Transcending Societal Issues for Space Exploration (12)
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THE NEED FOR AN INTERNATIONAL FRAMEWORK TO MANAGE LAUNCH AND LANDING BLAST EFFECTS ON THE MOON

Abstract

Over twenty years' research has improved our physical understanding and our modeling of lunar landers blowing dust, sand, gravel, and rocks with their rocket exhaust. The effects are complex and can be far-reaching. Research has shown that the dust-sized particles ejected by a Lunar Module-sized lander achieve velocities of 1 to 3 km/s [Lane and Metzger, 2012]. Since lunar escape velocity is 2.38 km/s, the ejecta are distributed globally and exceed orbital altitudes where an orbiting spacecraft can be damaged if the timing is unfortunate. Sand-sized particles are ejected at 70 m/s to 1000 m/s, so they, too are distributed globally and exceed orbital altitudes. Gravel-sized (1 cm) particles are ejected by an LM-sized lander at 30 m/s (67 mph) so they strike within 600 m of the landing site, and fist-sized rocks (10 cm) at 10 m/s (22 mph) striking within about 60 m. With smaller lunar landers and less thrust, the particles will travel into vacuum before achieving as high a fraction of the gas velocity, yet simulations show even small landers will eject particles to the 10s or 100s of kilometers, at least. With larger landers currently being developed, ejecta will travel at much higher velocities and in much greater quantity than the LM. The type of damage from ejecta impacting surrounding hardware also depends on particle size: surface abrasion and contamination by dust, sandblasting and pitting by sand, large-scale impact damage by gravel. We have direct evidence of the severity of damage the ejecta can cause because the Apollo 12 Lunar Module sandblasted the Surveyor III spacecraft. Pieces of Surveyor III were returned to Earth and analyzed then compared with modeling.

It is tempting to think of the blowing dust cloud as a continuum of material that can fully characterized using descent imagery cameras (with ambient light), microwaves, millimeter wave radar, passive infrared, or another bulk-detection method. However, the clouds are a mixture of particle sizes traveling between each other at different velocities correlated to size, scattering with size-dependence, resulting in size segregation that determines the amount and type of impact damage that will be sustained at various distances.

Mitigation may include building landing pads or hardening assets against damage. Several techniques for landing pad construction have been developed, and they are a tradeoff of the mass needed from Earth, the energy required, and the time to completion.

This talk will overview the research, what we know about lunar blast ejecta, and progress in developing mitigation techniques and their tradeoff. It will discuss why an international framework is needed to include agreement on how much damage is permissible to cause to other nation's hardware (because it is often be impossible to make the effects zero), how large a blast zone is permissible around various activities, when it is mandatory to build landing pads, and how nations should communicate their contribution to the ejecta environment of the Moon.