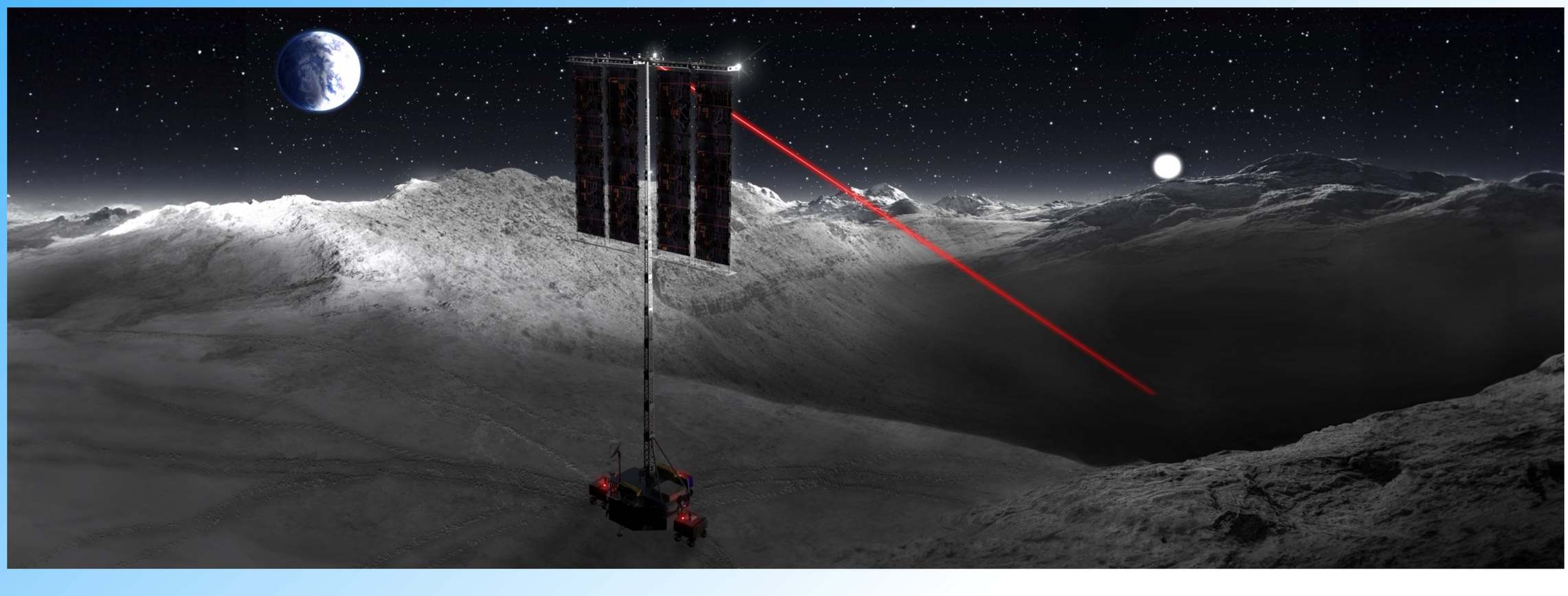
Design Study of Surface to Surface Laser Power Beaming on the Moon

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Introduction

Objective: engineering design of a near-term laser surface-to-surface power beaming station to transmit power to users in shadowed regions or during the night. Input system requirements were to be able to provide 300 W of continuous usable power to users including landers and rovers, at distances up to 10 km, with a total system landed mass under 625 kg. Due to surface irregularities and the close horizon of the moon, to achieve 10-km transmission the laser must be elevated above the surface. The Vertical Solar Array Technology (VSAT) program is developing a solar array mounted on a 10-m tall mast, intended to fit on a Commercial Lunar Payload Services (CLPS) lander, with target readiness date of 2028. At an optimum location near the south pole, the elevated array produces power for a majority of the lunar day.

Design

A 1.07-μ diode-pumped fiber laser based on a commercially-available model with 40% electrical to optical power conversion efficiency is mounted on the deck of the lander. Laser output is sent to the apex-mounted beam director by a fiber-optic cable. A 7 m² deployable radiator keeps the laser within operating temperature limits. 1595 W of laser optical power is directed by a steerable beam director with a 10-cm primary optic, resulting in a 1.5-m spot diameter (FWHM) at the maximum 10-km range. A 3.4-W diode-laser beacon on the receiver enables precise pointing of the beam. An array of InGaAs photovoltaic cells with conversion efficiency of 50% at the laser wavelength was baselined. This results in an output of 540-W DC on a 1.5-meter receiving photovoltaic array (slightly more if a larger receiving array is used). Of this received power, 300 watts is directly available to the user, while 242 watts is used to charge batteries for use while the beam is not available. The system also incorporates a 5G 60-Mbps data relay. Table 1 shows the mass breakdown, including mass growth allowance and system-level mass margin, and figures 2 and 3 show a visualization of the beaming station.

