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Author: Mr. Jaume Guasch
Cranfield University, Germany

Mr. Jacob Smith
Cranfield University, United Kingdom

CARLOS: CONCEPT FOR ACTIVE REMOVAL OF LOW-ORBIT SPACECRAFT

Abstract

The growth of debris in near-Earth space poses a risk for the operational life of in-orbit satellites. One of the modern challenges for the space community is to design sustainable solutions for Active Debris Removal (ADR) missions to restore Earth's orbital environment.

The design of an ADR mission in the context of ESA's Space Safety Programme (S2P) was proposed to a team of 16 students from Cranfield University which developed a low-cost concept to tackle this issue. The first phase of the project consisted of performing a feasibility study and an analysis of the space environment and the available options, where the target region, type of debris and de-orbit mechanisms were selected after multiple trade-offs.

Concept for Active Debris Removal of Low-Orbit Spacecraft (CARLOS) is the proposed solution, consisting of a pair of spacecraft, namely a de-orbiter and a mothership, that perform the sequential removal of 3 representative satellites (SPOT 6, Pleiades 1A and Pleiades 1B). This architecture allows the de-orbiter to perform a rendezvous and dock with the target by means of a robotic arm and a clamp, and then proceed to insert the target in a demise 700 km x 50 km orbit that will decay into the Earth's atmosphere. The mothership, staying in a parking 700 km orbit, acts as a refueling base for the de-orbiter. This modular approach allows for a more efficient use of the launch mass and higher flexibility if mission requirements change.

With a launch window in 2032 on board a Soyuz 2-1b, the pair of spacecraft has a dry mass of 398 kg for the de-orbiter and 421 kg for the mothership, and can remove a total of 2520 kg of space debris from the high-risk 700 km, 98.2^{o} orbital region. Some particular aspects of the mission are its low-cost approach (less than 50 million for the space segment), its design for complete demise at end of life, the dual-spacecraft design, the performance of refueling operations between them and autonomous de- and re-orbiting operations in the demise orbit.