IAF SPACE POWER SYMPOSIUM (C3)
Space Power System for Ambitious Missions (4)

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COMPARATIVE ANALYSIS OF SOLAR POWER SATELLITE SYSTEMS TO SUPPORT A MOON BASE

Abstract

This paper compares different concepts for a space-based power system to support a lunar base: a solar power satellite (SPS) with a microwave wireless power transmission system (WPT), solar reflector satellites, a hybrid of the two where the reflectors fly in formation with the SPS and concentrate sunlight onto the SPS, and the CASSIOPeiA SPS system.

Sizing of the transmitting and receiving antennae is conducted for a WPT concept utilising high frequency microwaves. Design of the microwave generator is based on gyrotron technology, with parabolic reflectors, and an array of rectifying patch antennae. The WPT solution consists of a number of satellites with solar arrays and transmission capabilities to provide continuous power to the receiving array.

Solar reflectors alleviate the issue of day-night cycles, for ground-based solar arrays, by providing constant sunlight. This concept could be extended by increasing the irradiance provided by the reflecting satellite, thus decreasing the size of the ground solar array required. However, reflective satellites struggle with efficiency stemming from the size of the footprint they create, which is dependent on the angular subtense of the Sun. This paper demonstrates that a hybrid design, utilizing both the reflector satellites and the WPT, would provide the greatest power to weight ratio - decreasing the size of the solar array required.

An important aspect in the effectiveness of solar powered satellites are their distance from the ground receiver, determined directly by their orbit. Smaller orbits allow for reduced distances between the satellite and ground; reducing receiver sizes. However, larger orbits increase transmission windows, reducing the required energy transfer rate. Another important consideration is the stability of the orbit. Stability is affected by the Solar Radiation Pressure, the gravitational pull of the Earth, and the effects of the non-spherical gravity field of the moon. Thus, when designing the orbit, these effects have been considered alongside the trade-off between larger and smaller orbits.

The solutions have been scaled and compared to the CASSIOPeiA concept architecture of a similar nature which will have been investigated to demonstrate the effectiveness of the concept provided.