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MISSION DESIGN FOR IN-ORBIT DEMONSTRATION OF ACTIVE DEBRIS REMOVAL THROUGH AN ION BEAM SHEPHERD SMALL SATELLITE

Abstract

Low Earth Orbits (LEOs) represent a limited resource. The presence of uncontrolled residual objects from past missions, labeled debris, is a significant issue. Debris occupy portions of this environment and pose a dangerous collision risk to spacecraft operating in their surroundings, thus limiting operational capabilities and access. It is therefore fundamental to develop methods and strategies to mitigate the hazards connected to debris to preserve the usability of the space environment over long timescales.

In Active Debris Removal (ADR) approaches, a chaser spacecraft actively pursues a target piece of debris, with the goal of safely removing it from orbit. Utilizing Small Satellite capabilities for ADR is considered beneficial for two main reasons: Firstly, pushing for commercial space operations, and hence oriented towards low budget, mass-producible platforms is in line with the emerging Space 4.0 trends. Secondly, contributing to the debris problem to a much smaller extent than a large spacecraft when a

failure or impact of a small one occurs. To further minimize impact risks, it is desirable to investigate ADR methods capable of manipulating the target's orbit from a safe distance, without the need for docking or berthing.

A promising ADR technique that is consistent with contactless operations constraints, and that is undergoing rapid development, is that of the Ion Beam Shepherd (IBS). This revolves around using a highly collimated ion beam to continuously exert a force at a close range on the debris to achieve a highly controlled deorbiting. However, to date, no demonstration mission has proven this concept in space. This paper presents an analysis for the plausible design of an in-orbit mission employed to increase the technology readiness level (TRL) of IBS capabilities for small satellites in LEO. The associated risks and challenges are discussed in detail, from preliminary operational concepts down to subsystem levels, and payload selection. Particular attention is given to mission critical elements, such as state-of-the-art electric propulsion, techniques for collision avoidance, methods for reconstruction of the dynamics of non-cooperative targets and hazardous effects connected to IBS.

The work was performed by a team of volunteers from the Small Satellites Project Group (SSPG) within the Space Generation Advisory Council (SGAC).