SPACE DEBRIS SYMPOSIUM (A6)
Political, Economic and Institutional Aspects of Space Debris Mitigation and Removal (Joint with Space Security Committee) (6)

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AFFORDABLE DEBRIS REMOVAL AND COLLECTION IN LEO

Abstract

We consider three debris removal campaigns in LEO based on the capabilities of a specially designed vehicle. The ElectroDynamic Debris Eliminator (EDDE) is a vehicle of a new class for LEO. It is solar-powered and uses electric current in a long conductor to thrust against the Earth's magnetic field. Operating without propellant, EDDE can repeatedly change its altitude by hundreds of kilometers per day and its orbital plane by several degrees per day. EDDE weighs about 100 kg, but it can move multi-ton payloads. A dozen EDDE vehicles can remove all large debris from LEO in about 7 years. They can all be launched on one ESPA ring (two per slot), but our analysis shows that phased deployment has advantages. Two EDDE vehicles can be launched every year and retired after 5 years of service. In 9 years of operation, 2,000 tons of large legacy debris and 97% of the collision-generated debris potential in LEO can be removed at an average cost of less than $400 per kg and an average annual cost of less than $90M. We also considered a campaign that removes only upper stages from LEO. In 7 years of operation, 1,000 tons of upper stages and 79% of the collision-generated debris potential can be removed at an average cost of less than $500 per kg and an average annual cost of about $70M. In these campaigns, debris objects are dragged to altitudes below ISS and released for natural decay. However, uncontrolled reentry may not be desirable for objects that are not expected to burn up completely, and there is a way to avoid it. In the third campaign, all old upper stages currently orbiting above 600 km in the 71-74, 81-83, and the Sun-sync clusters are moved to 600 km and assembled in several maneuverable collections, reducing the collision-generated debris potential by more than 70%. Each collection is propelled electrodynamically without fuel expenditure for the purposes of collision avoidance and orbit maintenance. When technology is developed, the collections may be reprocessed into construction materials, which could be the starting point for large-scale space manufacturing. Debris collection may provide launching states with a de facto relief from 1) strict liability for damages on the ground, because it prevents reentry; 2) at-fault liability for damages in orbit, because the object is moved by the collection entity; and 3) the object itself, once it is collected and recycled.