Paper ID: 77323
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IAF SPACE POWER SYMPOSIUM (C3)
Space Power System for Ambitious Missions (4)

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ORBIT OCCUPANCY OF A SOLAR POWER SATELLITE IN GEOSYNCHRONOUS ORBIT

Abstract

This paper addresses the available orbit capacity to place one or more Solar Power Satellites (SPS) in Geosynchronous orbit (GSO). With tens of thousands of satellites to be launched in the coming years, it has become evident that space is a valuable resource which requires appropriate management. Depending on the orbital parameters and satellites, there is a finite number of objects which can be placed in an orbit without incurring the risk of catastrophic collisions. This study aims to determine the number of SPS that can be safely placed in GSO without constant orbit control. Having an orbital period of one sidereal day, thus matching the Earth's sidereal rotation period, GSO provides continuous coverage over a location, making it particularly useful for telecommunication, remote-sensing and navigation services. Consequently, the GSO regime is already rather busy.

To obtain the orbit capacity of GSO, we first compute the orbit occupancy of a typical SPS subject to the relevant perturbations by propagating the mean motion of the SPS using a semi-analytical formulation in non-singular orbital elements. While doing this, we also account for: gravitational perturbations due to the Earth's zonal harmonics, the 3rd body effects of the sun and moon, as well as solar radiation pressure. We then use techniques borrowed from formation flying to establish the minimum separation of two or more objects within a period of time. The region of space occupied by the SPS over each revolution is then quantified using the proximity motion equation with respect to a geostationary reference point. This allows for the definition of a volume which is occupied by a single satellite. Once the volume is quantified and its long-term evolution is propagated semi-analytically, the orbit capacity problem translates into a dynamic bin-packing problem, where the number of volumes which can be placed into a given GSO slot is maximised. This is done while ensuring that the volumes of different objects do not intersect so that the probability of collision remains zero. The solution of the dynamic bin-packing returns the initial conditions required to safely place multiple SPS in GSO.

The paper will present the general orbit occupancy problem for an SPS. It will then describe the overall methodology and the solution of the dynamic bin-packing problem. Finally the paper will present a couple of example with two reference SPS architectures considering either a standard GEO or a GSO in the Laplace plane.