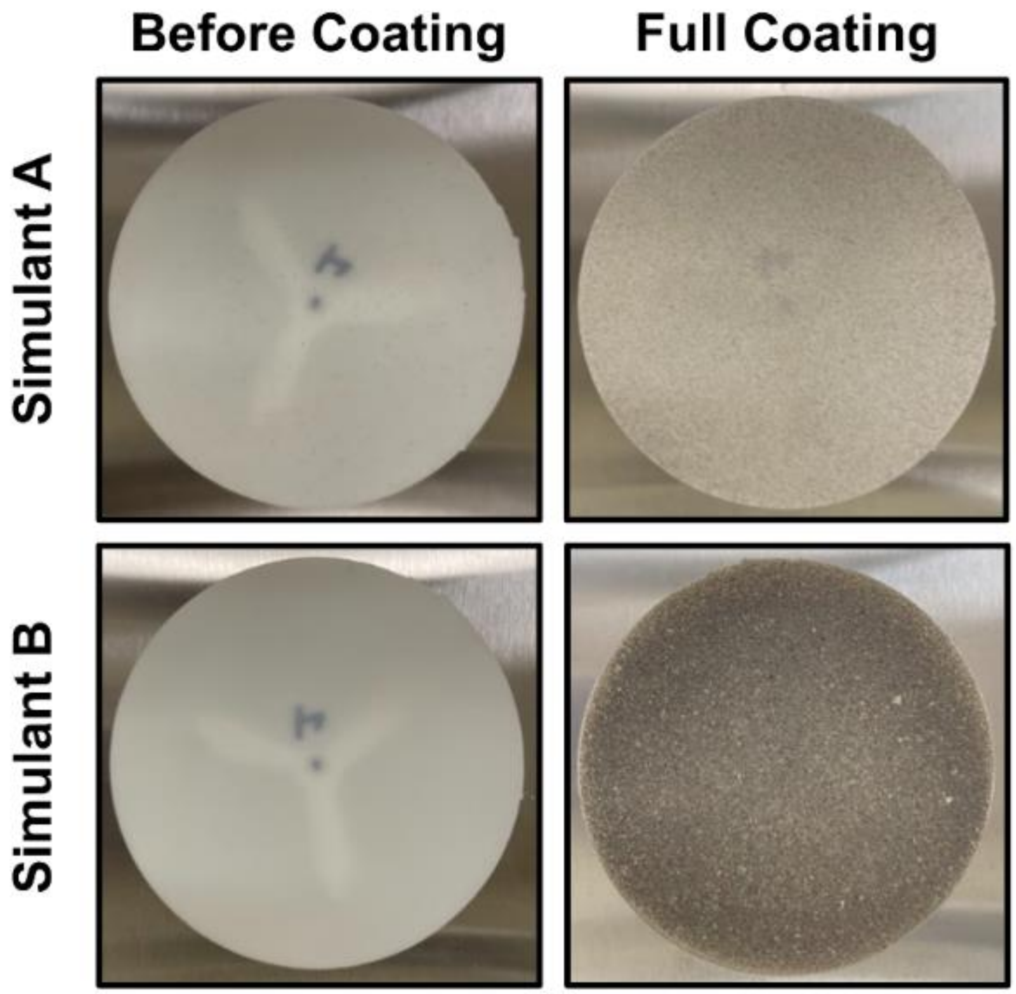


Sample image after passing through the CLAHE algorithm.

