Paper ID: 67037
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IAF SPACE POWER SYMPOSIUM (C3)
Wireless Power Transmission Technologies and Application (2)

Author: Mr. Gary Barnhard
XISP-Inc, United States

Dr. Seth Potter
XISP-Inc, United States

BOOTSTRAPPING LUNAR EXPLORATION TO SETTLEMENT: POWER AND ANCILLARY SERVICES BEAMING

Abstract

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 exploration/development/settlement.

Defining an incremental path to realize the necessary power infrastructure to support settlement and its precursor activities is a significant systems engineering challenge.

More specifically, it is necessary to determine what are the increments of scalable interoperable modular power and ancillary services needed to support exploration, prospecting, proving reserves, exploitation, habitation, and settlement of the lunar surface, as well as how the requirements for the same can be accommodated. In addition, each power and ancillary services increment can provide the necessary power and services needed to construct the next increment.

The current state-of-the-art with respect to surviving and operating through the night on the lunar surface is profoundly limited. While there are multiple terrestrial and even space qualified technologies that could be leveraged to design viable end-to-end power generation, storage, and distribution systems suitable for the lunar environment, the systems engineering of the same is nascent.

This paper will curate/generate, intersect, and converge multiple technology development efforts to yield a recommended set of deployable power and ancillary services beaming infrastructure payloads.

The first data set is the Vendor User's Guides for the NASA Commercial Lunar Payload Services (CLPS) contract lunar lander spacecraft and the data on the anticipated Human Landers.

The second data set is the customer requirements of prospective payloads which are broken into four increments. The first scalable modular increment of power services for initial exploration can be defined as up to 1 kW, a second more expansive increment to 10 kW supporting prospecting, a third increment to 100 kW proving reserves, and a fourth increment to 1,000 kW supporting exploitation, habitation, and settlement.

The third data set is the accumulated theoretical/experimental test data on transmitter options, the rectenna/receiver options, and the end-to-end efficiency for microwave, millimeter wave, and infrared/optical frequencies.

Working from the potential available input power increments, a similar scaling can be deduced. The DC-to-Beam conversion efficiency factored in, yielding estimates for the maximum power output electrical and the maximum power output thermal. Using the collection efficiency method, the received power can be calculated for various distances of interest. The resulting values will be translated into power and ancillary services infrastructure designs that are both robotic and EVA compatible for peer review. This updates Virtual IAC2020 work.