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Author: Dr. Elena Fantino
Khalifa University of Science and Technology (KUST), United Arab Emirates

Dr. Roberto Flores
International Center for Numerical Methods in Engineering (CIMNE), Spain
Ms. Amna Adheem
Khalifa University of Science and Technology (KUST), United Arab Emirates

ACCURATE AND EFFICIENT PROPAGATION OF SATELLITE ORBITS IN THE TERRESTRIAL GRAVITY FIELD

Abstract

Fast and precise propagation of satellite orbits is required for mission design, orbit determination in support of operations and payload data analysis. This demand must also comply with the different accuracy requirements set by a growing variety of scientific and service missions. This contribution proposes a method to improve the computational performance of orbit propagators through an efficient numerical integration that meets the accuracy requirements set by the specific application. This is achieved by (1) appropriately setting up the numerical propagator (relative tolerance and maximum time step), (2) establishing a threshold for the perturbing accelerations (Earth's gravitational potential, atmospheric drag, solar radiation pressure, third-body perturbations, relativistic correction to gravity) below which they can be neglected without altering the quality of the results and (3) implementing an efficient and precise algorithm for the harmonic synthesis of the geopotential and its first-order gradient (i.e., the gravitational acceleration). In particular, when performing the harmonic synthesis, the number of spherical harmonics to retain (i.e., the expansion degree) is determined by the accuracy requirement. Given that higher-order harmonics decay rapidly with altitude, the expansion degree necessary to meet the target accuracy decreases with height. To improve the computational efficiency, the number of degrees to retain is determined dynamically while the trajectory is being computed. The optimum expansion degree for each altitude is computed by ensuring that the truncation error of the harmonic synthesis is below the threshold acceleration. The work is a generalization to arbitrary orbits of a previous study that focused on communication satellites in geosynchronous inclined orbits. The method will be presented and a set of test cases will be analysed and discussed.