Paper ID: 99038
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23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation - SST (9)

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CHARACTERISING SATELLITE CONJUNCTION "WALK-INS" FOR ENHANCED COLLISION PREDICTION AND SPACEFLIGHT SAFETY

Abstract

The rapid increase in the number of objects in Low Earth Orbit (LEO) has significantly heightened the risks posed by orbital debris, necessitating an operational transition from passive observation to proactive characterization strategies. Among the most critical risks are "walk-in" sequences, where two objects in near-circular orbits progressively approach each other, often resulting in high-probability conjunction events. Understanding these sequences enables early collision detection, allowing smaller, more efficient manoeuvres that reduce operational costs, prevent debris generation, and mitigate the cascading risks of Kessler Syndrome, ensuring the long-term safety of orbital operations.

Examining the percentage of high-probability conjunctions preceded by precursor events within critical miss distances reveals opportunities for improving collision predictions. Leveraging these precursor conjunctions allows operational spacecraft to refine the in-track or cross-track uncertainties of secondary objects using advanced sensing systems. Integrating autonomous Attitude Determination and Control Systems (ADCS) with walk-in sequence data provides an approach that enhances the ability to anticipate high-risk conjunctions, streamline collision avoidance strategies, and reduce manoeuvring demands. Case studies will be analysed to characterise and categorise these events, identify consistent patterns, and improve predictive accuracy for close approaches. This combination of in-orbit capability and predictive walk-in frameworks supports measures to mitigate the increasing risks of orbital debris collisions and secure the long-term reliability and functionality of the orbital environment.