

## A Clearer View of Orbital Debris

DoD's new S-band radar space fence at Kwajalein should find and track most new LEO objects down to 2-5 cm. This may find ~20X more LEO debris than at present. This raises a question:

### *What debris detection is "good enough"?*

J.-C. Liou of NASA provided a useful criterion at Space2013: "The major mission-ending risks for most operational spacecraft, however, come from impacts with debris just above the threshold of the protection shields (~5-mm to 1-cm)."

For each of ~10,000 >10cm LEO fragments now tracked, there may be ~100 pieces of passive "cm-class shrapnel" capable of disabling most spacecraft. Avoiding cm-class shrapnel is a different challenge from military space situational awareness. A 100X larger catalog poses many challenges, but cm-class shrapnel is at least not a maneuverable threat.

Ground-based telescope fixes of sunlit LEO objects can be within meters, but predictions of future positions quickly grow uncertain. This is particularly true for small shrapnel. It has a larger area/mass ratio than satellites, so it reacts more to air drag. So one must either track small debris more frequently, or infer future changes in debris drag area as debris spin axis, orbit plane, and perigee phase slowly evolve.

A suitable network might need two half-meter telescopes at each of ~60 good sites world-wide, with each telescope slewing to new sunlit objects every few seconds. This would quickly wear out geared mounts, so agile direct-drive mounts are needed. During the middle of each night, the telescopes can look for GEO debris, and perhaps also serve as laser-comm downlinks.

The paper argues that telescopes can affordably find and track not just ~1% of lethal LEO debris as we do now, or perhaps ~20% of it with S-band radar, but potentially most of it. This should be of commercial value. A key question is whether that value is sufficient to support such a telescope network and the resulting conjunction analyses. The paper will address that issue.

The above abstract text is derived from that for another paper, but a substantial part of this paper will be new, in particular the estimation of network costs and potential benefits.