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PLUME SURFACE INTERACTION (PSI) EFFECTS ON THE LUNAR SURFACE

Abstract

Rocket Plume Surface Interaction (PSI) can eject large amounts of regolith particles, limiting visibility and reducing flight safety. Particles ejected from the surface at high velocities can damage spacecraft, its instruments, and surrounding hardware. We have learned from Apollo missions that the mean time to failure of a system can be significantly reduced by the presence of lunar dust on materials and mechanisms. Upcoming lander missions are expected to force dust transport across the Moon whenever a lander's rocket plume impinges on the surface, causing erosion and ejecting particles at high speeds. As a result, this interaction poses multiple risks to future lunar exploration missions, especially for astronauts. Thus, understanding PSI processes is paramount to the safety of the lunar exploration program. In order to better understand PSI, we are developing in-flight instrumentation and conducting ground tests to assess the PSI effects. A dedicated suite of PSI instruments is being developed to collect data during descent and landing. These instruments are designed to quantify PSI effects in the actual lunar environment for the first time ever, by collecting data that can only be obtained during landings on the Moon. Since PSI is poorly known and these instruments are first of a kind, it is necessary to calculate estimates of multiple parameters such as distance traveled, particle concentration, particle size distribution, particle impingement time, velocity range of ejected particles, and energy of impacts, to assess the requirements of the PSI dedicated instrumentation. These initial estimates have been done using various methods along with analysis of Apollo lunar data. The results demonstrate that ejected particles will be able to travel distances up to 160 km away from the landing site with velocities up to 1200 m/s. The ejected particles could cause significant damage to nearby hardware and could affect surface equipment more than 100 km away. Our estimates are being used to derive the requirements for the PSI instruments. These instruments will help advance lunar science by providing the scientific community with observational data regarding particle movement to inform lander providers, such as CLPS (Commercial Lunar Payload Services) of potential risks to their vehicles during landings due to PSI effects. Our results can be used to improve prediction capabilities and develop mitigation strategies for future missions. This is crucial in ensuring safety during landings on the Moon and possibly other planetary bodies like Mars.