Challenges of Space Power Beaming: Mission Enabling Technology for Continuous Lunar Operations

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This presentation will outline opportunities to leverage and extend the Xtraordinary Innovative Space Partnerships, Inc. (XISP-Inc) Technology Development, Demonstration, and Deployment (TD^3) mission for Space-to-Space Power Beaming (SSPB), planned for implementation on the International Space Station (ISS) for subsequent application to lunar surface operations. This presentation extends the paper CHALLENGES OF SPACE POWER BEAMING: FORGING PRODUCTION SERVICES FROM THE TECHNOLOGY DEVELOPMENT TRADE SPACE presented at IAC 2018 Bremen. The SSPB mission builds on foundational research in the field as well as mission development work accomplished to date by the proposed Principal Investigator (PI), XISP-Inc, and the XISP-Inc SSPB Consortium participants. This mission is a unique opportunity to foster the development of power and ancillary services beaming technology, by leveraging ISS resources to create a SSPB testbed environment on and near the ISS that supports the development of frequency-agnostic radiant energy beaming technology. The overarching objective of this mission is to hasten the development of viable applications of SSPB technology and ancillary services through focused incremental efforts that bridge the technology development "valley of death" as well as substantially mitigate perceived and actual cost, schedule, and technical risk associated with applications of the technology. The SSPB mission objectives include the technology development necessary to support the unbundling of a commercially relevant space power system (i.e., the separation of power generation, transmission, distribution, and loads) along with the multiplexing of ancillary services (e.g., data, communications, navigation, time) to enable Space-to-Space and Space-to-Alternate Surface, as well as Surface-to-Surface Power Beaming.

The ability to provide power and ancillary services when and where needed is essential to virtually all aspects of human endeavor and enables all forms of space development/settlement. The SSPB mission will deliver significant commercial value in the form of power and bi-directional ancillary services to a growing number of customers interested in co-orbiting with the ISS and lay the foundation for a myriad of Cislunar applications.

The first phase of the SSPB mission is Technology Development. This includes lab/ground test work (XISP-Inc & teammate Internal Research and Development (IRaD) and leverageable contract research & development) which will transition into highly configurable space-qualified instances of cognitive Software Defined Radio (SDR) transceivers, rectennas, and related control systems. These elements will have mutable/switchable apertures (frequency-agnostic radiant energy beaming source), separate and converged conformal rectenna/solar array/antenna constructs that are configurable/tunable (combination of phased array, reflectarray, and multi-layer/junction, and related technologies), and software-driven controls. The elements will be integrated to form an on-orbit testbed consisting of an ISS-based transmitter, a co-orbiting CubeSat flight test article, and related management operations control applications. The testbed will support the near–real-time characterization, optimization, and operationalization of an unbundled power and ancillary services beaming system.

In the second phase of the SSPB mission, Technology Demonstration, the results from the testbed will be used to create an enhanced technology demonstration of the commercial application of the SSPB technology by providing an additional source of power and ancillary services to a specially configured Cygnus pressurized logistics commercial cargo carrier, thereby enabling Cygnus to support crew-tended co-orbiting operations while the ISS resumes normal operations. The combination of the Phase I technology development and the Phase II technology demonstration will raise the Technology Readiness Level (TRL) of SSPB technology from the existing TRL of 4 to 8/9.

The third Phase of the SSPB mission, technology deployment, entails fielding an interface deployment kit for the use of space-based power and ancillary services that would be suitable for multiple space-to-space, space-to-lunar surface, and surface-to-surface applications. One of the addressable markets this deployment kit will be designed to facilitate is lunar surface operations through multiple lunar nights.