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# A CLOHESSY-WILTSHIRE BASED TOOL FOR THE PRELIMINARY OPTIMIZATION OF LOW-THRUST ORBITAL MANEUVERS

**Abstract**

This paper present a novel technique for the numerical approximation of the Clohessy Wiltshire (CW) equations in the case of non-impulsive constant acceleration maneuvers, such as the case of electrical propulsion operations with negligible propellant consumption with respect to the satellite mass.
First, a comparison with existing techniques for low thrust formulation is presented; at today, theoretical work on the mathematical description of constant accelerated non-Keplerian orbits has been performed but few applicative studies have been proposed. Therefore, a novel formulation in the CW frame is proposed, introducing non-dimensional parameters for the analysis of orbital maneuvers generalized problem; the parameters represent the equivalent true anomaly and the equivalent thrust and total impulse normalized with respect to the initial and final orbit characteristics. This allows to have a preliminary assessment tool for fuel optimization which can be particularized for the mission under analysis. As far as the authors are concerned, no such tool is currently available for preliminary mission evaluation.
The proposed set of modified CW equations is employed for the analysis of two reference cases: an optimal re-entry trajectory and a more general, two-impulses maneuver. In the first scenario, we optimize the fuel consumption of the maneuver once the re-entry orbit's altitude has been set; the problem can be solved analytically and yields an elegant, non-dimensional expression.
In second scenario, we extend the analysis to the case of a more general two-pulses maneuver (such as, for example, a change of orbit): in this case, the problem complicates due to the additional constraints imposed by the initial and final velocity vectors. The optimization problem is solved numerically and we demonstrate how a solution always exist under certain boundary conditions.
In both cases, the modified equations are compared against the traditional formulation. The errors arising from the approximation taking place in our model are proved to be negligible, especially under the hypothesis of low-thrust, pseudo-constant mass vehicles. Ultimately, this work provides a simplified tool for fuel optimization in orbital maneuvers for preliminary orbital dynamics assessment.