IAF ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (7)

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SMALL SATELLITES CO-ORBITING AROUND A LAGRANGE POINT 1 SPACE STATION

Abstract

The orbital mechanics and control of multiple satellites at Lagrange point L1 between Sun and Earth are studied in this paper. A 5000kg spacecraft (referred to as space station) sits at L1 while multiple smaller satellites (e.g. CubeSats) co-orbit around the space station. Thus, the problem extends the three-body problem (Sun, Earth and space station) to a four-body problem (Sun, Earth, space station and a CubeSat). New Lagrange points are found to be approximately 100m either side of L1. Orbits around the space station less than 100m are analysed using a method similar to Hill's expansion in the Earth-Moon system, and a full analytical description of prograde and retrograde periodic orbits and quasi-periodic tori is obtained by normal form expansion and confirmed by direct numerical integration. Larger orbits are located in the centre-manifold of the new Lagrange points, or in the centre-manifold of the original L1. We describe halo and horizontal Lyapunov orbits using a normal form expansion at these equilibria. Differential correction with the method of symmetry lines is used to find periodic orbits. The normal forms provide initial conditions on large and small invariant tori with irrational frequency ratio. These tori along with periodic orbits (both large and small) are used to analyse formation flight of two or more CubeSats controlled by solar sails. The control strategies required by different tori are discussed. Hence, an optimised orbit can be determined for both co-orbiting and formation flight.