Paper ID: 27405
oral

66th International Astronautical Congress 2015

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (4)

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INTERMEDIARY ORBIT PROPAGATION INCLUDING HIGHER ORDER ZONAL HARMONICS

Abstract

Intermediary orbits provide alternative analytical solutions to the artificial satellite problem. They are free from the essential singularity at the critical inclination, and are valid for any eccentricity below 1. According to recent claims, evaluation of intermediary orbits may be competitive to standard numerical integration of simplified models and is clearly faster than usual analytical solutions as Brouwer's one [1]. Hence, intermediary orbits can be very useful in providing satellite navigation solution for short time spans, as is the case of common onboard orbit propagators in the case of GPS outage.

Common intermediary orbits are constrained to capture only effects of the first order of J2, the earth's zonal harmonic of the second degree. However, it is known that the uncertainty introduced when neglecting second order periodic effects of J2 in the computation of initial conditions (which is of several meters for low earth orbits) is one of the most important source of errors in short-term propagations [2]. Hence, the inclusion of higher order periodic effects seems imperative for extending the validity of the intermediary solution to one or several orbit periods. The use of natural intermediaries, which are integrable after a contact transformation, may allow to include some of the second-order effects of the gravitational potential in the analytical solution, in this way notably improving the intermediary predictions.

We present an intermediary solution that includes the earth's gravitational effects of J2–J5. The uncertainties in the computation of initial conditions are then lowered to the centimeter level, in this way providing ephemeris predictions of acceptable accuracy in time spans of the order of one to several weeks. Because of the negligible power used in the evaluation of the intermediary solution, it may be useful even for the standard implementation of smartphone apps.

[1] Gurfil P., and Lara, M., Celest. Mech. and Dyn. Astron., Vol. 120, num. 2, 2014, pp. 217–232.

[2] Lara, M., presented at the workshop KePASSA 2014, Logrono, Spain, April 23–25, 2014 (arXiv: 1406.2200v1 [math.DS]).