VOLTA

Space Technologies

Space-Based Optical Wireless Power Transfer:

Progress Towards a Commercial End-to-End Architecture

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26th Space Resources Roundtable

Session 9 – Space Infrastructure

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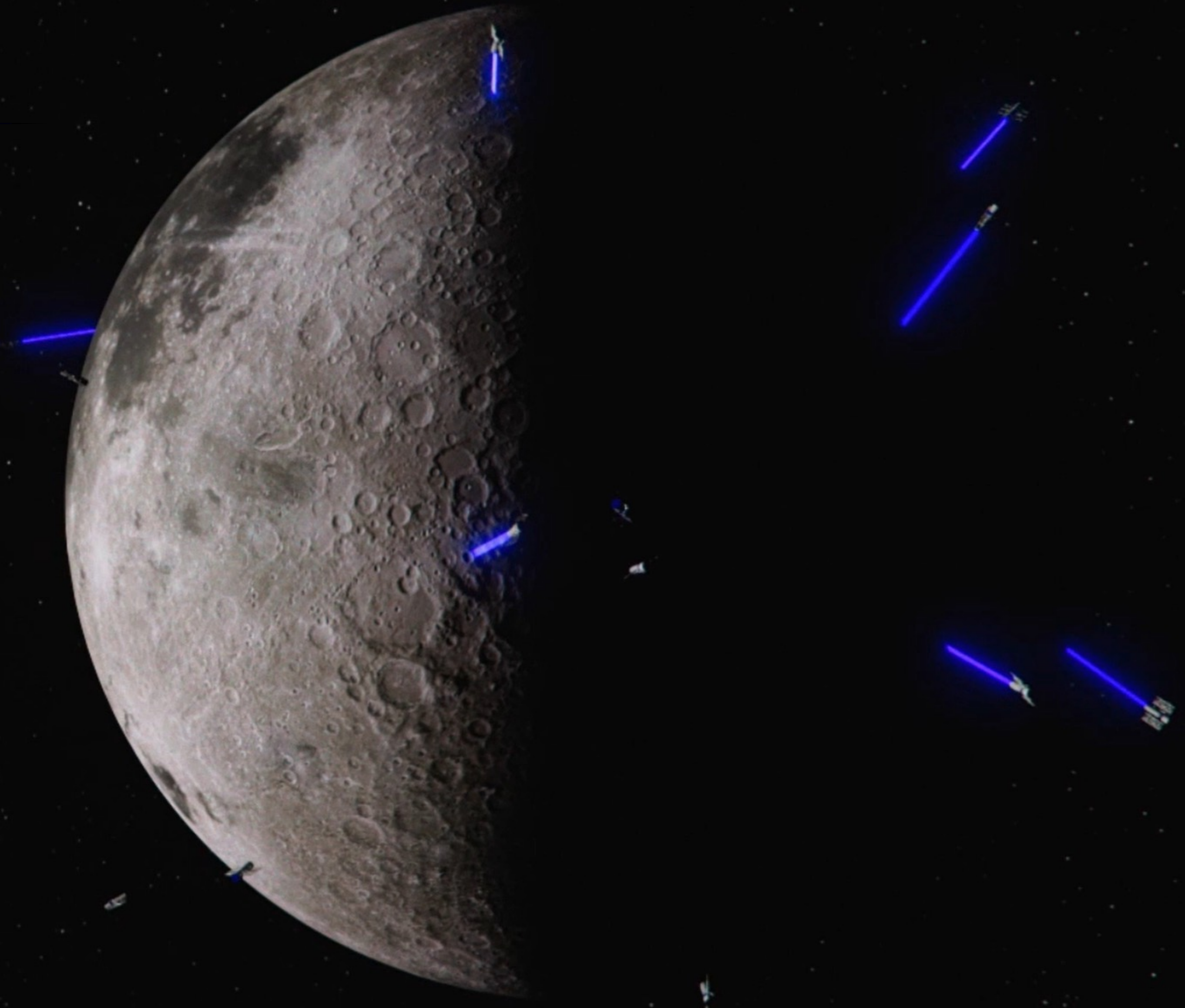
Topics