MEL Summary: Case 2_VSAT_Beamed_Power_LSR CD-2023-203	VSAT_LSR
Main Subsystems	**Basic Mass (kg)**
Laser and beam director	35.9
Attitude Determination and Control	1.6
Command & Data Handling	13.0
Communications and Tracking	22.5
Electrical Power Subsystem	106.7
Thermal Control (Non-Propellant)	70.9
Structures and Mechanisms	206.1
Element Total	***456.7***
Element Mass Growth Allowance (Aggregate)	98.0
MGA Percentage	21%
Predicted Mass (Basic + MGA)	554.7
System Level Mass Margin	68.5
System Level Growth Percentage	15%
Element Dry Mass (Basic+MGA+Margin)	623.2
Element Inert Mass (Basic+MGA+Margin)	623.2
Total Wet Mass (Allowable Mass)	***623.2***

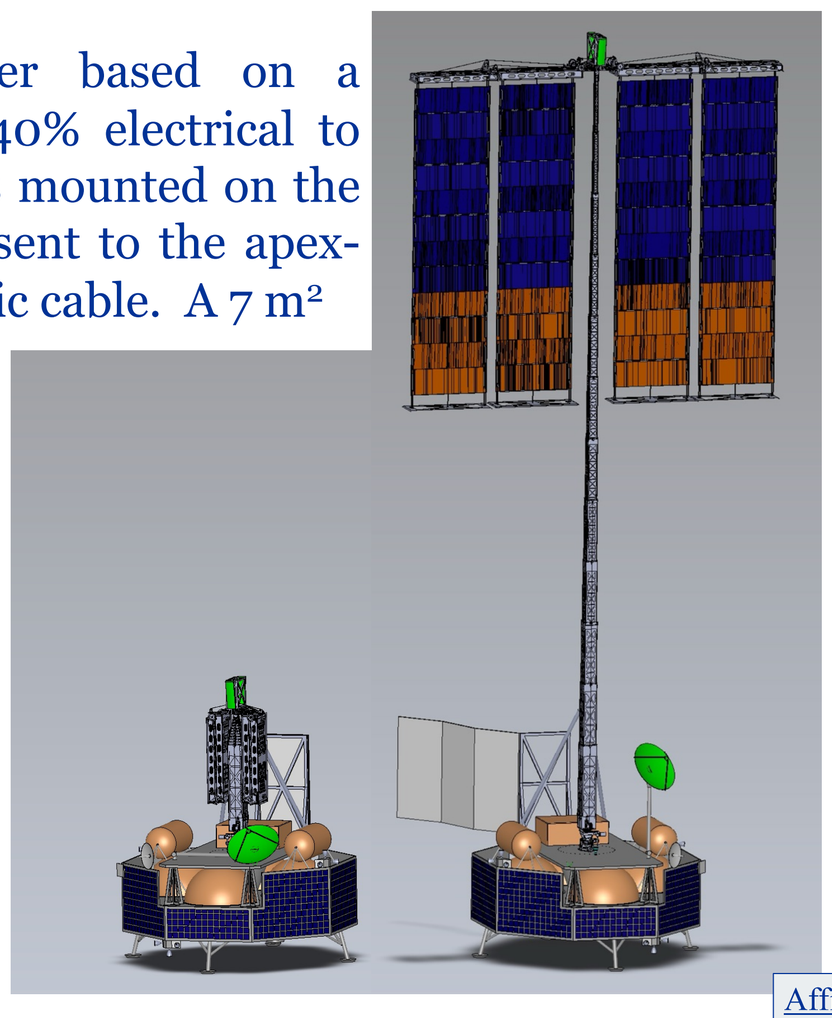
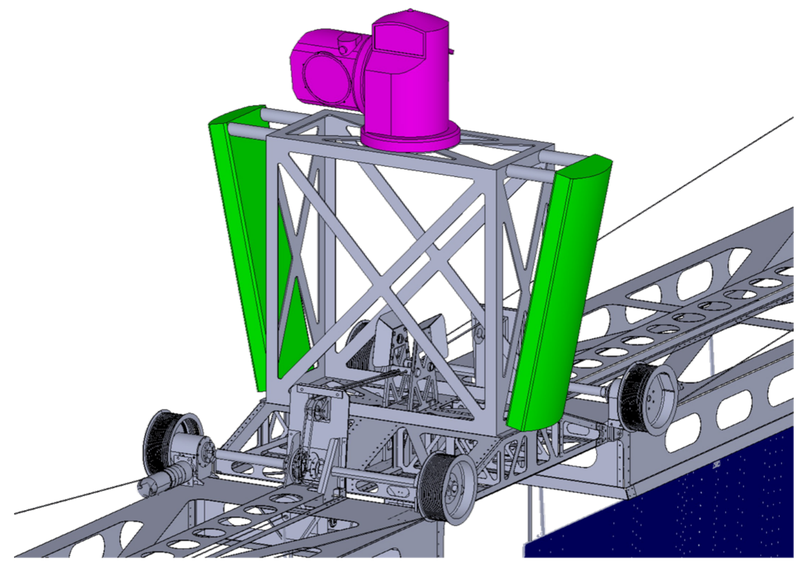


Table 1 (left): *Mass breakdown*
Figure 1 (center): *Beaming station stowed and after deployment on the surface*
Figure 2 (right): *detail showing beam director (magenta) and data-relay antenna (green) at apex of mast*



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