Testing an Integrated Concept of Operations in Analog Surfaces for Lunar Exploration

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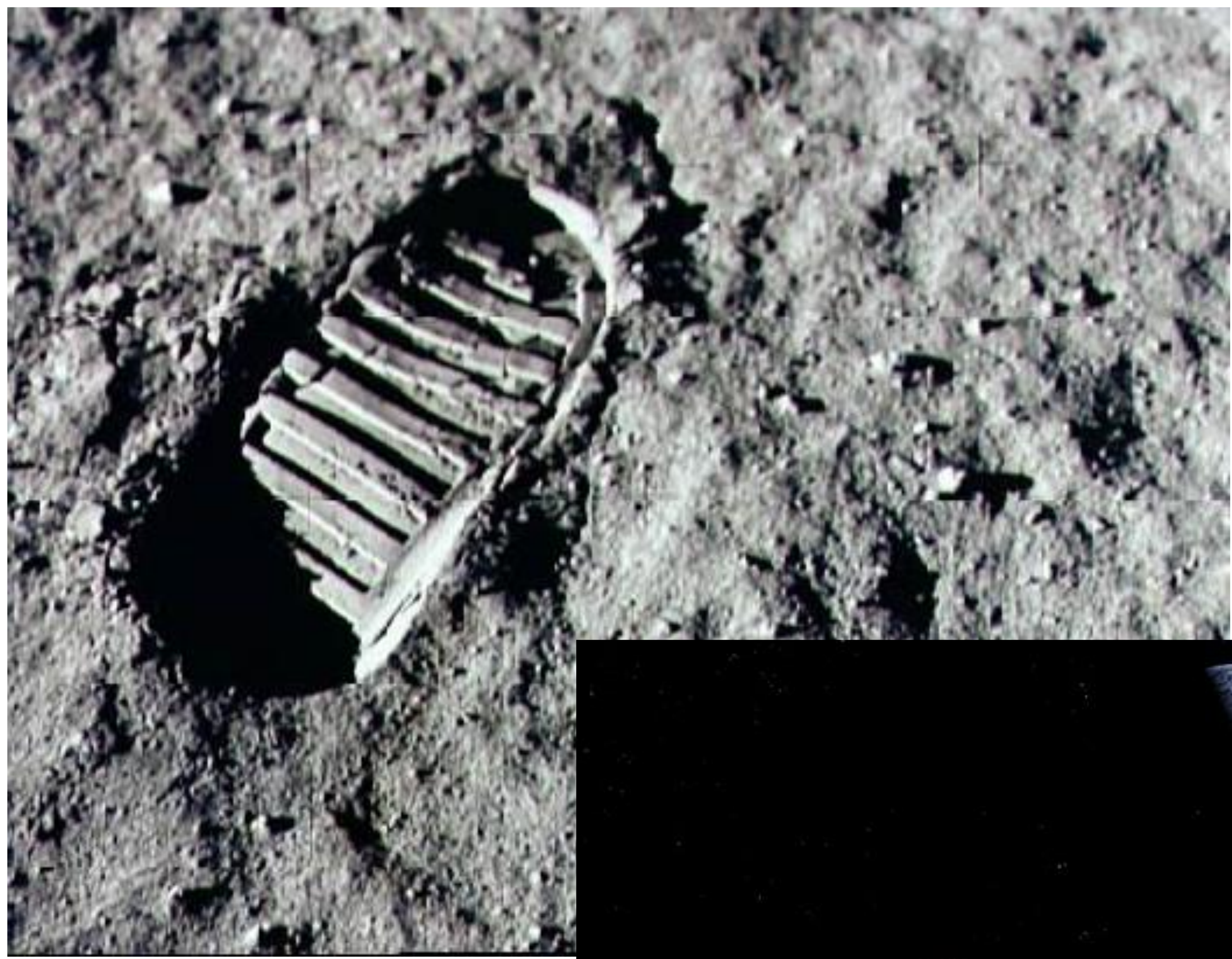
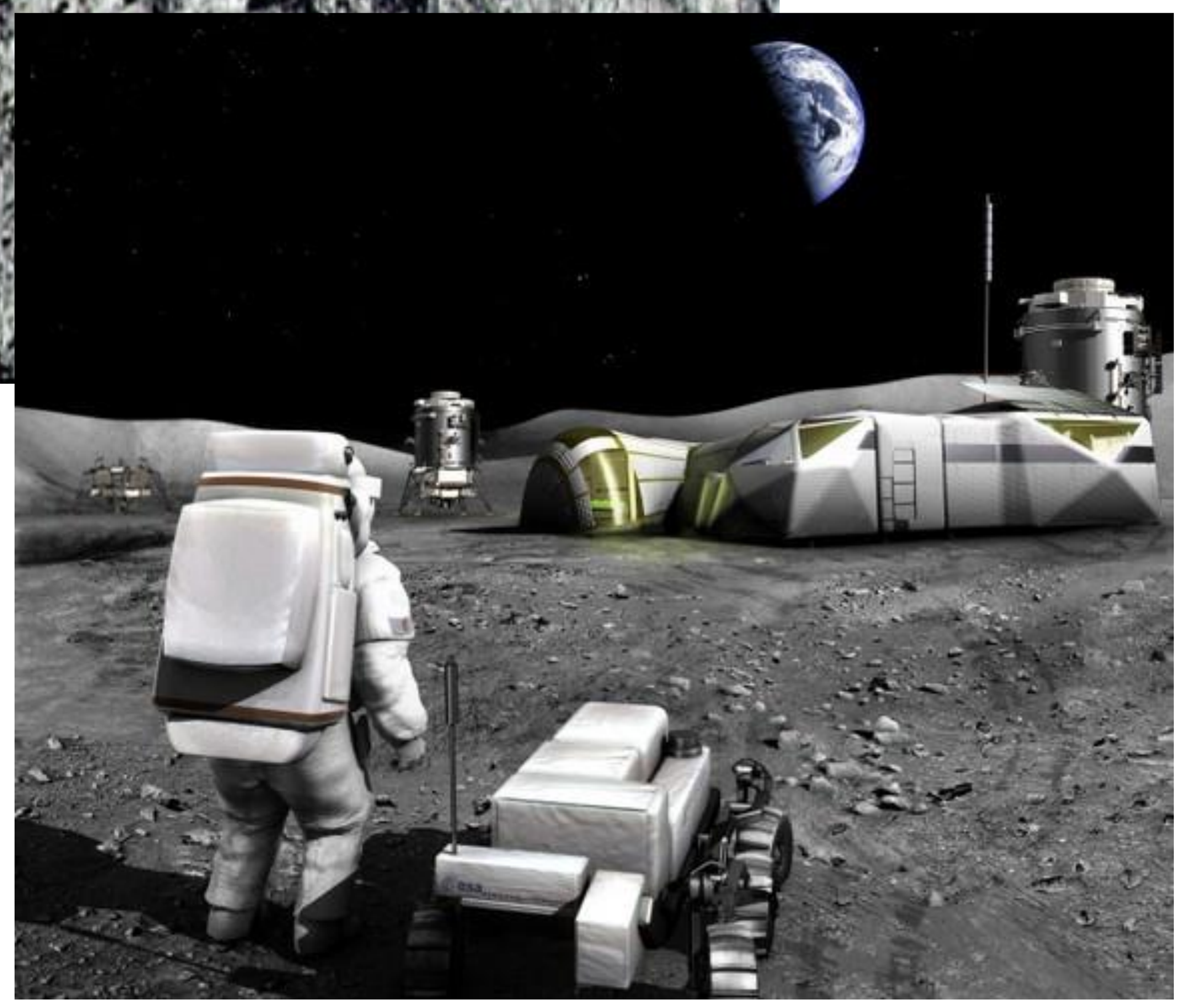
INTRODUCTION:





The National Aeronautics and Space Administration's (NASA) upcoming Artemis program plans to send manned and robotic missions to the Moon, utilizing the surface as a testbed for understanding the harsh environments that will be faced in future explorations to Mars. As we know from Solar System exploration missions, many planetary bodies are covered by regolith of various size distributions. The dusty regolith covering the Moon and Mars poses a substantial threat to the human and robotic activities planned during future missions that can range from minor hardware difficulties to overall mission failure.

