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EFFECTIVENESS OF KS ELEMENTS IN ORBIT PREDICTION USING EARTH'S GRAVITY, DRAG AND SOLAR RADIATION PRESSURE

Abstract

Predicting the orbit of a satellite is a fundamental requirement in many areas of aerospace, such as mission planning, satellite geodesy, re-entry prediction, maneuver planning, collision avoidance, and formation flying. The major perturbations which affect the orbit of a satellite are the non-spherical gravitational field of the earth, atmospheric drag, solar radiation pressure, third-body gravitational effects, etc. For near-Earth orbits, the forces due to the non spherical nature of the Earth and atmospheric drag play an important role. Whenever, the satellite is in high altitude (above 600 km) the solar radiation pressure is more important than the atmospheric drag. Thus inclusion of the effect of these perturbing forces becomes important for precise orbit computation of near-Earth orbits. To predict the motion of the orbit precisely a mathematical representation for these forces must be selected properly for integrating in the equations of motion. The classical Newtonian equations of motion, which are non linear are not suitable for long-term integration for computing accurate orbit. Many transformations have emerged in the literature to stabilize the equations of motion either to reduce the accumulation of local numerical errors or allowing the use of large integration step sizes, or both in the transformed space. One such transformation is known as KS transformation by Kustaanheimo and Stiefel, who regularized the nonlinear Kepler equation of motion and reduced it into linear differential equations of a harmonic oscillator of constant frequency. The method of KS elements has been found to be a very powerful method for obtaining numerical solution with respect to any type of perturbing forces, as the equations are less sensitive to round off and truncation errors. The equations are everywhere regular comparing to the classical Newtonian equations, which are singular at the collision of two bodies. Numerical studies with these equations were carried out using Earth's zonal harmonic terms, drag and solar radiation pressure. In this paper a detailed study is carried out for orbit prediction using KS differential equations by including the non spherical gravitational potential (zonal and tesseral harmonic terms) of the Earth, atmospheric drag and solar radiation pressure as perturbing forces. Higher order Earth's gravity (zonal and tesseral) terms are included by utilizing the recurrence relations of associated Legendre polynomial and its derivatives. To know the effectiveness of the theory, the results are compared with some of the existing theories in literature and real satellite data.