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GEO SATELLITE CONJUNCTION ANALYSIS AND COLLISION AVOIDANCE STRATEGIES

Abstract

In recent years, as satellites and debris have increased, the risk of space collisions has increased dramatically. On February 10, 2009, the collision between IRIDIUM-33, a US communications satellite, and KOSMOS-2251, a Russian military satellite, became a real risk factor. Space Situational Awareness (SSA) has become a very important issue in satellite operations to protect satellites from such collisions. Some countries use optical and radar equipment to collect orbital information of a space object approaching its satellites. However, satellite conjunctions are typically known by receiving a Conjunction Data Message (CDM) from Joint Space Operations Center(JSpOC). More detailed conjunction analysis and collision avoidance maneuvers(CAM) are then performed using calculated owner satellite orbit information. Especially, since geostationary satellites operate in a limited space, conjunction analysis and collision avoidance maneuver strategies are important. There are three orbit types of space object approaching to geostationary satellite. The first is a geostationary satellite in a nearby location. This satellite is operated by another organization and could not perform the scheduled station-keeping maneuvers. The second is an Inclined Geosynchronous Orbit (IGSO) satellite that can't maintain the north-south station keeping due to fuel shortage. IGSO satellite has some value of inclination angle and is a trajectory that passes through the geostationary orbit twice a day. The third is a Geosynchronous Transfer Orbit (GTO) object which is orbit of rocket body used for launching geostationary satellites. Since the GTO has an orbital period of 10.5 hours, it also passes through a geostationary orbit twice a day.

In this paper, conjunction analysis is performed in respectively for the three orbits of space object approaching the geostationary satellite mentioned above and possible collision avoidance maneuver strategies are designed. In the conjunction analysis stage, mutual distance between the two object is calculated in radial, along-track, and cross-track directions near the Time of Closest Approach (TCA). For a collision avoidance, the CAM strategies are divided into two methods. One is by varying the maneuver start time from 12 hours to 3 hours before TCA, the other is by changing maneuver direction in an along-track or cross-track. The final CAM strategies are derived in considering the minimum delta-velocity and maximum separation. The collision avoidance maneuvers are performed for three different cases of the conjunctions and the mutual distances before and after TCA are analyzed.