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ENVIRONMENTAL IMPACT OF SPACE DEBRIS REPOSITIONING

Abstract

Recent studies have shown that the environmental impact of a collision in low earth orbit (LEO) depend not only on the total mass involved but also on the altitude where the collision occurs. This fact is a direct consequence of the exponential dependence of atmospheric density with orbit altitude and can be directly inferred by looking at the two major collision events in LEO to date: the 2009 Cosmos-Iridium collision, which occured at about 789 km altitude, is estimated to have 90% of its fragments to reenter the atmosphere by 2024 while it will take until about 2090 for the case of the Fengyun-C debris (occurred at 865 km altitude in 2007) [Pardini, Anselmo, ASR 2011]. Following a similar reasoning, other authors have started including orbit lifetime criteria in the computation of the environmental criticality of LEO collisions and the ranking of target debris for active removal [Rossi et al., ASR 2015; Yasaka, IAC2011; Utzmann et al. IAC2012; Lewis et al. ESA2013; Kebschull et al. IAC2014; Anselmo and Pardini, Acta Astr.2015].

Going one step further, one could compute the change in environmental criticality experienced when a large space debris is not completely deorbited but rather displaced to a higher drag orbit. Depending on the initial and final altitude, this would reduce the environmental damage of a possible collision to a few years rather than decades or centuries while considerably lowering fuel expenditures and/or maneuvering time. As proposed in the ongoing FP7-funded LEOSWEEP project [Ruiz, Space Propulsion Conference 2014, Koeln, Germany], the cost of future debris removal missions could be dramatically reduced by resorting to low-deltaV repositioning of multiple debris with a single spacecraft rather than full deorbit of indvidual objects.

Building upon recent literature results and employing in-house numerical propagation tools, this article performs an extensive assesment of the environmental criticality reduction following reposition of high-ranking targets taken from the LEO upper stage population. Top ranking objects, mostly soviet Zenith upper stages, are displaced to a lower debris mass density region below Iridium altitude (780 km) and their environmental criticality is recomputed. A tradeoff with expected removal costs is also taken into account. Results show a decrease in the criticality-times-removal-cost product for a multiple repositioning mission compared to full deorbiting of all targets.