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FIRST RESULTS OF ESA'S COLLISION RISK ASSESSMENT AND AUTOMATED MITIGATION PROGRAMME

Abstract

Collision avoidance is an integral part of spacecraft operations today. It is essential for safeguarding own assets as well as preventing the proliferation of orbital debris. However, there are numerous apparent developments which challenge the way collision avoidance is currently carried out. With more spacecraft and constellations being launched, the number of conjunction events between two active spacecraft is increasing and requires coordination between the operators. The fact that low thrust propulsion systems are more frequently used, creates additional demands for ephemeris screenings and direct exchange between operators. The performance increase of existing surveillance networks and the availability of additional and commercial catalogue providers lead to an overall increase of conjunction notifications, yet also raise the issue of data fusion to properly assess the event.

In order to tackle these fundamental changes to the operational collision avoidance service, ESA, through the Space Safety Programme, created the cornerstone "Collision Risk Estimation and Automated Mitigation (CREAM)". The main objectives of CREAM are (a) to reduce manpower efforts and increase automation, (b) to shorten the time between decision and time of closest approach, and (c) to reduce the number of false alerts. Over the past two years, three main projects have been started and are currently ongoing, framed by several support activities. In this paper we present the current status and (preliminary) results of these activities.

A first element of the paper explores the possibilities for increasing automation and gaining time to delay the final decision whether to perform a collision avoidance manoeuvre or not, to the last moment. In this regard, we analyse concepts of shifting parts of the processing steps for collision risk assessment to on-board of the satellite (e.g. the orbit determination and prediction). On the other hand, late commanding/cancellation options are studied for effective collision mitigation.

We present the prototype of a coordination platform with web front-end and API access. The design is driven by the three pillars trust, coordination and future-proof architecture. This ensures that key elements of a future coordination system are respected: data confidentiality (trust by design), data credibility (validation), secure communication and data exchange, distributed ledged technology (tamper resistant audit trail), coordination protocols, operational simplicity (usability), anomaly handling, scalability, extensibility, compatibility with existing tools, and system robustness.

We show the possibilities of machine learning for predicting the outcome of a conjunction event. After preparing a training data set from millions of conjunction data messages, different regression and classification neural network models have been analysed. Albeit sharing the same goal, to predict the last state, the collision probability and the uncertainty prior to time of closest approach, the trained models are evaluated upon their performance to identify critical events early on and consider it as pre-selection for possible late or on-board decisions.