Paper ID: 24617
student

SPACE POWER SYMPOSIUM (C3)
Space-Based Solar Power Architectures / Space & Energy Concepts (1)

Author: Mr. Ian McNally
University of Glasgow, United Kingdom, i.mcnally.1@research.gla.ac.uk

Prof. Daniel Scheeres
Colorado Center for Astrodynamics Research, University of Colorado, United States, scheeres@colorado.edu
Prof. Gianmarco Radice
University of Glasgow, United Kingdom, Gianmarco.Radice@glasgow.ac.uk

COMPARISON OF ORBITAL LOCATIONS FOR SOLAR POWER SATELLITE SYSTEMS

Abstract

The solar power satellite (SPS) is an Earth orbiting satellite designed to act as an electric power plant in orbit. The literature suggests the most effective orbital location for these structures is in geosynchronous Earth orbit (GSO). This ensures 24-hour base-load power supply, with only small outages around the equinoxes and simplified transmitting antenna/receiving antenna geometry. A principle driver for the size of an SPS is the divergence of the power beam through diffraction as it is transmitted over the distance between orbit and Earth. This divergence is proportional to the transmission distance and wavelength and inversely proportional to the transmitting antenna diameter. Due to the large transmission distance from GSO to the Earth's surface and the long wavelength used for atmospheric penetration, a large transmitting antenna diameter is necessary to minimise divergence. For a large antenna to be economically viable, a large amount of power must be collected and transmitted, driving up the overall size of the system. Consequently, the cost of constructing an SPS in GSO is extremely high.

It is important therefore to consider lower altitude options, which allow for smaller SPS and lower cost to first power. In order to realise the goal of base-load power from GSO SPS, focusing on lower altitude systems initially is an essential step to prove the technology.

Previous work by the author analysed the benefits of utilising the geosynchronous Laplace plane (GLP) for a single large SPS delivering power to a single equatorial ground station. Stable Laplace plane orbits also exist for lower altitudes. The potential of lower altitude Laplace plane orbits for multiple-SPS constellations delivering power to a network of ground stations shall be investigated in this study. A range of different altitude Laplace plane orbits shall be considered. The ratio of cost to energy delivered for multiple SPS in the Laplace plane orbits shall be compared to the single GLP SPS as well as the 3 low-medium altitude SPS architectures proposed in the NASA Fresh Look study. These include constellations of SPS in the following orbits: a 1,500 km sun-synchronous orbit (SSO); an inclined 6,000km MEO; and finally, an equatorial 12,000km MEO. A first order averaged model of the dynamics accounting for Earth-oblateness, solar radiation pressure, and luni-solar gravitational perturbations shall be used to propagate the SPS orbits and hence, to evaluate the energy deliverable to a network of receiving stations over the SPS mission lifetimes.