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EARTH-SUN L1 AND L2 TO MOON TRANSFERS EXPLOITING NATURAL DYNAMICS

Abstract

This paper examines the design of transfers from the Earth-Sun libration L1 and L2 points towards the Moon using natural dynamics in order to examine the possibilities of disposing or extending the mission lifetime of a spacecraft in orbit around the Lagrangian point L2 at low cost to v. A spacecraft in orbit around L1 or L2 may have a small quantity of propellant left when its operational life has ended. It then becomes interesting to look at the possibilities of travelling along the unstable invariant manifold towards the Earth-Moon system in an attempt to extend the spacecraft's operational lifetime and repurpose the spacecraft for a second mission. Weak capture by the Moon can allow the spacecraft to be placed into a frozen lunar orbit or a variety of highly eccentric lunar orbits, depending on what level of v is available. In addition, the possibility of disposal by method of lunar impact is studied. Different strategies employing attitude thrusters and solar radiation pressure are explored in order to obtain an understanding of what is possible at varying levels of available v. It is also examined what levels of attitude control would be necessary to implement such strategies. The problem is initially modeled in the circular restricted 3-body problem for the Earth-Sun system and then converted into the circular restricted 3-body problem for the Earth-Moon system when the spacecraft nears the Earth-Moon system. The solar radiation pressure in the Earth-Moon system is modeled by placing an external source rotating about – and in the plane of – the co-rotating set of primary and secondary masses. Weak capture at the Moon is studied by method of lunar survivability maps where a range of initial conditions for the spacecraft approaching the Moon is propagated under the effect of the gravitational pull of the primary bodies to study orbit stability. From this, promising regions of initial conditions can be studied in more detail using a more complete dynamic model to inspect the influence of solar radiation pressure. This set of promising initial conditions can then further be reduced by propagating backwards to ensure that they are reachable from the Earth-Sun L2 region.