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THE DIFFICULTY IN DESIGNING AN ACTIVE DEBRIS REMOVAL MISSION: RESULTS OF THE ESA'S E.DEORBIT DETAILED DESIGN PHASE – ESA'S DEBRIS REMOVAL MISSION

Abstract

The e.Deorbit mission is ESA's response to the increasing population of space debris in the most congested zones in Low Earth Orbit (LEO). The most effective way to stabilise debris population is to remove the large non-functional objects from the most populated orbits which are the source of small debris, and e.Deorbit's objective is therefore to remove one large ESA owned space debris (ENVISAT) from LEO in order to pave the way for future multi-debris removal missions and ADR (Active Debris Removal) business schemes such as space tugs. Capturing and deorbiting an uncooperative object is extremely challenging; such a mission has never been performed and requires a number of key technology advancements as well as many complex problems to be solved on system level.

This mission was first studied in ESA's Concurrent Design Facility (CDF) at ESTEC in 2012, with the knowledge that ENVISAT would be uncooperative during capture. Following this, three parallel and competitive phase A activities were initiated in 2015. In 2016, the first Detailed Design phase (B1) was studied with two separate competitive and parallel activities, followed by a 'Consolidation Phase' in 2017. This Consolidation Phase aims to prepare for the E.deorbit phase B2 second detailed design (called 'Maturation phase') in the period from end 2017 to end 2019.

The Detailed Design phase did not just do a detailed satellite design but aimed at risk mitigation in five domains: collision risk between the chaser and target, casualty risk on-ground, risk of unsuccessful capture, risk of debris generation, and risk of schedule delay. The contractors were given performance indicators for all give risks, and actions were defined to improve all performance indicators and hence mitigate all risks.

The study highlighted several complications though in achieving the risk mitigations, and this paper gives an overview of typical complications to overcome when designing an ADR mission, some of which became evident only when doing a detailed design. Examples are the implementation of passively safe approach and collision avoidance manoeuvres, risk mitigation due to communication blockages during capture, unknown attitudes of the debris, robustness to rapidly changing objects (e.g. Sun, Earth) in sensors field of view, load transfers induced on the chaser by heavy debris target, sloshing due to synchronized motions around the target, distribution of platform and guidance payload tasks within the avionics, antenna pattern interference, plume impingement, etc. will all be discussed in this paper.