Why Should We Estimate the Future Costs of Orbital Debris?

Joe Carroll tether@coxnet

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Orbital debris is an expensive and growing problem. Most of the direct cost is due to small but lethal "shrapnel" that we do not track and hence cannot avoid. If only one debris management option made sense, decisions would be easy. But there are many options for reducing costs, such as preventing collisions by laser nudging, or removing or collecting large objects, or armoring new satellites, or flying low and reboosting frequently.

Decision-makers need $-based figures of merit to make rational decisions about orbital debris management options. If debris experts do not come up with good $-based figures of merit, then other factors will drive the key decisions. The results are likely to be less effective.

It is critical to estimate not just the costs of debris, but also how the costs may vary with debris management technologies and practices. This involves large uncertainties. But ***not*** estimating costs and cost sensitivities leaves far larger uncertainties. Outcomes become a matter of chance.

If you think that cost and sensitivity estimation are important but are still uncomfortable with it, these two books may be useful:

How to Measure Anything: Finding the Value of Intangibles in Business, by Doug Hubbard
The Wisdom of Crowds, by James Surowiecki

Estimating costs and sensitivities involves many tasks that require distinct skills. Below is a list of cost-related debris questions that may be of interest to committee members or their employers or students. I provide this list to trigger discussion. Other questions may be easier or more useful.

Historical costs and trends

1. What past LEO & GEO failures may be due to shrapnel, even if attributed to other causes?
2. What is the cost of all operating satellites in LEO, and in GEO (total, & not yet amortized)?
3. What added costs are imposed by sudden random failure, beyond loss of non-amortized life?
4. Using ORDEM or MASTER & existing LEO assets, what ***range*** of $/year loss is now likely?
5. What is the chance and resulting annual cost of a collision of 2 Zenit stages near 850 km?
6. What is the discounted future debris cost imposed by a new LEO sat, vs mass & altitude?
7. What debris questions concern space insurers most, and what are their cost implications?

Shrapnel lethality

8. What are the fragment mass spectra from DebriSat, DebrisLV, and other recent impact tests?
9. What body impact energy (J/g) may be ~50% likely to disable common LEO & GEO sats?
10. What satellite design changes might increase that energy (and how far and at what cost)?
11. What are the impact rates vs altitude in 51.6^{o} & 98^{o} orbits & GEO, vs Joules impact energy?

Optical detection and avoidance

12. What are the faintest LEO & GEO fragments detected ***and*** tracked by unclassified assets?
13. What observation rates are needed for actionable avoidance of 1E5-1E6 fragments in LEO?
14. What improvements in drag and other models are also needed for actionable avoidance?