Session S6: Near-term Demonstrators and Experiments

A 100 kW-Class Technology Demonstrator for Space Solar Power

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Abstract

A first step in the development of solar power from space is the flight demonstration of critical technologies. These fundamental technologies include efficient solar power collection and generation, power management and distribution, and thermal management. In addition, the integration and utilization of these technologies into a viable satellite bus could provide an energy-rich platform for a portfolio of payload experiments such as wireless power transmission (WPT). This paper presents the preliminary design of a concept for a 100 kW-class free-flying platform suitable for flight demonstration of technology experiments.

Recent space solar power (SSP) studies by NASA have taken a stepping stones approach that lead to the gigawatt systems necessary to cost-effectively deliver power from space. These steps start with a 100 kW-class satellite, leading to a 500 kW and then a 1 MW-class platform. Later steps develop a 100 MW bus that could eventually lead to a 1-2 GW pilot plant for SSP. Our studies have shown that a modular approach is cost effective. Modular designs include individual laser-power-beaming satellites that fly in constellations or that are autonomously assembled into larger structures at geosynchronous orbit (GEO). Microwave power-beamed approaches are also modularized into large numbers of identical units of solar arrays, power converters, or supporting structures for arrays and microwave transmitting antennas. A cost-effective approach to launching these modular units is to use existing Earth-to-orbit (ETO) launch systems, in which the modules are dropped into low Earth orbit (LEO) and then the modules perform their own orbit transfer to GEO using expendable solar arrays to power solar electric thrusters. At GEO, the modules either rendezvous and are assembled robotically into larger platforms, or are deployed into constellations of identical laser power-beaming satellites. Since solar electric propulsion by the modules is cost-effective for both self-transport of the modules from LEO to GEO, and for on-orbit stationkeeping

and repositioning capability during the satellite's lifetime, this technology is also critical in technology development for SSP.

The 100 kW-class technology demonstrator will utilize advanced solar power collection and generation technologies, power management and distribution, advanced thermal management, and solar electric propulsion. State-of-the-art solar concentrators, highly efficient multi-junction solar cells, integrated thermal management on the arrays, and innovative deployable structure design and packaging make the 100 kW satellite feasible for launch on one existing launch vehicle. Early SSP studies showed that a major percentage of the on-orbit mass for power-beaming satellites was from massive power converters at the solar arrays, at the bus, at the power transmitter, or at combinations of these locations. Higher voltage arrays and power management and distribution (PMAD) systems reduce or eliminate the need for many of these massive power converters, and could enable direct-drive of high-voltage solar electric thrusters.

Lightweight, highly efficient thermal management systems are a critical technology that must be developed and flown for SSP feasibility. Large amounts of power on satellites imply that large amounts of waste heat will need to be managed. In addition, several of the more innovative lightweight configurations proposed for SSP satellites take advantage of solar concentrators that are intractable without advanced thermal management technologies for the solar arrays. These thermal management systems include efficient interfaces with the WPT systems or other high-power technology experiments, lightweight deployable radiators that can be easily integrated into satellite buses, and efficient reliable thermal distribution systems that can pipe heat from the technology experiments to the radiators.

In addition to demonstrating the integration and use of these mission-critical technologies, the 100 kW-class satellite will provide a large experiment deck for a portfolio of technology experiments. Current plans for this technology demonstrator allow 2000 kg of payload capability and up to 100 kW of power. The technology experiments could include one or more wireless power transmission demonstrations, either to the Earth's surface or to a suitable space-based receiver. Technology experiments to quantify the on-orbit performance of critical technologies for SSP or space exploration are welcomed. In addition, the technology experiments provide an opportunity for international cooperation, to advance technology readiness levels of SSP technologies that require flight demonstration.

This paper will present the preliminary design for a 100 kW solar-powered satellite and a variety of technology experiments that may be suitable for flight demonstration. In addition, a space-to-Earth-surface WPT experiment will be discussed.