

MICROMETEOROID CHARACTERIZATION IN THE NEAR-LUNAR ENVIRONMENT

Steven Kilston, Ball Aerospace & Technologies Corp., PO Box 1062, Boulder, CO 80306 skilston@ball.com

There may be a significant scientific and operational need to measure the micrometeoroid flux distribution and size/energy distribution spectrum in the lunar environment. (When these particles impact the moon or a planet and survive they can then be called micrometeorites.) Most significant are the potential operational effects upon potential lunar-based telescopes (some even with liquid-surface primary mirrors), other instrumentation, and habitats for humans, such as those described in recent papers and conferences discussing lunar exploration mission concepts. All of these, as well as lunar-orbiting exploration-related missions and those in transit or operating in other space locations, may be subject to disturbances or damage by the micrometeoroids racing around the lunar space environment.

The scientific information deducible from measurements of the timing, velocity vector, number, and kinetic energy (therefore particle mass) distributions of micrometeoroids in various space environments in our solar system may lead to improved models of ancient and more recent comet and asteroid interactions and impacts. Further, that may broaden our understanding of processes of solid-body collisions in the formation of protoplanets and satellites.

The micrometeoroid flux near the moon may differ significantly from that near Earth, due to the different gravity fields and the possible deflection of particles by the larger body. The best I could do in a Google search for past micrometeoroid experiments near the moon resulted in finding references to these being incorporated in several Luna and Zond missions by the Soviet Union. I found no references to such near-lunar experiments on NASA or other nations' missions. First we should find out what may have been the scope of the data obtained by the Soviets, and also check how those data may compare with the results of NASA projects in this general area, such as the LDEF (Long-Duration Exposure Facility) and Genesis missions. (See <http://www.gps.caltech.edu/genesis/DocumentN.html>)

If it results that insufficient micrometeoroid characterization currently exists, then a relatively inexpensive but highly capable mission to fill the data gap would be developed in detail. My initial concept for such a mission involves a low-altitude lunar orbiter consisting of a spacecraft bus carrying a 3-dimensional coincidence detector with a basic design derived from

ground-based elementary particle detectors. The detector apparatus would be a hollow polyhedron (likely a cube) or sphere (quite possibly inflated to final shape after launch) on the surface(s) of which would be mounted an array of vibration sensors (e.g., microphones or microseismometers or piezoelectric devices).

In this initial concept, the detector surface would be a membrane (perhaps stretched over a frame), probably made of some plastic such as mylar. It would be thin enough that meteoroids in the range of kinetic energies of interest would easily penetrate at least two layers of such material, so that nearly all of the meteoroids encountered would enter the detector at one location, go through the hollow portion, and exit the detector surface at a second location.

The entry and exit events would be precisely timed by the vibration sensor signals, and the relative amplitudes at individual sensors would provide the data to measure accurately the locations of ingress and egress. In this way the direction and magnitude of the velocity vector would be determined. (For a detector volume of about a cubic meter, typical particle speeds of up to 50 km/s would result in detector transit times near 20 μ s, so we'd like event timing accuracies of $< 1 \mu$ s.) The entire sensor array's inertial orientation in space would be monitored by star sensors on the spacecraft bus, and the spacecraft position would be monitored by orbit analysis and communications signals received at the ground station.

Particle kinetic energies (and therefore masses) would be derived from the absolute levels of the sensor signals obtained at the various sensor distance from the ingress event, and possibly also by the difference in those signals from the ones measured at egress, if there is any significant slowing by the ingress penetration. (For a typical "large" particle, about 10 μ m in diameter, its mass would be near 10^{-12} kg, so its kinetic energy might be around 10^{-3} J. The membrane material and thickness would need to be specified with that in mind, and calibrated in lab collision tests, to generate a conversion matrix from the sensor levels to the impact particle kinetic energies.)

It is important to make the micrometeoroid measurements in wide variety of directions from the lunar center, and at many different times of the year so the effects of various comet dust streams and other clumpi-

ness can be evaluated. There may result scheduling and location implications for proposed lunar exploration activities and facilities, as well as design constraints.

In summary, the investigation proposed here would study existing datasets characterizing micrometeoroids, especially near the moon, and if significant critical information is found not to be available, develop a space mission concept to rectify that lack.