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Author: Mr. Lewis Walker
University of Strathclyde, United Kingdom, lewis.walker@strath.ac.uk

Prof. Massimiliano Vasile
University of Strathclyde, United Kingdom, massimiliano.vasile@strath.ac.uk

A STRATEGY FOR THE MITIGATION OF DEBRIS SHELLS IN LEO USING SPACE-BASED LASERS

Abstract

This paper presents an initial feasibility and impact assessment for a new mission concept for the mitigation of debris shells caused by collision events in Earth orbit, specifically targeted at sub-5cm fragments which are too small for optical tracking from Earth.

The concept employs a constellation of smallsats carrying continuous-wave lasers as well as cameras for optical acquisition and tracking of debris fragments. The constellation is deployed into the debris shell and continually scans for passing fragments with which to interact. After acquisition of a fragment with the camera, the laser illuminates and tracks the fragment to apply a small photon pressure force acting to lower the orbit.

The paper assesses the feasibility, and statistically analyses the impact of such a mission over a multi-year timeframe to determine the reduction of the shell's average lifetime. We first determine the possible interaction rate of a single satellite based on optical tracking limitations and propagated fragment orbits, then use a high-fidelity photon pressure model to determine the net momentum transfer numerically for the remaining set of viable encounters. The photon pressure model accounts for the size, shape and rotation of fragments by utilizing a surface element based approach accounting for occlusion and self-shadowing. These results are then extended statistically to more encounters with multiple satellites to estimate the overall mission impact on the shell's lifetime.