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ON-LINE COLLISION HAZARD ASSESSMENT FOR FRACTIONATED SATELLITE CLUSTERS WITH PROXIMITY RELATIVE MOTION

Abstract

The implementation of a multiple-satellite cluster, coordinated to act as a single "virtual" satellite, has become an important research area recently. A concept called System F6 has been proposed by DARPA and TTO. The key advantage of this concept is the ability to respond to uncertainty. Compared with a single, monolithic spacecraft, a fractionated free-flying spacecraft does not require accurate position or attitude maintenance if the relative distance does not exceed the allowed range, and a collision does not occur. The main motive of this paper is to propose an effective method for on-line collision hazard assessment for fractionated satellite clusters with proximity relative motion. It is difficult and unnecessary to calculate the complete collision probability because the encounter conditions are always changing with the varying relative motion. Until now, most researchers have focused on collision risk for the worst case; i.e., the exact minimum distance or the maximum instantaneous collision probability (ICP). Essentially, the existing methods only depend on the "static" parameters at a specific time, such as the relative position error covariance, the relative position and the equivalent enveloping solid. However, it is obvious that the collision risk when approaching is larger than when separating at the same position. Furthermore, the impact factors for cluster flight safety are complex and various, including the collision avoidance control capability, the relative navigation orientation rate, the communication system performance and even the reliability of all subsystems in a cluster. Therefore, it is necessary to introduce system performance parameters into the collision hazard assessment for fractionated satellite clusters. The present work analyzes several issues for two common methods of collision risk assessment at a certain time for satellites. Given the characteristics of fractionated satellite clusters with proximity relative motion, a new on-line collision hazard assessment method based on performance parameters is presented. Dynamic enveloping solids for each module are introduced to adapt to different encounter modes. Simulation results show the capability of this method to satisfy the real-time requirement for hazard assessment in each module during a short-term maneuver based on the introduced performance parameters.