Orbital Power Beaming to Provide Increased Mobility, Flexibility, and Science Measurements on the Lunar Surface. Wilbert A. Ruperto-Hernández[1], Emily G. Ballantyne[1], Naylah S. Canty[1], Gregory E. Benjamin[2], [1]NASA Langley Research Center, [2]Analytical Mechanics Associates, Inc. (Contact: wilbert.a.ruperto-hernandez@nasa.gov)

Introduction: One of the biggest challenges facing the expansion of lunar surface exploration is access to a reliable power source for purposes of surviving lunar night, exploring permanently shadowed regions, and achieving long traverses. Landers and rovers are currently limited in their range, performance, and lifetime due to power constraints. The concept of Space-Based Solar Power (SBSP) provides an attractive alternative solution to the power needs of lunar surface missions. The Orbital Power-Beaming Assets for Lunar Applications (OPAL) project seeks to develop a concept for a flexible orbit-to-surface power beaming architecture with a power-tunable and focusable optical power beaming system that will accommodate the needs of future lunar surface assets – or clients herein.

Fig. 1. Artist's rendering of future lunar missions enabled by power beaming from orbit

Lunar Surface Client Power Needs: Representative clients include small landers, crewed unpressurized rovers, prospecting rovers, along with other science and crew-supporting assets requiring between tens and hundreds of watts. The current baseline power architectures require surface clients to be power self-sufficient or rely on power from another surface asset. In turn, these approaches impose constraints on the lifetime, surface access, mobility range, payload mass, and overall return on investment (e.g., science data return) for these clients.

OPAL Payload Systems: Results from the ongoing study underscore the benefits of a power-tunable and spot-size focusable optical power beaming system to better service lunar assets as compared to a non-tunable and non-focusable system. A non-tunable and non-focusable optical power beaming system may still deliver some energy, but it could result in an ineffective and inefficient architecture (e.g., larger than required power generation and thermal radiators in orbit). In contrast, a tailored and flexible optical power beaming system can not only improve efficiencies and service more clients, but also reduce unwanted impacts on the clients such as heating of sensitive components on or near the vehicles as well as astronauts nearby. Additionally, this focusability could help reduce disruptions of pristine lunar environments such as volatization of resources inside permanently shadowed regions.

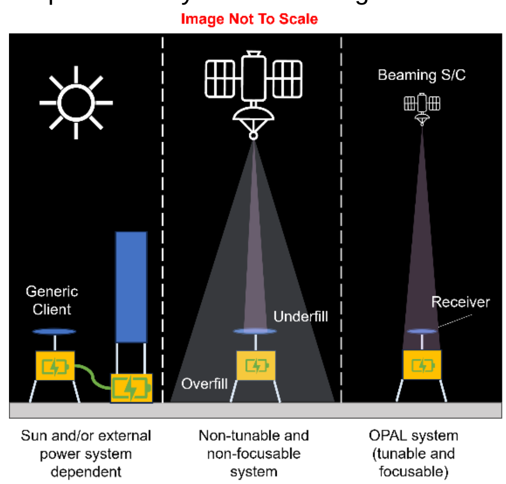

Fig 2. Comparison of power generation and energy transfer approaches

Approach: While promising, the concept of delivering power from lunar orbit has been found to be a tightly coupled engineering problem that requires a systems-of-systems approach. Therefore, the OPAL team is employing a blend of systems analysis with traditional systems engineering to concurrently refine the OPAL concept and define top-level requirements for the aforementioned payload. This approach involves parametric sizing, power analyses, orbital analyses, definition of client power needs & ConOps, technology assessments, and high-level optical beam design and simulations.

The team is interested in engaging with other government agencies, industry, and academia counterparts to exchange information related to, but not limited to, technology developments in core and enabling technologies (e.g., lasers, optomechanical and precision pointing systems, thermal radiators, etc.), community interest, and other ongoing activities.