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Space Debris Removal Concepts (6)

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LIGHTFORCE PHOTON-PRESSURE COLLISION AVOIDANCE: EFFICIENCY ANALYSIS IN THE CURRENT DEBRIS ENVIRONMENT AND LONG-TERM SIMULATION PERSPECTIVE

Abstract

This work provides an efficiency analysis of the LightForce space debris collision avoidance scheme in the current debris environment and describes a simulation approach to assess its impact on the long-term evolution of the space debris environment.

LightForce aims to provide just-in-time collision avoidance by utilizing photon pressure from ground-based industrial lasers. These ground stations impart minimal accelerations to increase the miss distance for a predicted conjunction between two objects. In the first part of this paper we will present research that investigates the short-term effect of a few systems consisting of 10kW class lasers directed by 1.5 m diameter telescopes using adaptive optics. The results found such a network of ground stations to mitigate more than 85 percent of conjunctions and could lower the expected number of collisions in Low Earth Orbit (LEO) by an order of magnitude. While these are impressive numbers that indicate LightForce's utility in the short-term, the remaining 15 percent of possible collisions contain (among others) conjunctions between two massive objects that would add large amount of debris if they collide. Still, conjunctions

between massive objects and smaller objects can be mitigated. Hence we choose to expand the capabilities of the simulation software to investigate the overall effect of a network of LightForce stations on the long-term debris evolution. In the second part of this paper, we will present the planed simulation approach for that effort.

For the efficiency analysis of collision avoidance in the current debris environment, we utilize a simulation approach that uses the entire Two Line Element (TLE) catalogue in LEO for a given day as initial input. These objects are propagated for one year and an all-on-all conjunction analysis is performed. For conjunctions that exceed a range threshold, we calculate the probability of collision and record those values. To assess efficiency, we compare a baseline (without collision avoidance) conjunction analysis with an analysis where LightForce is active. Using that approach, we take into account that collision avoidance maneuvers could have effects on third objects. Performing all-on-all conjunction analyses for extended period of time requires significant computer resources; hence we implemented this simulation utilizing a highly parallel approach on the NASA Pleiades supercomputer.