Testing

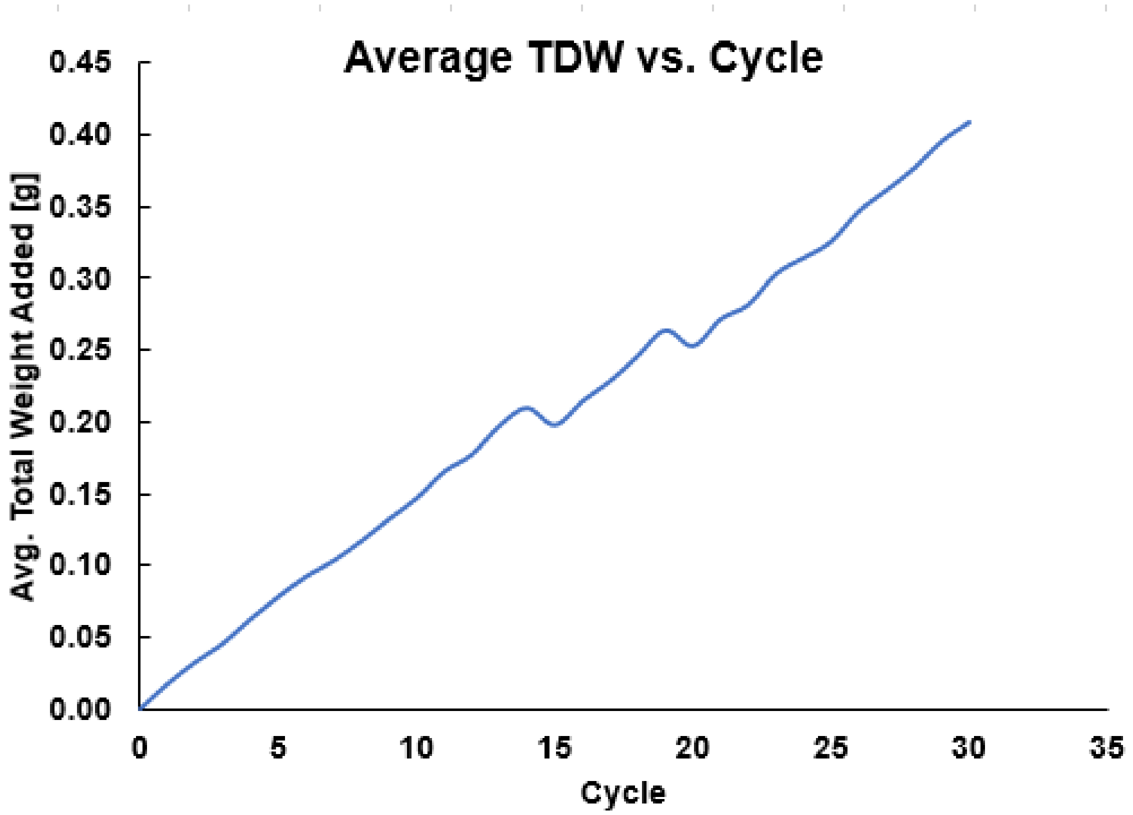
Because the original study focused on mars simulants, some “dialing in” had to be done with the lunar simulants.

Multiple variables were adjusted, including Simulant types, amounts, settling times, and the use and speed of an additional fan



