OPTICAL MONITORING OF THE DUST ENVIRONMENT AROUND LUNAR EXPLORATION SITES.

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Abstract: Lessons from the Apollo program showed that dust perturbed by human activities on the lunar surface can significantly interfere with the operation of mechanical, thermal and optical systems[1].

During the Artemis program, monitoring the local dust environment created by surface activities will be critical to understanding and mitigating problems associated with lunar dust. This could be accomplished at many locations using in situ dust detectors; however, a complementary, and arguably more comprehensive, approach would be to measure the intensity of scattered sunlight from dust.

Such measurements could be obtained using modest cameras and will yield the abundance of dust along an observer line-of-sight. Observations along several look-directions can reveal the dust spatial distribution and can also constrain the minimum grain size by measuring the angular width of the forward scattering lobe. Perhaps most importantly, these measurements would constrain spatial and temporal variations in dust ejection and deposition rates. Optical measurements of this type can be very sensitive, as demonstrated by the recent detection of faint FUV sunlight scattering by dust in the permanent impact-generated ejecta cloud surrounding the Moon[2]. Using a precomputed grid of scattering properties for realistically-shaped grains, we simulate spectral intensities for the scattering of sunlight by a plausible steady-state distribution of low-speed (~ms^{-1}) dust around an exploration site. We assume dust has a power law mass distribution[3] and the site has a scale size of ~100 m. This is used to assess the feasibility of using commonly available wide-angle optics and commercial off-the-shelf (COTS) image sensors to create a simple notional dust monitoring camera (Fig. 1).

To explore this possibility, we model the dust detection sensitivity of cameras constructed using COTS components with flight heritage: the PL1 (LEIA) imager aboard the Light Italian CubeSat for Imaging of Asteroids (LICIACube) part of NASA's Double Asteroid Redirect Test (DART) mission[4], as well as sensors available from Hamamatsu and Ximea. Our present dust scattering grid spans UV to near-IR wavelengths and is computed for multiple grain shapes and sizes.

Results indicate that a simple but well-baffled camera can successfully detect a steady-state dust cloud created by human (artificial) activity with a peak concentration of < 1 μg m^{-3} for a polar site on the Moon—well below what might be expected during surface activities on Artemis missions. Additionally, zodiacal light can be monitored and used as a periodic calibration source[5].

References: [1] Winterhalter, D. (2020), NASA/TM−2020-5008219. [2] Glenar, D.A., et al. (2019), Fall AGU meeting, #P21B-06. [3] Horányi, M. et al. (2015), *Nature*, 522, 324–326. [4] Cheng A.F. et al. (2020), *Icarus*, 352, 113989. [5] Glenar, D. A. et al. (2014), *JGR Planets*, 119, 2548–2567.

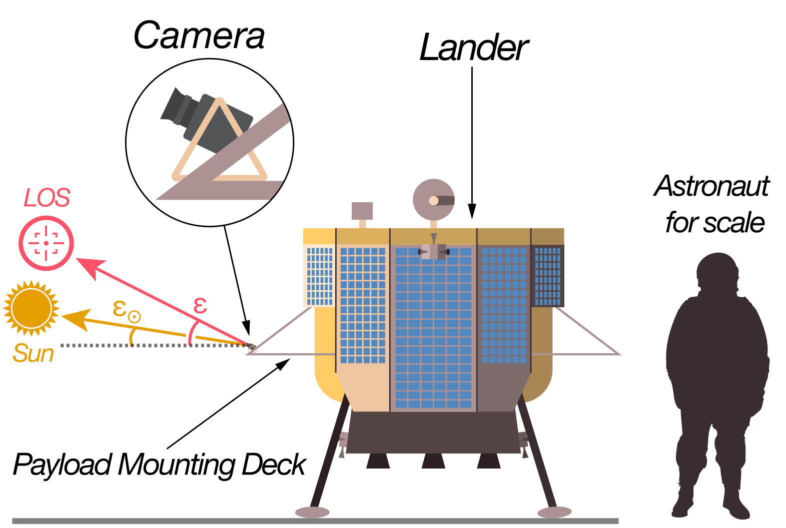

Figure 1 | Schematic showing dust model observation geometry and mounting of a small notional camera aboard a robotic lander (e.g., polar configuration of Astrobotic's Peregrine Lander for NASA's Commercial Lunar Payload Services program). A silhouette of an astronaut is provided for scale. Observation geometry showing elevation/azimuth angles to Sun and line-of-sight (cross hair symbol). Our results indicate that during Artemis missions a COTS-based camera could even detect highly tenuous dust clouds produced by surface operations with peak mass abundances of <1 μg m^{-3} for a polar site on the Moon.