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AVOIDING COLLISIONS IN SPACE VIA AERODYNAMICALLY-INDUCED ALONG-TRACK ORBIT VARIATIONS

Abstract

The increasing number of actors in space has led to an increased risk of on-orbit collisions. Predictions have shown that if action is not taken to mitigate the risks of collisions in space, the additional debris resulting from these collisions may render space unusable for generations to come. This reality necessitates that future spacecraft take an active role in debris mitigation and collision avoidance instead of contributing to the problem.

Large satellites containing propulsion systems have utilized thrusters to actively avoid debris objects as well as to perform post-mission disposal burns. However, many small satellites such as CubeSat do not contain propulsion systems and generally do not perform active collision avoidance or post-mission disposal. Drag devices have been developed for small satellites to expedite post-mission de-orbit, but the significantly increased surface area from a drag device greatly increases the risk of an on-orbit collision per unit time. For satellites containing retractable drag devices such as the Drag De-Orbit Device (D3) developed at the University of Florida, aerodynamic drag modulations can be used for active collision avoidance, mitigating the increased collision risk caused by the larger surface area.

This paper discusses a means of calculating the necessary drag profile for active collision avoidance that can be applied to any satellite capable of modulating its ballistic coefficient. An analytical solution is first developed relating changes in the drag profile of a satellite to perturbations in the future orbit of the satellite. This analytical solution is then used to estimate the ballistic coefficient profile a satellite must follow to achieve a desired miss distance from an impending collision with the minimum amount of time spent maneuvering. Numerical methods and a high-fidelity orbit propagator are utilized to refine this estimate. This paper also presents an analysis of the aerodynamic collision avoidance capabilities of a satellite based on its orbital regime and drag modulation capabilities. In the perceived application of this theory, a satellite operator receives a conjunction notice indicating a potential collision several days in the future. Based on a risk assessment, the satellite operator determines a desired miss distance from the debris object and uses the aforementioned theory to compute and apply the drag modulation necessary to achieve this orbit adjustment with minimal interruptions to nominal satellite operations.