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INSTRUMENTS TO STUDY ROCKET PLUME SURFACE INTERACTIONS (PSI) 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 the spacecraft, its instruments, and any surrounding hardware. We have learned from the 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 lunar lander missions are expected to force dust transport across the Moon whenever a lander's rocket plume impinges on the lunar surface eroding the surface 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 simulate PSI. A dedicated suite of PSI instruments is being developed to be used during descent and landing. These instruments are designed to quantify plume surface interaction (PSI) effects in the actual lunar environment for the first time ever, by collecting data that can only be obtained on during landings on the Moon. The PSI instrument suite will focus on measuring the (1) plume-induced pressure distribution on the lander base and characterize the plume structure by infrared imaging, (2) surface erosion rate and crater formation as a function of time, and (3) ejecta particle speeds and energy flux, and particle impacts and deposition on the lander deck. This research will determine the characteristics of PSI experimentally. It will help advance lunar science by providing the science community with observational data regarding particle movement and distribution and inform commercial providers of Human Lander Systems (HLS) and CLPS (Commercial Lunar Payload Services) landers of the potential risks to their vehicles during landing. The data collected will be used to improve prediction capabilities for future missions and support the development of mitigation strategies. The data will also support scientists and engineers developing dust mitigation technologies to protect future lunar surface systems. This is crucial in ensuring safety during landings on the Moon and possibly other planetary bodies like Mars.