POWER BEAMING FOR ROVERS IN LUNAR PERMANENTLY SHADOWED REGIONS. Ross Centers[1], David Dickson[2], Joshua Schertz[3]. [1,2,3] Colorado School of Mines, 1500 Illinois St., Golden, CO 80401; [centers, ddickson, jschertz]@mymail.mines.edu, Radiant Lunar, 4207 SW Reservoir Dr., Redmond OR 97756

Introduction: Lunar ice is found in permanently shadowed regions (PSRs) [1], yet no power source is available. Nuclear power is expensive, scarce, and adds risk to commercial business plans [2]. Transmitting photovoltaic power from generation stations on highly illuminated ridges would support exploration and development of lunar ice resources in PSRs [3]. We propose a power system based on photovoltaic generation, laser transmission, and photovoltaic/thermal reception to support resource exploration activity. We estimate the end to end power efficiency of the system at 25-61%, and the achievable pointing accuracy supporting ranges of up to 20km.

The first power customers in PSRs will be exploration rovers, with representative power demands in the kilowatt scale [4]. With a source of transmitted power, rover missions can be deployed at commercial cost and scale. Our power system consists of a 30m^2 photovoltaic array driving a 4kw power laser, received by rovers via a small photovoltaic/thermal panel (Fig. 1).

Laser-based power beaming is an attractive alternative to direct reflected sunlight [5] for applications where small illumination zones at long range is needed.

Considerations for Design: Power efficiency is of historical concern for laser power transmission systems [6]. Modern lasers offer efficiencies enabling kilowatt scale power output with practical generation array sizes. Reception efficiencies can be maximized with receiving array photovoltaic bandgaps tuned to the frequency of monochromatic laser light. Practical reception efficiency in PSRs is enhanced by direct heat capture of non-electrical energy: ambient temperatures near 30K drive extensive heating requirements [7].

Pointing accuracy is a major design consideration, driving the system's useful range. Arcsecond pointing accuracy enables 20km range to small targets. Precise actuation and vibration mitigation are required to achieve this. Piezoelectric actuators backing the aiming reflector provide arcsecond accuracy, and can actively mitigate <100hz low-amplitude vibrations. Larger vibrational disturbances are mitigated by a stepwise action of sun tracking and coarse pointing rotary actuators, by careful design of the cooling system, and by thermal insulation of the supporting mast. Closed loop feedback enables laser cutoff in case of pointing errors.

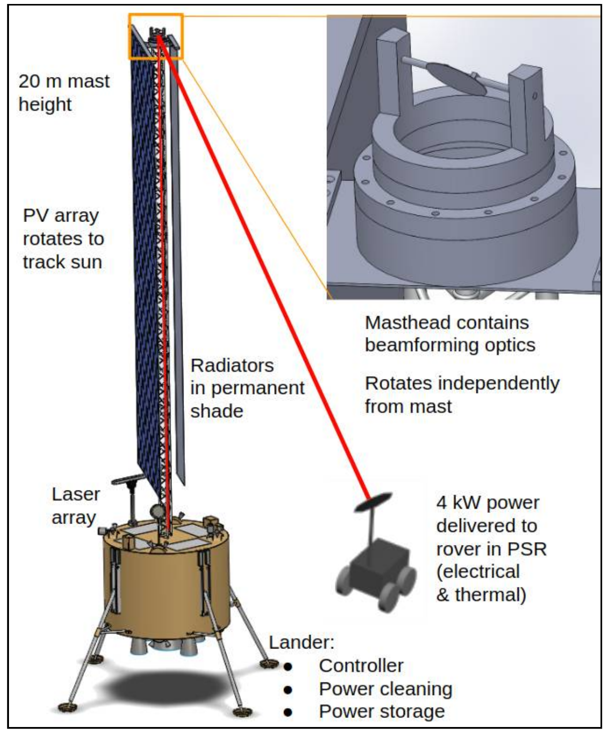

Fig. 1. Laser power system concept sketch.

Considerations for Deployment and Operation: A key precursor for deployment will be careful site selection for a.) clear view and line-of-sight of the PSR region being prospected, b.) suitability of terrain for landing the power system in terms of slope, levelness, and stability, c.) near 360-degree view of the sun for the purpose of solar array exposure over the course of the lunar month, and d.) proximity to other planned lunar installations outside the PSR, both public and private.

References:

[1] Li, Shuai, et al. Proceedings of the National Academy of Sciences 115.36 (2018): 8907-8912. [2] Powering Exploration: An Update on Radioisotope Production and Lessons Learned from Cassini, House, 115th Cong. (2017). [3] Enright, John, et al. SPS'97 (1997). [4] Zakrajkek, McKissock, et. al. AIAA SPACE (2005). [5] Stoica, Adrian, et al. NAIC Phase II (2017). [6] Welch, David F. IEEE Journal of selected topics in quantum electronics 6.6 (2000): 1470-1477. [7] Vasavada, Ashwin R., et al. Journal of Geophysical Research: Planets 117.E12 (2012).