Long Term Orbit Propagation Using a Semi-analytical Theory Numerical Test Case for Space Debris

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The current scenario of Space Situation Awareness imposes demanding requirements in orbit propagation techniques. According to Inter-Agency Space Debris Coordination Committee, there are about 170 million space debris objects, 98% of them in Low Earth Orbit (LEO, altitude less than 2000 kilometers).

Space debris surveillance requires fast and precise orbit predictions for the great amount of objects which orbit the Earth. Semi-analytical theories for orbit propagation are very efficient tools for precise determination of orbits, which reduce considerably the computational cost in comparison with analytical or numerical standard techniques of orbit propagation.

In this work, an analysis of the short period perturbation effects in the orbital elements, used as initial conditions in a semi-analytical orbit propagation, is performed. We use the Draper Semi-Analytical Satellite Theory developed in the Massachusetts Institute of Technology [1].

The data used in the simulations has been obtained from the Final Orbits of the International GNSS Service [2, 3]. The transformations from the International Terrestrial Reference System to the Geocentric Celestial Reference System have been done using the Standards of Fundamental Astronomy from the International Astronomical Union [4, 5].

The simulation results, performed for different combinations of initial conditions, show how differences between the semi-analytical prediction values and the values obtained from the International GNSS Service are reduced when orbital elements with filtered daily-periods are used as initial conditions (see Table 1).

Table 1: Differences between IGS final orbit and the semi-analytical propagated orbit for different initial conditions.

Orbital Element	Maximum Difference	Minimum Difference
Semi-major axis (km)	7	0.286
Eccentricity (rad)	3×10^{-3}	9.76×10^{-5}
Inclination (deg)	0.037	0.032
Argument of the perigee (deg)	6	0.8
Ascending node right ascension (deg)	0.011	0.002

The minimum differences correspond to diurnal filtered initial conditions.

References

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