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Author: Mr. Deepak Gaur
Amity School of Engineering, India, deepakgauraerospace@gmail.com

ANALYSIS OF CLOSE PROXIMITY OPERATIONS IN NEAR-EARTH ELLIPTICAL ORBITS

Abstract

Proximity operations is a component of nearly every Earth-orbiting spacecraft mission. This may come in the form of formation flying, docking with another spacecraft, collision avoidance (COLA) or conjunction, or simply intercepting the desired satellite orbit without the presence of another satellite. The behaviour between two closely orbiting objects is such a common problem, mission designers solve that it is essential for them to develop intuition regarding the relative motion of these objects. One tool that is commonly used to build this intuition is the Clohessy-Wiltshire (CW) equations. These equations represent the motion of a "deputy" satellite relative to a "chief" satellite for circular, close-proximity orbits. This enables quick, back-of-the-envelope calculations to determine relative positioning after some time or determine the magnitude of an impulsive maneuver, or V, necessary for the two satellites to rendezvous. A major drawback of these CW equations is that they are only applicable for circular orbits, and there is no such thing as a perfectly circular orbit in practice. This analysis focuses on evaluating the domain of eccentricity that the CW equations still provide sufficiently accurate relative motion approximations as well as investigate an alternative, the Tschauner-Hempel (TH) equations, which do not constrain the problem to circular orbits.