LASER OPTICAL VISUALIZATION OF EJECTA FROM THE LUNAR LANDSCAPE.

A. Nicholas[1], C. Englert[1], D. Janches[2], M. Sarantos[2], T. Finne[1], C. Brown[1], S. Budzien[1]. [1]Space Science Division, Naval Research Laboratory, Washington, DC, [2]Heliophysics Science Division, NASA Goddard Flight Center, Greenbelt, MD.

Introduction: The lunar landscape is continuously bombarded by micrometeoroids originating from asteroids and comets. This influx of meteoroid material accounts for approximately 1.4 tons per day. The impact of these micrometeoroids can produce dust ejecta and even vaporize small portions of the lunar surface. Models of the dust ejecta predict four orders of magnitude larger values [1] than were observed by the Lunar Dust Experiment onboard NASA's Lunar Atmosphere and Dust Experiment (LADEE) spacecraft. We propose to build an instrument for deployment on the lunar surface to monitor micrometeoroid flux and associated dust ejecta via the use of a large-scale virtual witness plate.

Instrument Concept: The instrument, Laser Optical Visualization of Ejecta from the Lunar Landscape (LOVELL), concept is based on creating a sheet of light just above the lunar surface and observing photons scattered by incoming micrometeoroids passing through the lightsheet as well as the resulting dust ejecta from the impacts. A fisheye camera lens coupled to a detector provides a method to monitor the scene. This system creates a virtual witness plate for the observations as seen in Figure 1. The functional area of the virtual witness plate is scalable and defined by the components of the system: the power of the laser, the optics field of view (FOV) and aperture, and the detector sensitivity. The scalable nature of this instrument is unique in that it allows significant area coverage compared with other detection phenomenology that rely on impact observations.

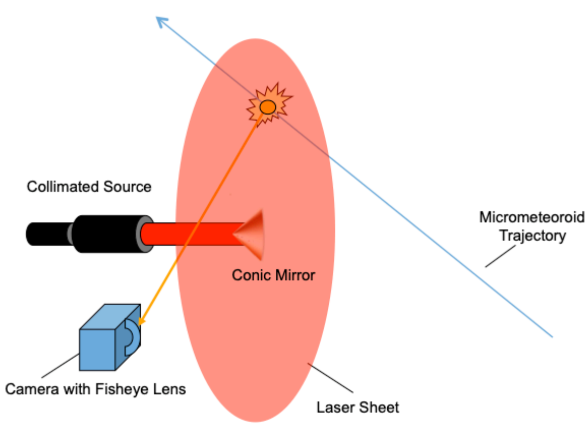

Figure 1. A graphical depiction of the lightsheet Concept

Packaging the lightsheet sensor for use on the lunar surface involves a ruggedized system including the light source, fisheye lens, detector, control electronics, axicon and associated optics, power source, and thermal control systems. The collimator and laser optics can be stored in the lid with the leveling feet. Figure 2 presents a sequence of images showing (clockwise from upper left) the stowed, open, and transparent and fully configured views of the LOVELL sensor. Estimated size, mass and power of the sensor are 50 x 38 x 32 cm (stowed) the periscope height is TBD, with a mass of 25 kg, and a power draw of ~100W with options to run off solar arrays and batteries or externally supplied power.

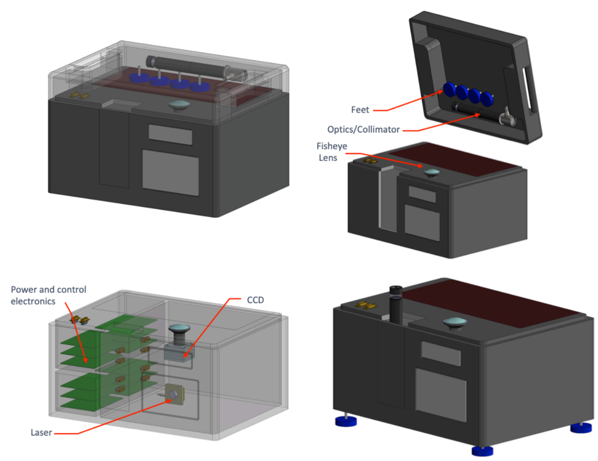

Figure 2. Isometric views of the sensor.

The lightsheet sensor performance has been estimated based on a laboratory version of the lightsheet sensor being developed for orbital debris observations [2,3] that utilizes a 30W output laser with spaceflight heritage, an 0.85 cm camera aperture and assumes the following input parameters for the incoming micrometeoroid: V = 15 km/s, albedo = 0.15, size ranging from 0.005 mm to 1 mm. The table presents the un-tailored instrument performance as maximum detection range and observed area for each of the size bins. The ejecta is expected to be more abundant, slower and hence easier to detect and not the limiting case.

Performance (V = 15 km/s, 30W laser, albedo=0.15)

Object Size (mm)	0.005	0.010	0.015	0.02	0.05	0.1	0.5	1.0
Detection Range (m)	0.136	0.216	0.283	0.343	0.632	1.0	2.9	4.7
Observed Area (m^2)	0.058	0.147	0.252	0.370	1.255	3.2	27.0	68.1

The site selected on the lunar surface would ideally be free of obstructions above the laser sheet height within a radius of 5 m from the center of the axicon. Figure 3 represents a deployed configuration with the laser sheet shown in green. This would require some astronaut initial instrument setup at the desired location on the lunar surface. The estimated cost to develop and operate the investigation is $12M. Data from the mission will be used to compare with dust ejecta models and the micrometeoroid flux rates will be used to inform safety engineers on proper shielding needs for the lunar surface.

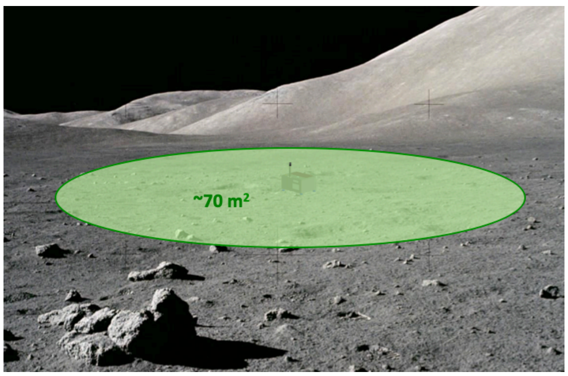

Figure 3. A graphical representation of a 70 m^2 virtual witness plate on the surface of the moon (image not to scale), image courtesy of NASA.

Acknowledgments: The authors would like to acknowledge the Chief of Naval Research for supporting this work.

References:

[1] Pokorný P., et al. (2019) Journal of Geophysical Research: Planets, 124, 752–778.

[2] Nicholas A. C. et al. (2019) *1st International Debris Conf. Proceedings, #6036,* https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/orbital2019paper_program.htm

[3] Englert C. R. et al. (2014) *Acta Astronautica, 104, 99-105*.