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SPACE STATION CONCEPT FOR ACTIVE DEBRIS REMOVAL APPLYING ECODESIGN PRINCIPLES

Abstract

Humankind is increasingly reliant on space-based systems to support technology on the ground. All these systems, in particular in low Earth orbit, are facing potentially disruptive damage from space debris. Unless significant mitigation and remediation efforts are taken, a cascading chain of orbital collisions could occur, making orbital operations a challenge for hundreds of years. In the era of space commercialization, the number of launches is increasing and will keep growing to cover for the emerging mega-constellations. Mitigation will not be sufficient and active debris removal will need to be implemented.

An active debris removal mission, that is aligned with the European Space Agency's initiative to preserve and protect the orbital and terrestrial environments called Clean Space, is proposed. Engineering design principles, named EcoDesign, were followed to lessen the negative impact of the space mission on the terrestrial environment. Using concurrent engineering at the European Space Research and Technology Centre, two space mission concepts are proposed and analyzed through a tradeoff study between mission architectures. The two solutions were carried out by space professionals from 18 countries in the framework of the Space Studies Program from the International Space University with the support of ESA's Concurrent Design Facility experts.

The first mission concept, named "single-chaser", makes use of a single servicing satellite launched into the same orbit of the space debris to be removed; after acquiring the target, the chaser itself performs a controlled reentry maneuver.

The second mission concept introduces an "in-orbit servicing station", consisting of two chaser spacecrafts and an expendable module with "deorbiting kits". One chaser is permanently docked to the module

to provide attitude control, electrical power, thermal regulation and communication with the ground stations. The other chaser undocks from the station to approach the target and performs active debris removal. After the rendezvous, capture, and stabilization of the debris, the chaser will attach the deorbiting kit to the target debris. The kit will then initiate a controlled reentry of the debris while the chaser returns to the station for servicing. The re-entry maneuvers in both mission concepts are based on the "design for demise" concept to align with the EcoDesign methodology. This project merges two innovative concepts in a mission: EcoDesign and a reusable station. Its implementation would not only lessen the increasing threat of space debris significantly but also reduce the negative environmental impact of the mission on Earth.