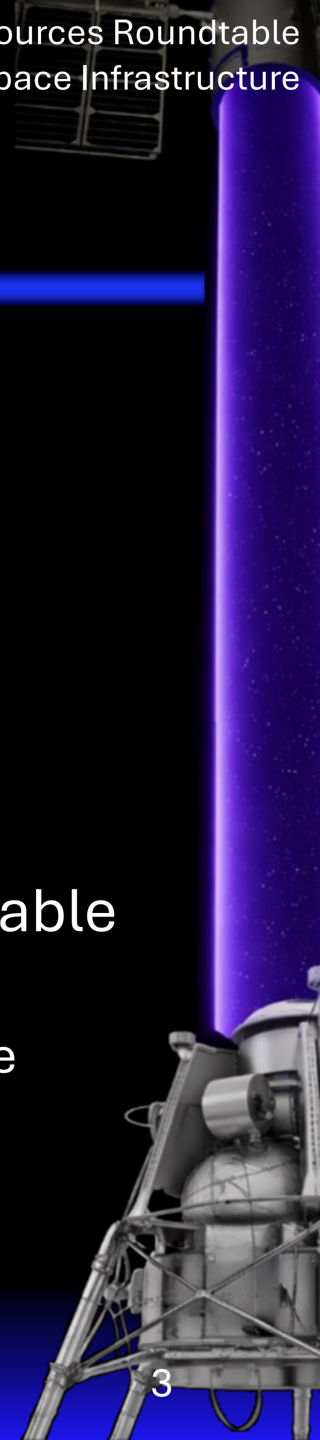
1. Overview
   - Volta Space Technologies
   - Motivation
2. Laser Testing
   - Shock & Random Vibration
   - Thermal Vacuum
   - Radiation
   - Lifetesting
3. Receiver Testing
   - Efficiency
   - Thermal
4. Findings & Future Work

