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Orbit Determination and Propagation - SST (9)

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ORBITAL PROPAGATION CHALLENGES AND SOLUTIONS FOR SST FRAGMENTATION SERVICES

Abstract

Space Surveillance and Tracking (SST) operations encompass a wide range of activities: from sensor tasking, orbit determination, correlation and cataloguing of space objects, to in-orbit fragmentation events modeling and conjunction analysis (Flohrer, T., 2017). In all these applications, orbital propagation plays a prominent role. Accuracy in predicting positions and velocities of the objects orbiting the Earth is crucial to carry out SST tasks as effectively as possible. However, each application poses different constraints in terms of accuracy and computational time. Hence, the capability to tune orbital propagators on specific application requirements may allow improving the global efficiency of SST services. The proposed paper discusses these challenges and presents an adaptive orbital propagation environment integrated in a modular architecture and developed for fragmentation modeling and collision risk assessment. Within this framework, the tool is exploited together with break-up simulation based on the popular NASA EVOLVE 4.0 model (Johnson, N. L., 2001). While classic settings, such as the included orbit perturbations and the error tolerance of the numerical solver, strongly influence the speed and the theoretical accuracy of the propagations, the latter is also impacted by the uncertainties in fragments parameters and their evolution. In case of a possible collision event, high accuracy propagation is used to propagate the trajectories of the parent objects from the epoch of the last available Two Line Elements (TLE) up to the predicted break-up event epoch. The event is then modeled using EVOLVE 4.0, and the fragments are propagated with particular attention to the computational burden relevant to the possibly large number of objects.

Fragments propagation can also be exploited in the case of real fragmentation events. In both cases (simulated and real fragmentation) the main scope is relevant to sensor tasking and collision risk assessment. In the latter application, challenges arise concerning the uncertainties on the propagated trajectories of the fragments. Thus, the proposed paper also discusses the interface of fragments propagation with risk assessment techniques conceived for large number of objects and relatively long timescales such as Cube and Orbit Trace methods. Propagation results are analyzed using the NASA's General Mission Analysis Tool (GMAT) for simulated data, while the tool is also tested on real fragmentation events in collaboration with the Italian SST Operations Center (ISOC).