Paper ID: 19299
student

SPACE DEBRIS SYMPOSIUM (A6)
Poster Session (P)

Author: Mr. Alessandro Morselli
Politecnico di Milano, Italy, alessandro.morselli@polimi.it

Dr. Roberto Armellin
Politecnico di Milano, United Kingdom, roberto.armellin@soton.ac.uk
Dr. Pierluigi Di Lizia
Politecnico di Milano, Italy, dilizia@aero.polimi.it
Prof. Franco Bernelli-Zazzera
Politecnico di Milano, Italy, franco.bernelli@polimi.it

THE USE OF B-PLANE IN SHORT-TERM AND LONG-TERM ENCOUNTERS

Abstract

The aim of this paper is to verify analytically the assumption of rectilinear relative motion for close encounters between two resident space objects. For high relative velocity, the duration of the encounter is a few seconds, hence collision probability is reduced to a two-dimensional integral projecting the combined covariance matrix on the B-plane. This assumption is not valid for encounters at low relative speed, which typically occur in the geostationary ring or in medium Earth orbit. The relative position and velocity vectors are numerically integrated using Differential Algebra, implemented in the language COSY-Infinity, to obtain their high order polynomial approximation as a function of the uncertain initial position and velocity of the two objects and, thus, the Taylor expansion of their time of close approach (TCA). A gravitational model of degree 10, including accurate models for atmospheric drag, third body perturbation and solar radiation pressure (with dual cone shadow) are considered. Using partial inversion techniques and differential algebraic tools, the Taylor expansion of the TCA is obtained and plugged in the maps of relative position and velocity vectors. In this manner, the polynomial approximation of these two vectors components as a function of both objects initial orbital states is obtained. The initial positions and velocities are sampled according to their statistical distribution and are propagated to TCA by evaluating the resulting polynomial approximations. Since the B-plane is defined as the plane perpendicular to the relative velocity vector at TCA and containing the relative position, the above distributions are a measure of the effectiveness of the rectilinear motion approximation. A set of close approaches is selected for numerical validation, ranging from high velocity encounters in LEO to very low velocity encounters in GEO. The statistical distribution of the relative velocity and position vectors is computed by means of Monte Carlo simulations, first considering uncertainties on initial positions of the two objects only and then both uncertain initial positions and velocities. The sample distribution on the B-plane is also obtained to check whether it can still be considered Gaussian after days of propagation with an accurate numerical simulator.