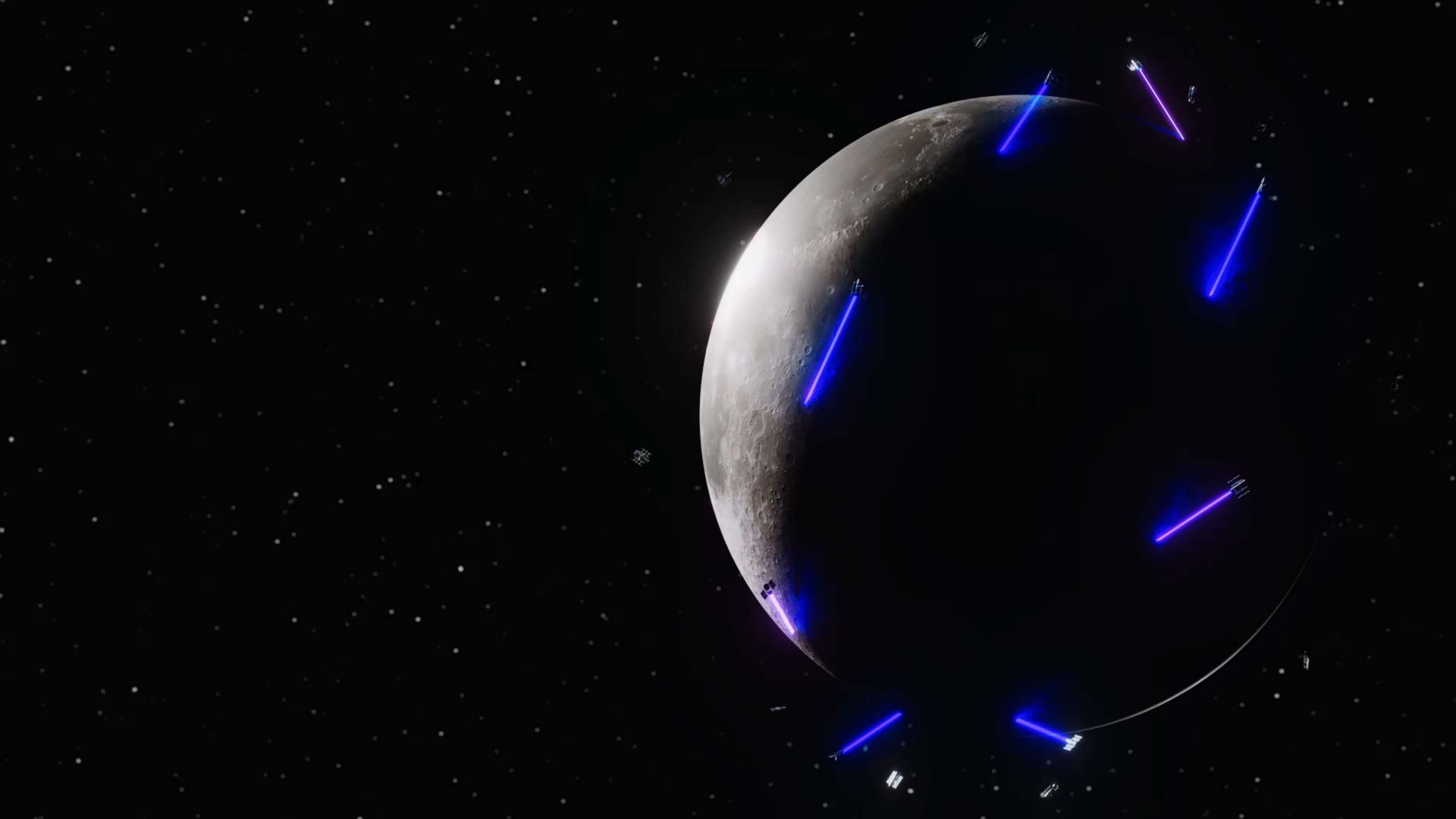


Volta Space Technologies

1 – Overview

- Founded in 2020 in Montréal, QC, Canada
- Exited stealth and started US operations in 2024
- We build lasers, optical systems, and photovoltaic receivers for space applications
- Offices in Broomfield, CO and Montreal, QC
  - 8 employees in Montreal, 5 in Broomfield, 2 in the DC metro
- Our mission is to make space-based power cheaper and more readily available to support science and national security missions
  - We serve as the extensible distribution layer connection generation and use or storage

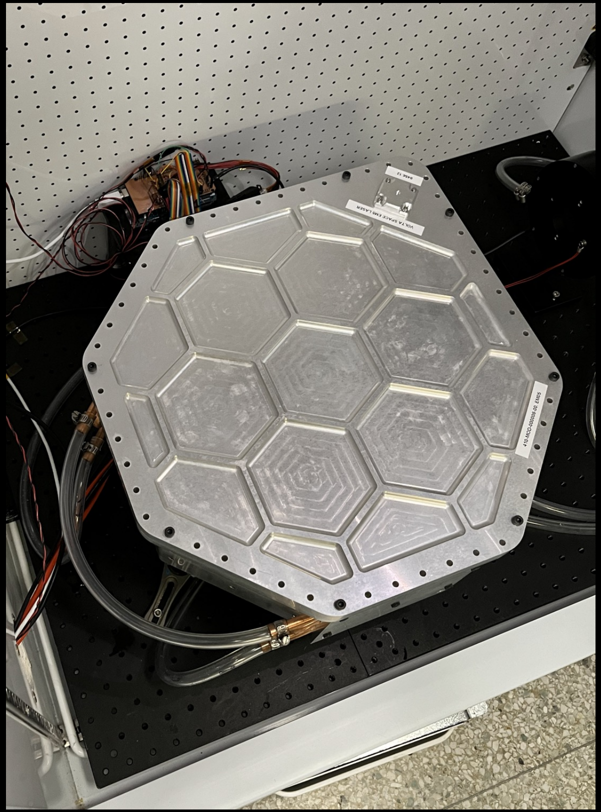




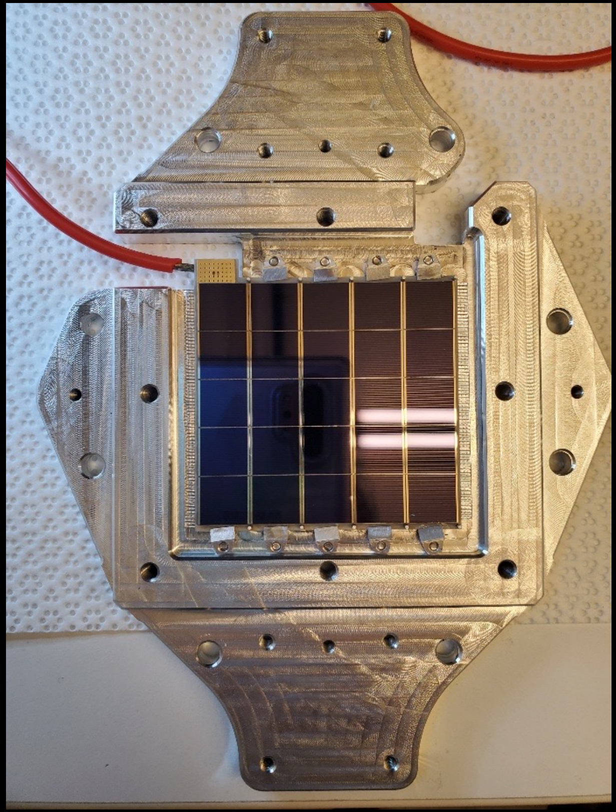
Motivation

1 – Overview

- Deep space and lunar environments are characterized by:
  - Shock and vibration during launch and landing
  - The absence of any meaningful atmosphere
  - Extreme temperature swings
  - High energy radiation
- Lasers and laser receivers don't love these environments