A better understanding of regolith properties must be acquired to implement mitigation approaches. We will use a strategic concept of operations (CONOPS) to evaluate the effects of lunar dust on human and robotic activities to ensure the safety of future missions to the Moon and Mars.

References:

[1] McKay, D. S., Fruland, R. M., & Heiken, G. H. (1974). Grain size and the evolution of lunar soils. *Lunar and Planetary Science Conference Proceedings, 5,* 887–906.

[2] Gaier, 2005; Wagner, 2006; Latch et al., 2008; International Agency Working Group, 2016

[3] Brisset, Julie, et al. "Regolith behavior under asteroid-level gravity conditions: low-velocity impact experiments." *Progress in Earth and Planetary Science* 5.1 (2018): 73.

Testing an Integrated Concept of Operations for Lunar Dust Quantification, Characterization, and Mitigation

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THEMES:

THEME 1: Characterize the interaction between equipment and dusty surfaces and quantify the levels of dust production from robotic and human activities.

This theme will be impacting the study of (1) how operations on dusty surfaces generates increased dust pollution; (2) how hardware performance is impacted by these increased dust levels; and (3) mitigation options for hardware protection. We will quantify the amounts of dust that will be lifted during equipment activity (impacts, grinding, drilling, etc.) in various environmental conditions (low-pressure, low gravity) and at various scales (local, intermediate, global).

