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Abstract #
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Characterisation of the Dust Cloud During Landing on Lunar and Martian Surfaces

Authors

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Abstract

Successful space exploration missions are dependent on the design of vehicles that can sustain the extreme conditions of extra-terrestrial environments. Among the many aerodynamic challenges involved during the final descent of landers lies the presence of regolith. When retro-propulsive nozzles impinge on planetary surfaces, dust dispersion occurs, causing fine particles and debris to be ejected at very high speeds. These particles can obstruct vision and cause damage to hardware due to sandblasting, as observed in the Apollo missions and the samples returned from Surveyor III.

Due to the increasing interest in establishing permanent habitats in the Moon and exploring the possibility of crewed missions to Mars, an understanding of Plume-Surface Interactions (PSIs) is essential to design larger vehicles and hardware that are regolith resistant. In addition to ensuring safe soft landings, long-term systems such as In-Situ Resource Utilisation (ISRU) systems will require dust contamination resiliency, to avoid problems such as seal failure or degradation of solar arrays [1].

Researchers have applied a range of numerical models to simulate the interaction between dust particles and the surrounding flow field, combining both continuum and rarefied gas solvers [2]. Modellings of both lunar and Martian landings have been developed [3,4,5], however, validating the results has been difficult due to the lack of experimental data.

At the University of Glasgow, a 70m^3 volume dirty vacuum chamber has been designed, in collaboration with ESA-ESTEC, to recreate extra-terrestrial environments, such that the flow physics occurring during landings can be simulated. Dust clouds resulting from the impingement of plumes into a regolith bed will be parametrised in terms of their particle concentrations, trajectories, and velocities. High-speed imaging and light-scattering methods such as Particle Image Velocimetry (PIV) will be used to obtain these measurements. A heat exchanger simulating a lander's exhaust nozzle will be fired into a bed of regolith simulants and the dust cloud developed will be captured by cameras placed at different orientations. Laser sheets will be used for edge detection and to recreate the three-dimensional dust cloud, tracking its evolution. Having parametrised the resulting PSIs, further experiments will focus on the study of regolith and Shock-Boundary Layer Interactions (SBLIs) present in the nozzle.

The findings of this research will provide valuable insights into the interaction between regolith and the flow field surrounding the spacecraft, which will be critical when planning future space missions and achieving the goal of a sustained Lunar presence/habitat.

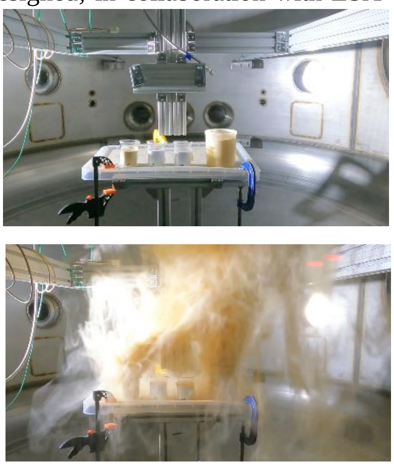

Figure 1: Outgassing of regolith simulants: glass spheres and walnut shells under vacuum.

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