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LOW THRUST AUGMENTED SPACECRAFT FORMATION FLYING FOR ON-ORBIT INSPECTION

Abstract

Communications satellite operators stand to generate considerable extra revenue from extended spacecraft lifetimes offered by on-orbit inspection, refuelling and repairs, and as such there is a clear commercial demand for developments in this area. Although the concept of on-orbit inspection has been explored in the past, the advent of modern low thrust propulsion enhances the capabilities of an inspection spacecraft and provides access to rich new families of low thrust augmented formation flying trajectories. With low thrust, an inspection spacecraft's relative motion can be actively forced to enable operationally advantageous new classes of non-Keplerian inspection orbits. Using the Clohessy-Wiltshire equations in a rotating frame, two-spacecraft formations are developed to facilitate new modes of on-orbit inspection. It is first demonstrated that low thrust propulsion can modify the period of the (decoupled) out-of-plane motion, producing a complex new family of orbits relative to the target spacecraft for visual inspection. Non-Keplerian orbits are then used to produce continually displaced inspection trajectories, while a method is developed for patching families of displaced non-Keplerian orbits, and indeed Keplerian orbits, in the rotating frame. Low thrust orbits are also developed for Sun-vector tracking, to provide a constant Sun aspect angle in the rotating frame, providing constant illumination of the target spacecraft for visual inspection. Finally, forced relative orbits are considered for a range of propulsion technologies including impulsive, electrostatic, and solar sail propulsion, and it is found that the thrust and propellant requirements for a small inspection spacecraft are modest and well within the capabilities of existing propulsion technology, for geostationary satellite inspection applications.