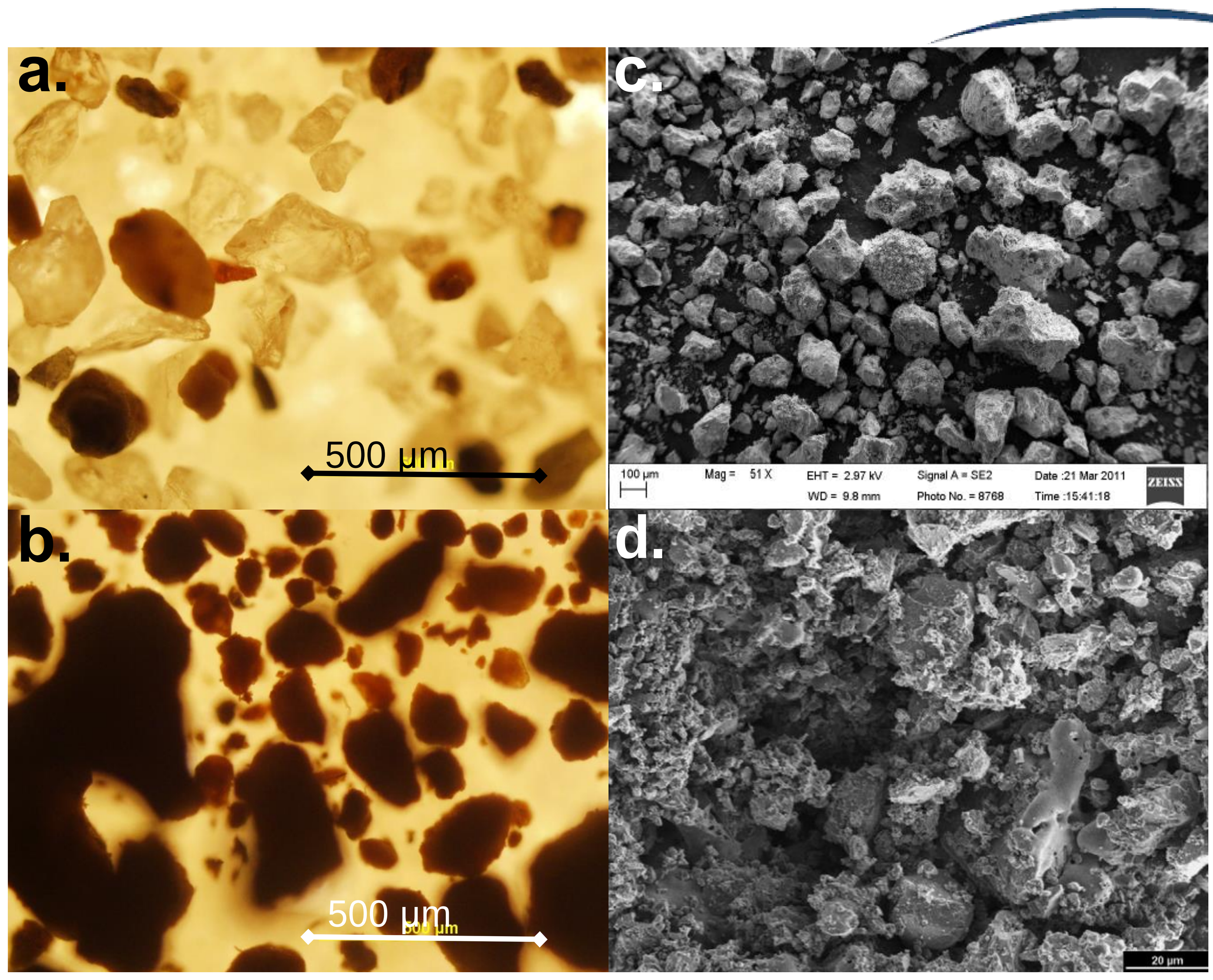

Figure 1: Microscope pictures of regolith and simulants.(a) Quartz sand grains, characteristic of Earth type regolith; (b) JSC Mars-1 simulant grains displaying rounded shapes similar to the sand grains; (c) Scanning Electron Microscope (SEM) pictures of JSC-1 Lunar simulant grains, showing similar shapes and surface structure[3] to (d) SEM pictures of actual Lunar regolith collected in a mare basalt region during the Apollo 12 mission. Credit: Brisset, et al. (2018); Robens, et al. (2007).

THEME 2: Optimizing science measurements on surfaces covered in regolith.

In this theme, we will conduct instrument performance measurements after the implementation of dust-mitigating solutions in various environmental conditions and compare the measured performance with the one before implementation

THEME 3: Prevention and mitigation of Lunar Dust for sustained human presence and operations on the surface of the Moon.

We will develop and integrate CONOPS testing for NASA operational protocols aimed at mitigating the impact of dust on equipment and measurements. These protocols, together with the data gathered during our project, can then be further expanded and used as needed for the generation of possible planetary protection procedures to work on pristine regions of the Moon.

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CONCLUSION:

Our focus on understanding regolith interactions with human and robotic activities will allow us to prepare for space missions to the Moon and gain experience for missions to Mars. We can accelerate scientific knowledge and experience in operations testing relevant to current NASA goals, and provide insight in a possible organizational structure for optimum human-robotic surface exploration.

Figure 2: NASA ARDS rover field testing for astrobiology science on planetary surfaces.

PROJECT IMPACT:

Our investigation will allow the scientific and regulatory communities to gain knowledge of dust/regolith interactions with biological life and help significantly advance our practical experience in operations procedures on Earth, in order to prepare for future space. We will gain further understanding of needed capabilities for operations in extreme environments and learn how to create effective scenarios with realistic conditions for human and robotic interfaces. Accomplishing these goals will provide a substantive framework of understanding that can be used for implementing Planetary Protection (PP) protocols, procedures, and policies guiding our future habitation of Lunar and Martian surfaces.