Active Elimination of Small-Scale Orbital Debris *

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Accumulation of space debris, approximately 19,000 man-made objects larger than 10 cm and numerous smaller objects, resulting from decades of space utilization by human beings have rendered the space environment hazardous. The lifetime of the debris in the much exploited Sun-synchronous orbit where the debris concentration is particularly high can be centuries. While larger debris are fewer and can be tracked and avoided the smaller-scale debris are numerous and are hard to track individually. Their collision with active satellites is more likely and could be catastrophic. At present there are no credible solutions for their removal making them particularly dangerous and can soon challenge our access to space. We discuss a concept for de-orbiting small-scale debris with characteristic dimension of about 10 cm or less from the highly populated sun synchronous orbit region by injecting micron scale dust grains in this region to artificially increase drag on the debris. The drag enhancement is most effective when dust grains counter rotate with respect to the debris. Our concept is designed to target small-scale debris in orbits with perigee above 900 km where the natural debris lifetime can be very long. For a specific example we focus on small debris with ballistic coefficient (Mass(kg)/Area(m^2)) 5 or less. A ballistic coefficient of 5 represents small debris in a variety of sizes and shapes. For example, broken pieces of satellites (aluminum, density 2.7 gm/cc) with dimension 10 cm × 10 cm × 1.5 mm or 30 cm × 30 cm × 1.5 mm, etc. The density of the dust cloud necessary to de-orbit small debris is sufficiently low such that the orbits of larger active satellites with much larger ballistic coefficients are minimally affected. Various implementation schemes and possible detrimental effects of the injected dust cloud on active satellites and their mitigation will be discussed.

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