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RENDEZVOUS AND PROXIMITY OPERATIONS DESIGN OF AN ACTIVE DEBRIS REMOVAL SERVICE TO A LARGE CONSTELLATION FLEET

Abstract

Large constellation deployment in the Low Earth orbit (LEO) environment is on the way to change the paradigm of space resources exploitation in the next few years. Possible failures within constellation assets in orbit endangers the rest of fleet operations, particularly for constellations orbiting at an altitude that does not provide the required conditions for a natural re-entry. An Active Debris Removal (ADR) service is necessary for large constellation providers to ensure the long-term sustainability of the constellation. The ESA SUNRISE program, led by D-Orbit in collaboration with Politecnico di Milano, will provide an ADR service to LEO large constellations satellites. This work presents the design and analysis of the Rendezvous and Proximity Operations (RPO) to approach the uncooperative failed satellites of a large LEO constellation to be removed with a robotic capture strategy. In the design, the safety feature is considered of paramount importance to ensure the reliability and effectiveness of the autonomous proximity operations. The designed phases described in this work comprehend the far and mid-range rendezvous, the inspection fly-around trajectories, and the target preparation for capture. Within the latter, a solution of contactless detumbling using a plume impingement technique is considered to manage the situations where the failed satellite fast tumbling motion prevents the chaser from a safe synchronization to the grasping point. The far and mid-range rendezvous design is performed considering the analytical solution of the energy optimal guidance and control using impulsive manoeuvres using the relative orbital elements parametrisation. The two main features and focus of the far-mid range rendezvous are the trajectory safety, formulated considering the passive safety formulation in the relative orbital elements space, and observability improvement of the angles only navigation solution obtained with the manoeuvres planning. The inspection phase is developed considering fly around trajectories around to the target exploiting walking ellipses to guarantee passive safety. Lastly, the impingement control and the synchronisation forced motion are simulated, evaluating a trade-off between the two different operations depending on the target initial conditions. The simulations results are presented together with the preliminary delta-v budget allocated to the RPO phases.