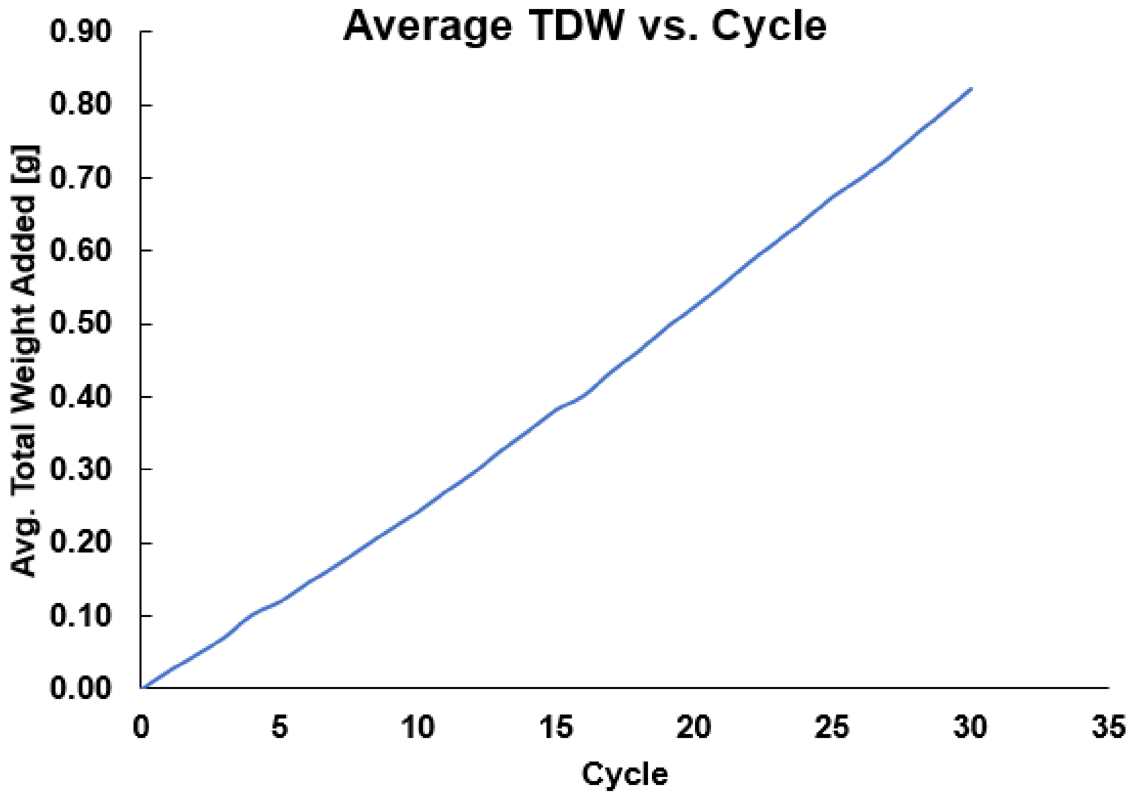
Images shown of test surfaces before and after coating with two different lunar dust simulants

Results



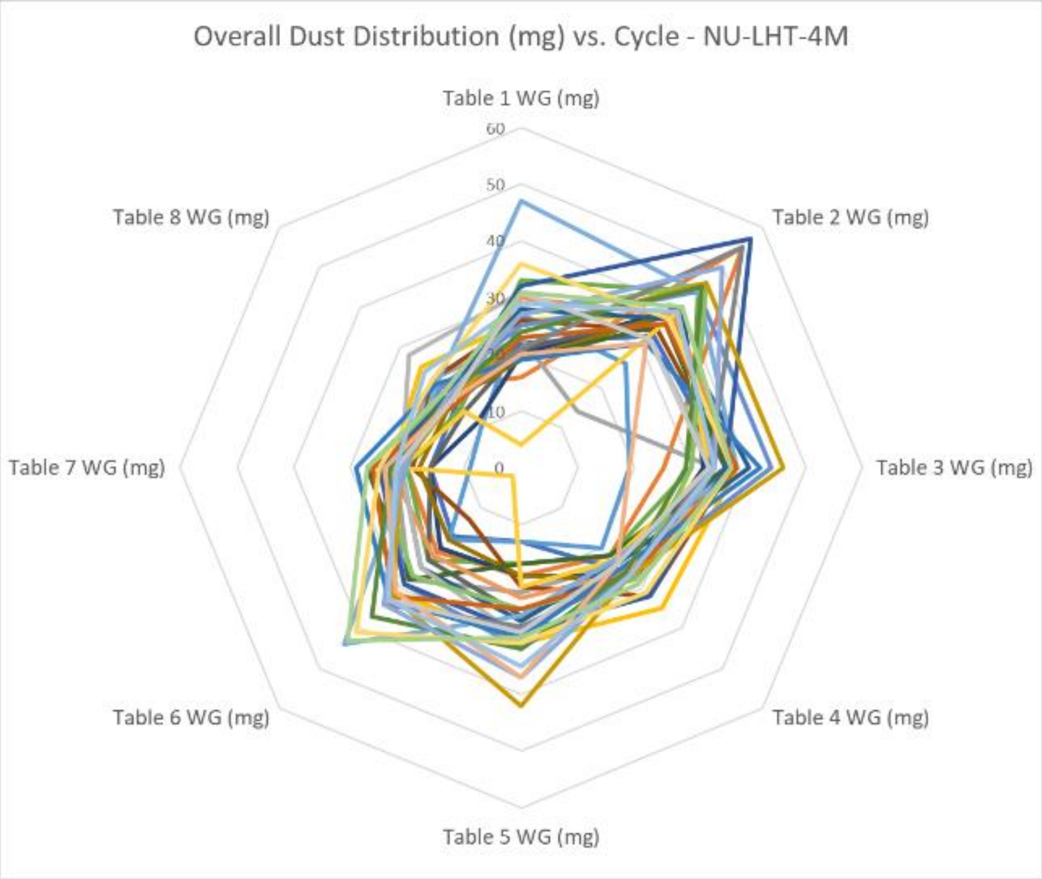
Average dust distribution by mass per dust loading/test cycle based on orientation/location on the test platform and averaged total dust weight (TDW) gained per test cycle/operation for simulant LHS-1D