Laser unit discussed in this presentation

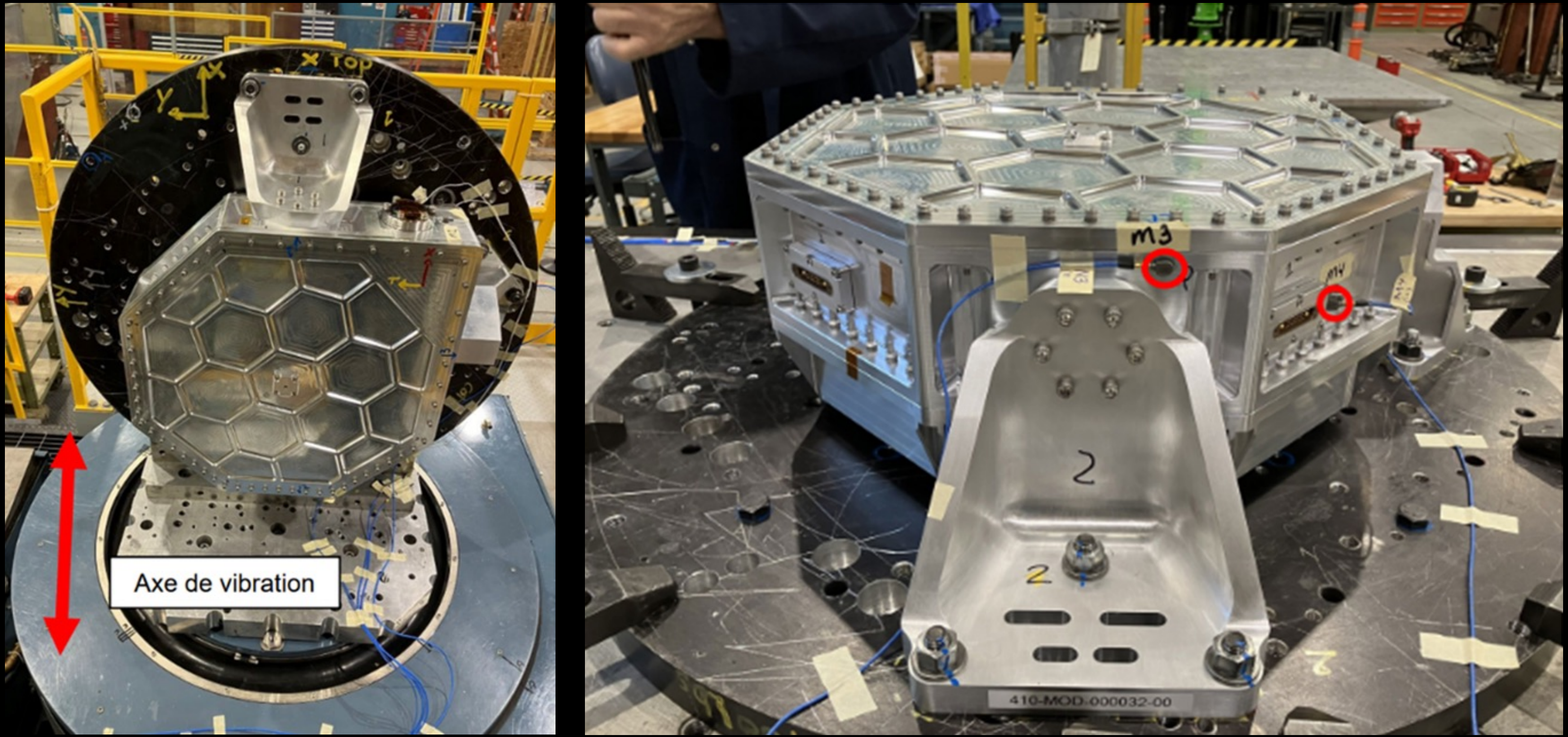


Receiver array discussed in this presentation

Shock & Random Vibration

2 – Laser Testing

- Our shock/vibration profiles were taken from the Falcon 9 Maximum Predicted Environment (MPE)
- Pre- and post-shock/vibration testing of the laser showed no performance degradation

