A Laser Power Beaming Demonstration for CLPS Landers

BIG Idea Challenge Team

Colorado School of Mines and University of Arizona

INTRODUCTION

A student team from the Center for Space Resources at the Colorado School of Mines and the SpaceTREx lab at the University of Arizona are working on a minimal mass laser power beaming demonstration for CLPS landers (Figure 1). With funding from NASA's BIG Idea Challenge, we are developing ground demonstration hardware (Figures 2,3) for an autonomous power beaming system .

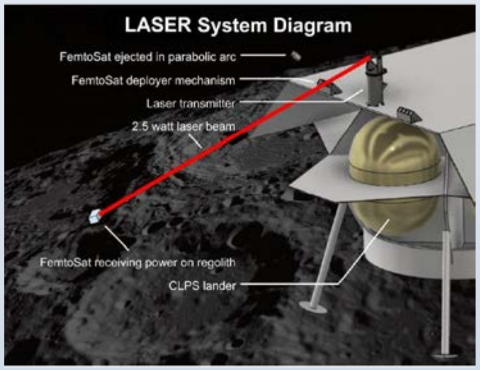

Figure 1: COOPS for a Minimum Viable Demonstration of Laser Power Beaming on the Lunar Surface. With an 8W power budget and multiple independent receivers, the system can demonstrate autonomous target recognition and power distribution to multiple targets.

CONCEPT OF OPERATIONS

- The system consists of a laser transmitter and several ejectable receivers, mounted on the top deck of a CLPS lander.
- After landing, the receivers are ejected from the lander to ranges of 3-30 meters. Each receiver is covered in photovoltaic panels and contains a battery, microcontroller, IMU, and radio.
- The receivers communicate their charge status and approximate location to the transmitter.
- The transmitter locates each receiver and charges each to maintain full battery charge for mission duration.
- Receivers can host miniaturized scientific equipment.

DEMONSTRATION AND WORK IN PROGRESS

We have demonstrated laser power beaming over 30 meter range using a 4W diode laser at 793nm collimated to a 6cm beam, received by a FemtoSat based transmitter in a 3x3x6cm form factor, massing 84g (Figure 2). The receiver hosts a battery, microcontrollers and radios for telemetry, and communicates its charge status and charging rate back to the transmitter. Limited volume inside the receiver precludes a sophisticated charge controller, but experiments with a maximum power point tracking controller on a similar panel demonstrated 5.6% DC-DC efficiency (not shown).

Our completed transmitter (Figure 3) features a 2-axis gimbal and a Raspberry Pi based controller to communicate with the receivers and coordinate charging. Closed loop beam control is possible by backfeeding receiver charge telemetry indicating laser illumination; coarse localization is determined by radio time-of-flight measurement while fine localization is accomplished by raster scanning a search area with the receiver transmitting telemetry from its charge controller.

In the coming weeks, the team will conduct integrated testing demonstrating autonomous target localization and charging.

Figure 2: Laser Power Transmission at 30 Meters. Clockwise from top left - (a): the receiver being charged by the laser transmitter at 30 meters. (b): over-the-shoulder view of the transmitter optics tube looking downrange to the receiver. (c): team member Joshua Schertz configuring a beam profiler. (d): team member Curtis Purrington preparing the test environment.

Figure 3: Prototype Laser Transmitter. A 75mm collimating lens delivers 4W illumination at 793nm. The transmitter autonomously locates and charges several 3x3x6cm receivers at ranges up to 30m.

FUTURE DIRECTIONS

The concept can be scaled up to use a higher power fiber laser with custom photovoltaics to transfer hundreds of watts over several kilometers (Figure 4). With faculty advisor Dr. George Sowers as principal investigator, the team has submitted a proposal to NASA's LuSTR solicitation for further concept development.

Figure 4: A Laser Powered Rover Exploring Ice in a Permanently Shadowed Crater. (Matt Olson)

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