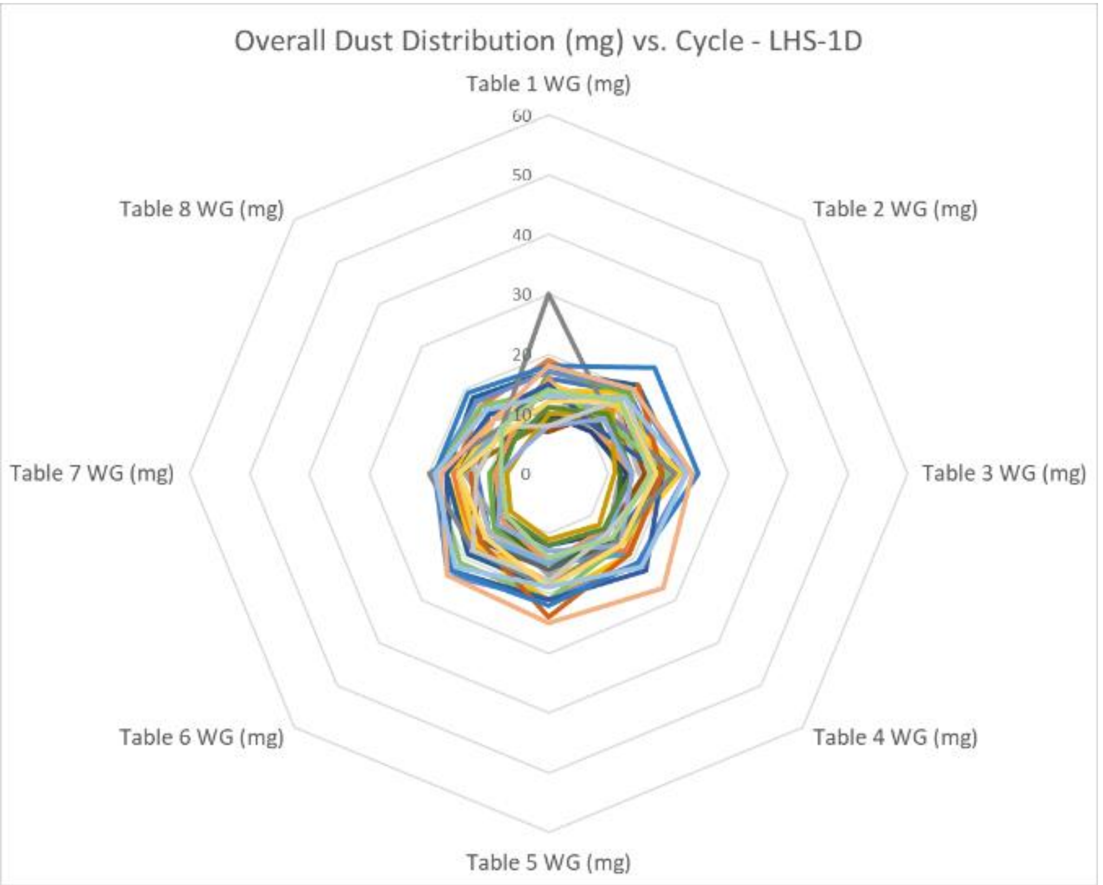
Results



Average dust distribution by mass per dust loading/test cycle based on orientation/location on the test platform and averaged total dust weight (TDW) gained per test cycle/operation for simulant NU-LHT-4M

