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SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Technologies (5)

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ANALYSIS OF THE CONCEPT OF NON-COOPERATIVE TARGETS AND ASSOCIATED TAILORED ACTIVE DEBRIS REMOVAL METHODS

Abstract

Millions of space debris objects orbit the Earth, a threat to operational satellites and possible impact on our daily life. Related to the Kessler syndrome and associated research, the number of space debris is increasing and to make the space environment stable, about 5-10 large debris objects should be removed from space each year. However, space debris objects can vary widely in characteristics, such as rocket upper stages, non-operational satellites or residuals from explosions or collisions. In most cases, space debris objects are non-cooperative targets and, although rendezvous and docking to a cooperative target is a mature technology, capturing and de-orbiting a non-cooperative target is still a massive challenge.

In analyzing active space debris removal (ADR) methods, we have recognized that such methods and their application range depend largely on the characteristics of the non-cooperativeness of the objects and that the concept of non-cooperativeness is insufficiently understood. The objective of this paper is to critically research various levels of non-cooperativeness and define their characteristics and behaviors. Based on that understanding, we can then assigned the ADR methods to the different debris objects, which leads to a generic and efficient usage of ADR methods for certain problems.

We have grouped non-cooperativeness in terms of knowledge and capturability. Lack of knowledge leading to non-cooperativeness can be due to orbit and attitude information, physical properties, such as moments of inertia, or size, shape and surface properties but also intentional retention by the owner or legal and regulatory issues. Such lack of knowledge is also associated with specific timing aspects, as knowledge can e.g. be gained by in-orbit inspection. Non-cooperativeness in terms of capturability can be related to, e.g., possible docking locations, known but high spin rates or tumbling or, in the future, intentional standardized docking interfaces.

Following such a classification, we have mapped existing ADR methods to those classes of non-cooperativeness . The ADR methods are divided into several categories, including robotic arm, contactless methods, net capturing method and measure of increasing area to mass ratio. We did an analysis in a matrix to check whether the classification is helpful and obtained some interesting results. For example, the contactless methods could be more suitable for capturing debris with unknown attitude but known orbit information. Details of the results are presented in the paper.