AUTONOMOUS LUNAR DUST OBSERVER FOR THE SYSTEMATIC STUDY OF NATURAL AND ANTHROPOGENIC DUST PHENOMENA ON AIRLESS BODIES.

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Introduction: Most of the lunar surface is covered with a thick layer of regolith composed of rock fragments and dust that have evolved through billions of years of constant destructive meteoroid bombardment. From the Apollo mission experiences, it is clear that long term lunar surface experiments and human activities, as anticipated for the Constellation program, must necessarily deal with the ubiquitous presence of dust. A sustained return to the moon will afford a unique opportunity to characterize and understand the dust suspension and transport "weather" phenomena on airless bodies

Phenomenological Objectives: Unlike terrestrial dust that is oxidized, shaped, and chemically transformed by intimate contact with water, water vapor, and with other atmospheric gases, lunar dust contains a large fraction of sub-micron size particles that levitate against lunar gravity in the airless environment. The surface and suspended particles are charged by photoelectric, triboelectric, or solar wind processes. The lunar surface is exposed to the solar wind and to ultraviolet radiation from the Sun. On the dayside, photoemission of electrons from the lunar surface produces a photoelectron layer with a scale height of a few tens of cm. The positive surface potential of ~10V produces a vertical electric field that can cause dust particles in the regolith to lift off the surface. Observations of the western lunar horizon shortly after sunset by the Surveyor 5, 6, and 7 spacecraft showed a glow of forward-scattered light near the lunar surface [1]. This glow is believed to be light scattered by dust particles launched off the lunar surface at low speeds (~1 m/s) by electrostatic forces. The Lunar Ejecta and Meteorites Experiment (LEAM) deployed on the surface of the Moon by the Apollo 17 astronauts also apparently detected relatively slow-moving dust particles moving under the influence of near-surface electric fields ([2]Berg et al., 1976, [3]Colwell et al., 2006). Both the LEAM and Surveyor observations suggest enhanced electrostatic transport of dust near lunar sunrise and sunset. At terminator crossings large potential differences can exist over small spatial scales as some facets of the local topography are directly exposed to the solar UV flux while neighboring facets are in shadow. This can lead to large local electric fields which may help to mobilize dust ([4]De and Criswell, 1977; [5] Criswell and De, 1977).

The systematic study of these and as yet undiscovered dust transport phenomena, and the development and testing of effective dust mitigation strategies for sensors and human operations, could be well served by the development and deployment of a simple autonomous dust mapping lidar system that could observe both the transient dust environment associated with human activities and the long term naturally occurring lunar dust.

Autonomous Lidar Dust Observer: Ball Aerospace and Technologies Corp. is engaged in the design of a lightweight easily deployed lidar system specifically optimized for this application. Deployed by astronauts, the Autonomous Lunar Dust Observer (ALDO) would map and record the natural and anthropogenic dust environment by producing panoramic 3D views of range-resolve backscatter from an eye-safe laser in and around the sortie sites. Figure 1 illustrates the ALDO concept.

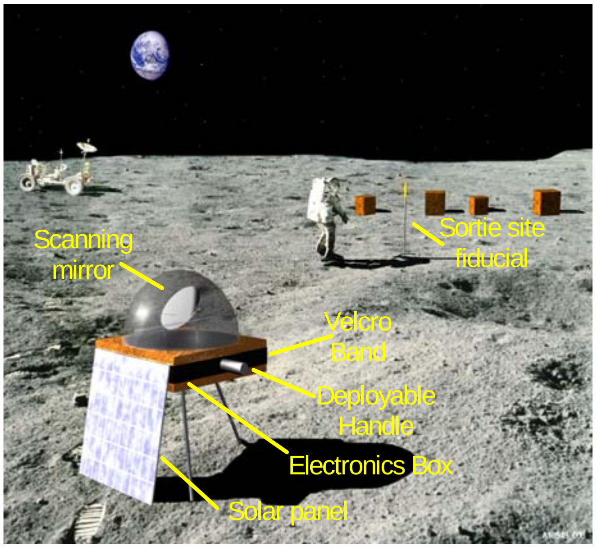

Figure 1 ALDO deployed at a lunar sortie experiment site. The system is self-contained, operationally flexible, self-locating, and autonomous.

For observing anthropogenic impacts of human activities and specific sortie operating procedures, the scanned-beam light detection and ranging (lidar) system would repeatedly map a volume delineated by elevation angles extending from the lunar surface to ~25°, 360° of azimuth (pointing both toward and away from the sortie site), and out to a range of perhaps 2 km. The sortie-site imaging mode will also reveal the extent and transport of the dust lofted by micrometeoroid impact events, giving real-time insight into regolith formation and gardening processes. For maximum sensitivity studies of natural phenomena, ALDO is scanned repeatedly over a shallow range of elevation angles at a fixed azimuth to reveal fine structure of the boundary layer dust profile. In addition, ALDO can be pointed at a fixed elevation and azimuth (including vertical) to produce high time resolution, dust scattering profiles. When the astronauts complete the sortie mission, ALDO can be left behind to observe the decay of anthropogenic effects, and the effects of lander take-off. Longer term observations from ALDO will result in rich data sets on terminator crossings, nighttime vs. daytime phenomenology, the general characteristics of dust plasmas, effects of the solar wind and, from ALDO observation at multiple sites, the relative suitability of site types as specific experiment locations. The observations made by ALDO will also have direct applicability to understanding and quantifying similar phenomena on other airless bodies such as NEOs, and supports multiple NASA strategic goals and Science Outcomes (specifically 3B.1, 3B.2, 3B.3, 3C.1, 3C.2, and 3C.4).

This paper discusses feasible instrument capabilities and architectures, and potential science applications for the study of both natural and anthropogenic dust phenomena.

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