Design Study of Surface to Surface Laser Power Beaming on the Moon.

G.A. Landis[1], S.R. Oleson[1], and the Compass engineering team, [1]NASA Glenn Research Center, 2100 Brookpark Road, Cleveland OH. Contact: geoffrey.landis@nasa.gov

Introduction: Using a laser to send power to a photovoltaic receiver has been proposed to transmit electrical power on the moon, particularly for applications such as powering a rover in near-polar permanently-shadowed regions (PSR) where solar power is not available[1,2].

In this work, we did an engineering design study of a near-term laser surface-to-surface power beaming using the VSAT as the laser platform.

Study: To maximize the distance of beaming, taking into account possible surface irregularities and the short distance to the horizon of the moon, it is desirable to emplace the laser at an elevation above the surface. The Vertical Solar Array Technology (VSAT)[3] is a NASA program developing a solar array mounted vertically on a 10-m tall mast, designed for emplacement on a Commercial Lunar Payload Services (CLPS) lander to provide 10-kW (BOL) power near the south polar region of the moon, with a target readiness date of 2028. We used this design as the starting platform and the power source for a laser power beaming station. By mounting the laser beam director at the top of the solar array mast, a viewing distance to power receivers up to 10 km is possible.

Requirements for the system were to be able to provide 300 W of continuous usable power to users including CLPS landers, VIPER[4] class rovers, or the proposed Lunar Terrain Vehicle. The requirement was to able to transmit power to a distance of up to 10 km, over a design lifetime of 5 years, and fitting within a total system landed mass under 625 kg.

Design: Figure 1 shows the beaming station mounted on the top of a VSAT array on a conceptual CLPS lander. A commercially-available high-power 1.07-µ diode-pumped fiber laser is mounted on the deck of the lander, with laser output sent to the laser beam director by a fiber-optic cable. A 7 square meter deployable radiator keeps the laser within operating temperature limits. The beam director, based on the design of a prototype unit developed by the University of California Santa Barbara[2], is shown in green at the top of the mast. The system is powered by the 7-kW VSAT array.

Concept of Operations: The system beams power for 57% of the time, with 44% of the time idle (accounting for the time when the VSAT array is itself in shadow). 1595 Watts of optical power are output in the beam. Accounting for receiver efficiency and beam losses, this results in an output onto the 1.5-meter receiving photovoltaic array of 542 watts. Of this, 300 watts is directly available to the user, while 242 watts is directed to the batteries for use while the beam is not available.

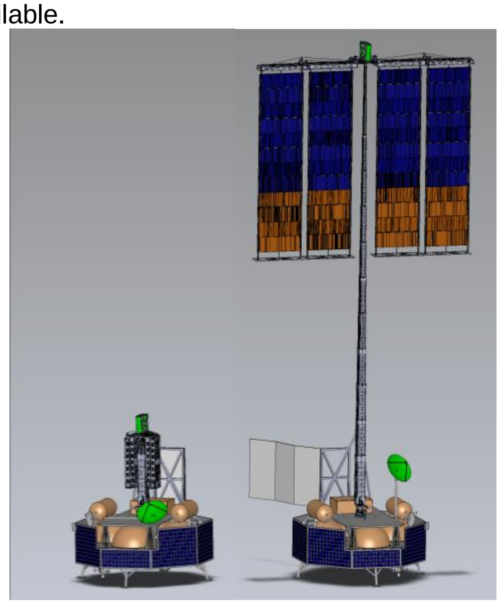

Figure 1: Beaming station stowed (left) and after deployment of the thermal radiator and VSAT array and 10-m mast (right). (note that the bottom third of the array area is populated by dummy panels rather that solar cells, part of a technology demonstration[3] to show capability of deploying a larger array.)

Conclusion: An engineering design and concept of operations was done for beaming laser power from a small lander to users (landers or rovers) within a 10-km distance.

References:

1. G.A. Landis, "Power Beaming for Lunar Polar Exploration," *LSIC Fall Meeting,* Oct 14-15, 2020.
2. P. Lubin, "NASA LuSTR Review: Moonbeam-Beamed Lunar Power," *LSIC Spring Meeting,* March 18, 2021.
3. C. Taylor and R. Pappa, "Game Changing Development Program-Vertical Solar Array Technology (VSAT) Project," Game Changing Development Program Review, Sept. 19-21, 2023. https://ntrs.nasa.gov/citations/20230012849

4. R. Vaughan, "VIPER–Volatiles Investigating Polar Exploration Rover: Mission Overview," International Small Satellite Conf., May 11, 2020.