Collision Avoidance Management for Earth Observation Constellation Missions

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ABSTRACT

Effective and efficient constellation management consists of more than managing multiple, independent spacecraft. There are requirements at the constellation level that must be maintained, for example, keeping all of the spacecraft within the same orbital tube, managing global daily average access, or maintaining the phasing of the constellation to ensure revisit times are maximized across the constellation. At the same time, each of the spacecraft within the constellation have finite resources, such as propellant, that must be managed to ensure they are spent evenly across the constellation to prevent premature depletion on one or more individual spacecraft.

These additional challenges in managing constellation missions create the need for a risk mitigation/operations support tools for Earth Observation satellite constellations, such as the Canadian Space Agency’s RADARSAT Constellation Mission (RCM). RCM, with three spacecraft at an altitude with a high concentration of other orbiting objects, expects to be subject to relatively frequent collision avoidance (COLA) manoeuvres compared to previous RADARSAT missions. In addition, RCM is required to maintain the orbital requirement of staying within a tube of +/- 100 m around a reference orbit. Maintaining this tube will inherently require a large number of manoeuvres before taking COLA manoeuvres into account. Thus, for off-nominal events like COLA manoeuvres, mission operators must be able to plan burns and recover the spacecraft to nominal operations quickly, while keeping to the tube requirement and preserving consumables like fuel. To this end, MDA has recently developed the Constellation Management Tool (CMT) for the Canadian Space Agency (CSA) within the Space Technology Development Program.

Using knowledge of the RCM concept of operations for standard orbital tube maintenance, MDA developed an algorithm for recovery of the orbital tube after a COLA manoeuvre. The CMT application ingests a tradespace of COLA manoeuvres from the CSA-developed Collision Risk Assessment and Mitigation System (CRAMS). The CMT filters the CRAMS manoeuvre tradespace for a user-defined probability of collision and miss distance, then uses the new algorithm to determine optimal recoveries for each candidate COLA manoeuvre.

Ultimately, CMT provides an assessment of the CRAMS tradespace, including tube recovery options, based on various optimization criteria. This can provide a useful tool in the operational COLA process in the light of frequent tube maintenance manoeuvres and constellation considerations.