Introducing MISS, a new tool for collision avoidance analysis and design

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ABSTRACT

Technical and organizational requirements for Space Situational Awareness (SSA) and collision avoidance activities are steadily increasing alongside the growing use of space-based assets. This affects a wide range of topics, from policy aspects such as the new guidelines under development by the Inter-Agency Space Debris Coordination Committee, to the continuous improvement and introduction of SSA capabilities like the Space Fence. Already in testing mode, this new tracking and monitoring system developed by Lockheed Martin for the US Air Force will improve accuracy and allow to follow objects significantly smaller than the previous 10 cm limit. From the operational point of view, recent reductions in the cost of access to space, spurred by increased competition in the launch market and new cost-effective platforms, together with the proposed deployment of large mega-constellations will naturally lead to an increase in the number of close approaches. In this context, operators will not only have to decide if and how to perform a collision avoidance manoeuvre (CAM), but also do so minimizing the risk of additional close approaches down the road. An additional degree of flexibility (and complexity) comes from the growing variety of propulsion systems. Many current satellites complement or substitute traditional impulsive thrusters with low-thrust electric propulsion systems or others like sails and tethers. Put together, these elements define an increasingly complex scenario for satellite operators, who require fast and reliable tools for the analysis of potential conjunctions and the design of CAMs.

Gathering recent advancements in CAM analysis and design, the MISS (Manoeuvre Intelligence for Space Safety) software tool has been introduced to provide an integrated approach to SSA-related operational activities. MISS is developed within the ERC-funded project COMPASS (Control for Orbit Manoeuvring through Perturbations for Application to Space Systems), which studies orbital perturbations and how they can be leveraged for mission design. The tool provides a holistic approach to CAM design, considering both impulsive and continuous, low-thrust manoeuvres (including not only electric thrusters, but also other devices such as sails). Several design strategies are considered, mainly maximizing miss distance or minimizing collision risk, and physically-significant interpretations of the CAM are provided by leveraging the b-plane representation. Analytic and semi-analytic techniques are exploited to provide a fast and flexible tool. Particularly, the use of state transition matrices (STMs) allows for the fast propagation of uncertainties and to perform extensive sensitivity analyses over different parameters of the close approach and the spacecraft (e.g. area to mass ratio or drag and reflectivity coefficients). Whenever possible, STMs are computed analytically; in the rest of cases, they are obtained through the semi-analytic propagation of the single-averaged variational equations using PlanODyn.

In this talk we will introduce the core aspects of MISS and show its performance through several test cases based on actual operational data.