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ASSESSMENT OF RULE-BASED OPERATIONS OF MANOEUVERS AVOIDING COLLISIONS BETWEEN ACTIVE SPACECRAFT

Abstract

The rapidly growing number of satellites in lower earth orbit especially due to constellations will lead to an increased number of conjunctions between operational spacecraft. The ability of both objects to perform active collision avoidance manoeuvres allows for greater flexibility in performing these but may also increase the risk of collisions in the case of insufficient communication, misinterpretation or an uncoordinated avoidance manoeuvre by both operators. Therefore, unlike conjunctions involving space debris, those collision avoidance operations require a coordinated action between two satellite-operators. Precise and accepted rules have to be defined on how the manoeuvres are performed and especially what spacecraft has to evade. The implementation of such rules will allow the application of automated processes, which are essential to allow the efficient handling of the ever-growing number of conjunctions.

As part of ESA's Space Safety Programme the cornerstone component "Collision Risk Estimation and Automated Mitigation (CREAM)" encompasses the development of techniques for automated manoeuvre decisions, concept studies and protoflight developments for the use of Signal-in-Space commanding, development of techniques and protocols supporting manoeuvre coordination between operators and aims at testing these techniques with a demonstration mission.

Different collision avoidance rules and the implications of their application are examined in the "Rules4CREAM" activity at the Technical University of Darmstadt to help shaping the future evolution of CREAM. Therefore, different sets of rules were defined, based on various parameters like the conjunction geometry or the mission type. For the generation of a representative number and distribution of conjunctions, a large-scale orbit-simulation is implemented, considering typical satellite operations, perturbations, as well as the availability of orbit-data for operators. Different future scenarios are simulated, based on current and expected trends in growth and distribution of the satellite population. Different levels of inter-operator communication are considered in the simulation.

Based on the generated conjunctions the defined rulesets are analysed. Models to calculate the expected lifetime reduction due to fuel loss and mission downtime for each satellite are implemented. The effects of different scenario-parameters, for example the total number and distribution of different satellite-classes and the existence of a shared catalogue is examined. The goal of the project is to identify promising rulesets and defining necessary requirements and relevant constraints for future inter-operator processes. In this paper the technical approach and results of Rules4CREAM are presented as well as a status update of the CREAM cornerstone of ESA's Space Safety Programme.