SIMULATOR FOR PLANETARY INTERACTIONS OF DUST AND REGOLITH (SPIDR): A NEW TOOL FOR PREDICTING DUST TRANSPORT FROM LUNAR SURFACE OPERATIONS.

H. M. Sargeant[1], J. Dyson[2], H. Otto[3], J. Long-Fox[1], D. Britt[1], and S. Sheridan[4]. [1]The University of Central Florida (HannahMarie.Sargeant@ucf.edu), [2]The University of Leicester, [3]Engineerdo, [4]The Open University.

Introduction: The majority of the lunar regolith is defined as "soil" which is the < 1 cm fraction, where approximately 50 wt % of lunar soil is finer than 50 µm [1]. Soil grains are irregular in shape and have a high surface area, resulting in increased physical adhesion to objects and cohesion with other grains [2]. Lunar soil is highly cohesive, a result of mainly van der Waals forces and electrostatic interactions. These sharp, charged grains can cause serious mechanical and electrical problems for lunar surface rovers and instruments.

To mitigate against the damaging effects of lunar soils, their behaviour in the lunar environment and the methods of mobilisation from the lunar surface must be understood. We have developed a tool for modelling the dust that is kicked up from surface operations on rocky planetary bodies: *Simulator for Planetary Interactions of Dust and Regolith* (SPIDR). This Discrete Element Method (DEM) simulation can be used to predict how lunar dust particles are mobilized and where they are deposited following rover traverses. Modifications can then be made to the rover design and/or operation to minimize unwanted dust mobilization and build-up.

Simulation Development: SPIDR simulates the lunar surface environment using LIGGGHTS [3], an open source DEM particle simulation software. In the simulation, we fill a tray with particles that exhibit representative grain size [1], charges (from triboelectric charging) [4], density [5], and weight (due to lunar gravity). We have also introduced electric fields (E-fields) that can be adjusted to represent the different charging environments on the lunar surface (e.g. a day-side E-field of 18 V up to a height of 1 m [6,7]. Other material properties are taken from [8].

To validate SPIDR, we introduced an Apollo 16 Lunar Roving Vehicle (LRV) wheel and fender into the particle tray, and applied comparative wheel speed and sinkage values to those measured during the LRV traverses [9,10]. Initial results indicate that the particle velocity (up to 4 ms^{-1}), and dust cloud shaping (series of arcs) is similar to that recorded in footage at the lunar surface during the Grand Prix traverse (Figure 1).

Current Status: SPIDR input variables, particularly the cohesion Energy Density (CED) are under review. CED calibration consists of laboratory angle of repose (AoR) tests on lunar regolith samples to compare with an AoR DEM simulation. We will also modify SPIDR to process smaller particles to represent the finest fractions (<2 µm). These small grains are expected to interact with E-fields sufficiently enough to modify

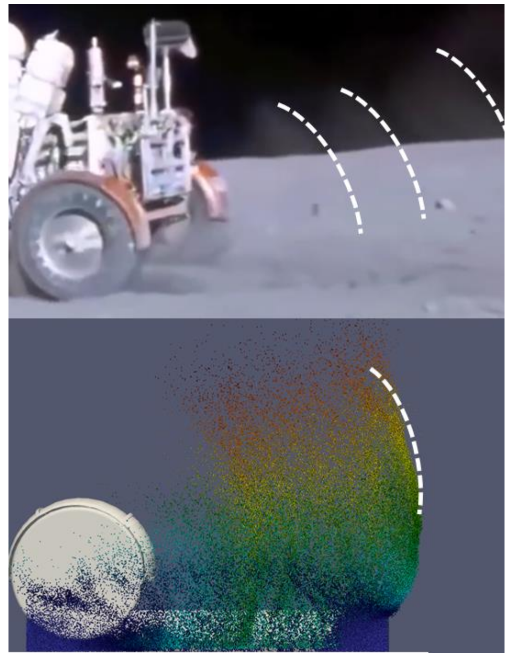

Figure 1 Above: Image from the Apollo 16 'Grand Prix' traverse (Credit: NASA). Below: Test simulation of SPIDR using a simplified LRV wheel and fender design.

their trajectory. We will evaluate how the finest dust fractions are transported under different E-field conditions. This analysis can be applied to any proposed lunar wheel design and operation mode.

Acknowledgements: We thank Ron Creel for LRV CAD files and information. This work was funded by the European Commission through its Horizon 2020 programme grant agreement #822018 and by CLASS NASA cooperative agreement #80NSSC19M0214.

References: [1] Zeng X. et al. (2010) *Jour. of Aero. Eng*., 23(4), pp. 213-218. [2] Carrier III D. W. et al. (1991) *Physical Properties of the Lunar Surface*, in, *Lunar Sourcebook*, pp. 475-594. [3] CFDEM Project (2021) *LIGGGHTS*, https://www.cfdem.com/liggghtsr-open-source-discrete-element-method-particle-simulation-code. [4] Sickafoose A. et al. (2001) *Jour. of Geophys. Res.: Space. Phys*., 106 (A5), pp. 8343-8356. [5] Kiefer W. et al. (2012) *Geophys. Res. Let.*, 39(7) pp.1-5. [6] Freeman J. & Ibrahim M. (1975) *The Moon*, 14 (1), pp. 103-114. [7] Stubbs T. et al. (2006) *Adv. In Space Res.*, 37(1), pp.59-66. [8] Otto H. et al. (2018) *Particuology*, 40, pp.34-43. [9] Hsu H. & Horányi M. (2012) *Amer. Jour. Of Phys*., 80(5), pp.452-456. [10] Costes N. et al. (1972) *Mobility Performance of the Lunar Roving Vehicle: Terrestrial Studies - Apollo 15 Results.*