Title: Space-to-Space Power Beaming - A Commercial Mission to Unbundle Space Power Systems to Foster Space Applications

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One of many paths forward for hastening the development of viable applications of space solar power technology is through focused incremental technology development efforts. This effort will serve to mitigate cost, schedule, and technical risk associated with the short, mid, and long term application of the technology. The development will provide both a capability of demonstrable value to some number of customers co-orbiting with the International Space Station (ISS) and a testbed environment for the technology. This presentation and paper is on one development objective - unbundling space power systems (i.e., the separation of power generation, transmission, management, and loads). We have a unique opportunity to foster the development of space-to-space power beaming by leveraging International Space Station (ISS) resources to create a space-to-space power beaming testbed environment on and in the vicinity of ISS.

What is the problem being addressed?

XISP-Inc has hypothesized that unbundling power systems (i.e., the separation of power generation, transmission, control, storage, and loads) can:

- reduce spacecraft complexity and thereby reduce cost, schedule, and technical risk
- reduce mass and/or volume required to accomplish a given mission
- reallocate mass and/or volume to enhance or enable missions
- impart additional delta-V along velocity vectors of choice to enhance or enable missions
- foster the development of loosely coupled modular structures to enable:
  - formation flying of multiple spacecraft (e.g., interferometric groups, swarms)
  - distributed payload and subsystem infrastructure to simplify the accommodation of multiple plug-in and plug-out interfaces
  - large scale adaptable space structures that minimize conducted thermal and/or structural loads.

What is the relevance of the problem to the questions of known interest to NASA & others?

• The XISP-Inc proposed cubesat target demonstrating power beaming from ISS will require the cooperation of several elements of NASA and Industry, but would result in near term demonstration of space-to-space power beaming, and allow rapid iteration of designs and experiments.

• Establishing a functioning ISS power beaming testbed could allow experimentation and validation of components of larger power beaming systems, and reduce the risk of the development of the larger dedicated systems

• Although the experiments with ISS and cubesats would be small scale, there could be

immediate applications for subsatellites near ISS, as well as designs for distributed payloads and sensors for deep space missions including lunar and asteroidal assay work.
• A primary mission of XISP-Inc is to develop cooperative arrangements with different parts of NASA and different industry partners. The early implementation of a power beam demonstration on ISS, coordinated by XISP-Inc, could enhance and enable the demonstration of other power beaming designs.

What is the proposed solution?

- Space-to-space power beaming is an application of Space Solar Power technology which could be tested/implemented now to immediate benefit as well as serve as a means of incrementally maturing the technology base.
- XISP-Inc has brought together a truly innovative partnership of interest parties to accomplish technology development work in this area including both government, commercial, university, and non-profit sectors. Many formal letters of interest have been submitted to NASA and/or XISP-Inc and are available on request.

This mission starts with the design and implement/prototype a parametric model for unbundled power systems for spacecraft propulsion and/or sustained free flyer/surface operations in conjunction with the NASA ARC Mission Control Technologies Laboratory and other interested parties. The opportunity to craft viable technology demonstrations will establish the basis for a confluence of interest between real mission users and the technology development effort. This could lead to a range of technology development missions on the ISS and subsequent fight opportunities that can make efficient and effective use of beamed energy for propulsion and/or sustained operations. This has come to pass and there is now a concerted effort to move forward with mission development.

Several potential research opportunities have emerged that could make use of a combination of resources currently available or that can be readily added to ISS:
Of particular interest is the use of one or more of the available Ka band (27 to 40 Ghz) communications transmitters on ISS as well as the potential for adding one or more optimized W band transmitters (75 to 110 GHz). The use of simplified delivery to ISS of enhance equipment and/or flight test articles as soft pack cargo from Earth, the Japanese Kibo laboratory airlock to transition flight systems to the EVA environment, the Mobile Servicing Center for ram-starboard deployment positioning with a zenith bias, and simplified deployment mechanisms can serve as a useful first step toward demonstrating an ability of ISS to support coorbiting freeflyer spacecraft systems. This combination of equipment allows for power transmission, far field/near field effect analysis and management, formation flying/alignment, and various propulsion approaches to be tested and used to the benefit of multiple experiments; as well as provide augmented power, communications, and some level of attitude control/positioning services to a co-orbiting free-flyers and/or other elements (e.g., BEAM, Dragon, Cygnus, etc.). This combination of equipment could be repurposed as crew-tended free-flyers for some number of extended duration micro-g/production manufacturing cell runs. Also, commercial space applications include mission enhancements, expansion of operational mission time, and out-bound orbital trajectory insertion propulsion.