Critical Conjunction Detection and Mitigation

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ABSTRACT

The German Space Operations Center (GSOC) has been performing collision avoidance operation since 2009. Additional to the operational satellites currently 5 in LEO and 2 in GEO, conjunction monitoring and mitigation for several satellites in LEO and MEO are also supported, which are operated by other organizations or ended the operation phase. The Conjunction Data Message (CDM) provided by the US Strategic Command (USSTRATCOM) is currently the main source for the collision risk assessment against space objects due to the quality and timeliness of the available information.

In the collision avoidance operation, numerous conjunctions are reported daily, which were detected within certain thresholds. Early detection of possible critical conjunctions among all predicted events is therefore important to handle critical situations promptly and efficiently. In the collision risk assessment, the collision probability is one of the key parameters for the criticality evaluation, which can be used for a detection of possible critical events or an avoidance maneuver decision. Therefore the threshold of the collision probability shall be defined carefully to handle conjunctions in different conditions, i.e. hitradius, orbit accuracy, approach geometry, orbital region.

When a critical conjunction is detected, the collision risk shall be closely analyzed and an avoidance maneuver shall be planned carefully if necessary to reduce the risk below a certain criteria. The typical collision avoidance maneuver is to increase the radial separation by an in-track thrusting half an orbit before the closest approach. A certain separation can be achieved in a short period and also with a relatively small maneuver in this way. Additionally, the satellite can easily come back to the nominal orbit shortly after the closest approach. However, the maneuver selection to reduce the collision risk depends also on other conditions, such as ground contacts, the satellite maneuver plan, and last but not least an avoidance of encountering other objects. In addition, a maneuver planning for some specific cases like multiple encounters of a single object shall be taken into account. A capability of the maneuver trade-off is therefore required, which enables an operator to decide an appropriate avoidance maneuver for different scenarios in a quick way.

In this paper, the criteria for the critical conjunction evaluation are first discussed, showing the results of the probability threshold analysis and examples of past conjunctions handled for the operational satellites. The maneuver planning process for a critical conjunction is then presented, together with the operational maneuver planning tools and its application to several conjunction cases. The paper concludes with a discussion of the critical conjunction detection and mitigation process, which is applicable in the operation, and suggestions on further improvements.