Results

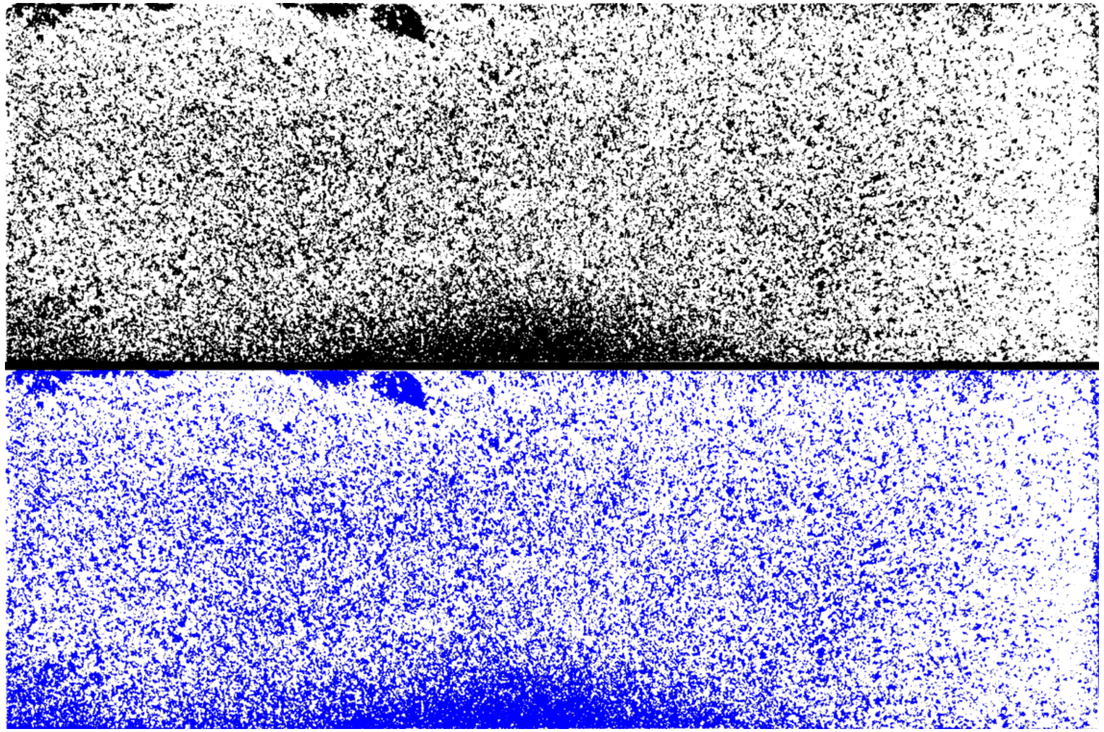




Radar graphs display the dust distribution across all 8 test tables for each cycle of dusting. Measurements are in mg and each graph contains 30 cycles worth of data.

Results

- Pixels are counted, and dusted pixels vs total are weighed as a percentage
- To combat non uniform handling of slides, multiple cropped images were taken – small crops are 20-25 of the surface area, large crops are 50-75% of the surface area



A cropped image after the CLAHE Algorithm is applied (top), with dust (white) highlighted on the glass surface (blue).

Conclusions

- Simulants substance matters – we see more uniformity from the smaller particle simulant the LHS-1D, whereas the larger particle simulant, the NU-LH-4M was less prone to “dusting” and less uniform in its coverage
- The delivery system is consistent in its delivery of material, and the imaging is showing promise to quantify the level of coverage for the data collection
- Dust testing will be an important factor in future missions to planetary bodies where surface regolith will be present. Development of these methods and validation of the data collected will be an important factor in the testing of the equipment and materials developed for those missions.

Acknowledgements

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References

- 1. Hollingsworth, D. Keith, et al. “Reduction in Emittance of Thermal Radiator Coatings Caused by the Accumulation of a Martian Dust Simulant.” Applied Thermal Engineering, vol. 26, no. 17-18, 2006, pp. 2383–2392.
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