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IMPROVING LEO DEBRIS DRAG PREDICTION BY INFERRING SPIN AXIS

Abstract

The USAF uses a High Accuracy Satellite Drag Model (HASDM) to improve drag predictions in LEO. It infers recent 3D air density maps from frequent radar updates of 80 objects with stable drag. But it does not predict future trends in drag area of individual debris objects.

Most small debris from collisions or explosions is likely to spin rapidly when created. Decay of spin of metal debris should be mostly from eddy currents in earth's magnetic field. "Coin-flip" spin or wobble may decay within months and flat spin within years in aluminum or copper. Other metal and non-metal debris should spin far longer.

Magnetic materials may precess in the earth's field, but most debris spin axes may vary far more slowly than perigee precession and nodal regression. Those cycles may greatly affect drag area on weekly timescales, particularly for flat-spinning debris. Catalog data should already show periodic B* variations, but only from past trends, not predicted ones. Inferring spin axis from past trends should allow prediction of future drag area trends. Combining this with HASDM air density maps should allow better orbit predictions and longer times between observations.

The new S-band radar at Kwajalein may see most LEO debris down to 2-5 cm depending on range. Such debris will usually be lethal to high-value LEO spacecraft, even with shielding. Small debris also has higher area/mass than satellites and so more response to drag. Small debris will also be seen only during closer passes, so there will be larger gaps between observations. So uncertainties in predicting satellite-debris conjunctions will be far more from debris than satellite uncertainties. However sensitive the new S-band radar is, most of the debris it sees will be small but still lethal, much more sensitive to air drag than satellites, and visible far less often.

Besides allowing better conjunction predictions, inferring drag area should also allow more accurate association of new observations after a long observation gap. This allows a larger and more useful debris catalog for any sensor network. This in turn allows active satellite avoidance from a larger fraction of the lethal debris in low earth orbit.