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USEFUL ALTERNATIVE PARAMETERIZATION OF AN ORBITAL STATE VECTOR WITH APPLICATION TO FORMATIONS OF LEO SATELLITES

Abstract

A group of LEO satellites in a formation is subject to various environmental forces that affect the orbital motion of the satellites in an undesired manner. Thus, differential drag and differential gravitational forces may generate a secular drift among the satellites. The design of orbital maneuvers, as a part of a formation control algorithm, is often based on a set of constraints that are imposed on the satellites motion. A standard approach to formulate these constraints is by imposing a set of equations among the mean orbital parameters of the satellites. For a control algorithm which accounts for the first-order geopotential perturbations due to Earth oblateness, this parameterization provides analytical simplicity, since at this accuracy level the mean (a, e, i) semi-major axis, eccentricity , and inclination are constants. However, the design of orbital maneuvers, often entails an additional cumbersome transformation to the corresponding osculating parameters, as these parameters are directly related to the satellite instantaneous state vector. Yet, the osculating parameters are time dependent and so they do not share the Keplerian-like simplicity of their corresponding constant mean parameters. In this talk, an alternative parameterization scheme that can simplify calculations of LEO formation control, at the $O(J_2)$ level of accuracy, is presented. This parameterization was previously employed in the analysis of the motion of a small object around a black hole. Similar to the mean parameters these alternative parameters are constant at the level of first-order $O(J_2)$ perturbations; and similar to the osculating parameters they are directly related to the instantaneous Cartesian state vector in a simple manner. Therefore, they provide a parameterization scheme that can simplify an otherwise more cumbersome maneuver calculations. In this talk, this simplification is illustrated by constructing an analytical expression for a two burns optimal orbital maneuver, which is useful for the control of a LEO formation. The resultant maneuver, is analogues to the Hohmann transfer and also accounts for the first order $O(J_2)$ geopotential perturbations.