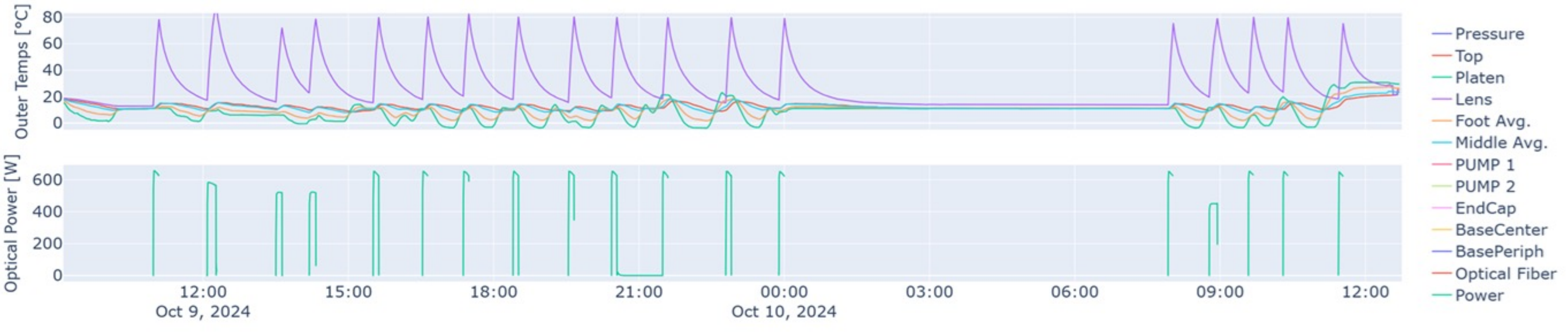


Shock & random vibration test fixture with laser mounted

Thermal Vacuum

2 – Laser Testing

- Periods of operation were followed by idling, simulating repeated beaming sessions from lunar orbit to lunar surface
- The laser demonstrated repeatability and predictable temperature-driven behavior; low temperature increasing beaming time, high temperature lowering it

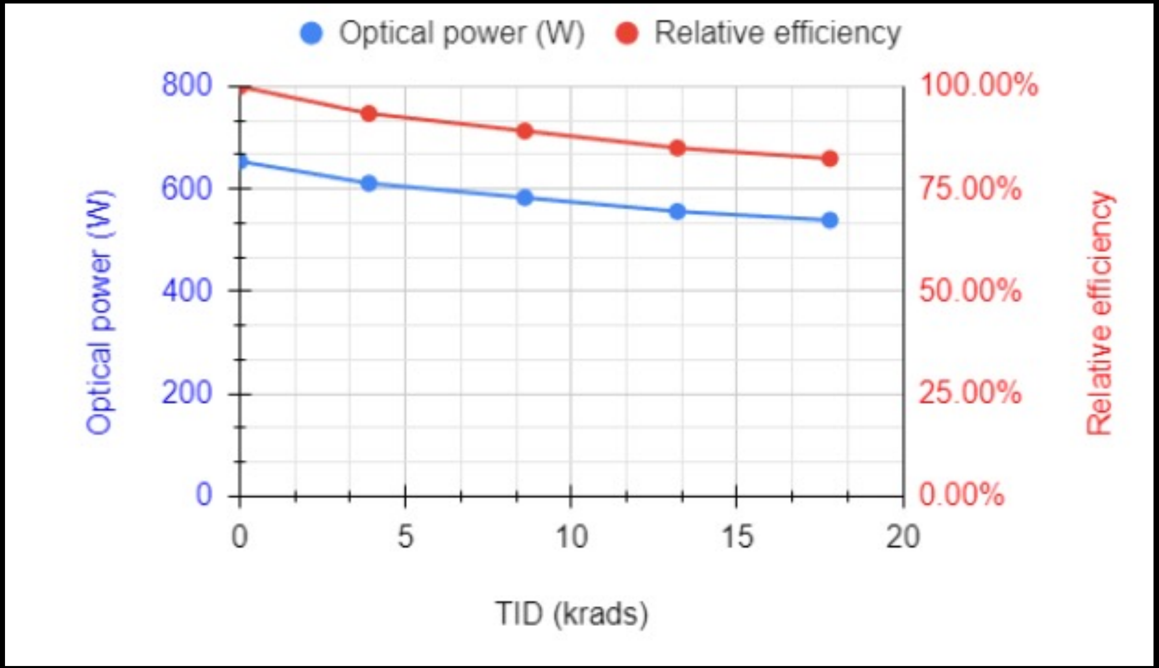


Thermal vacuum testing results for 18 beaming sessions at various starting temperatures

Radiation

2 – Laser Testing

- A 15-year mission with an orbital vehicle in a 50km circular, lunar orbit would result in ~0.3 krad of total ionizing dose (TID)
- Testing up to 17.8krad showed a 17.58% loss in output optical power
- We expect a typical mission to see <5% performance degradation

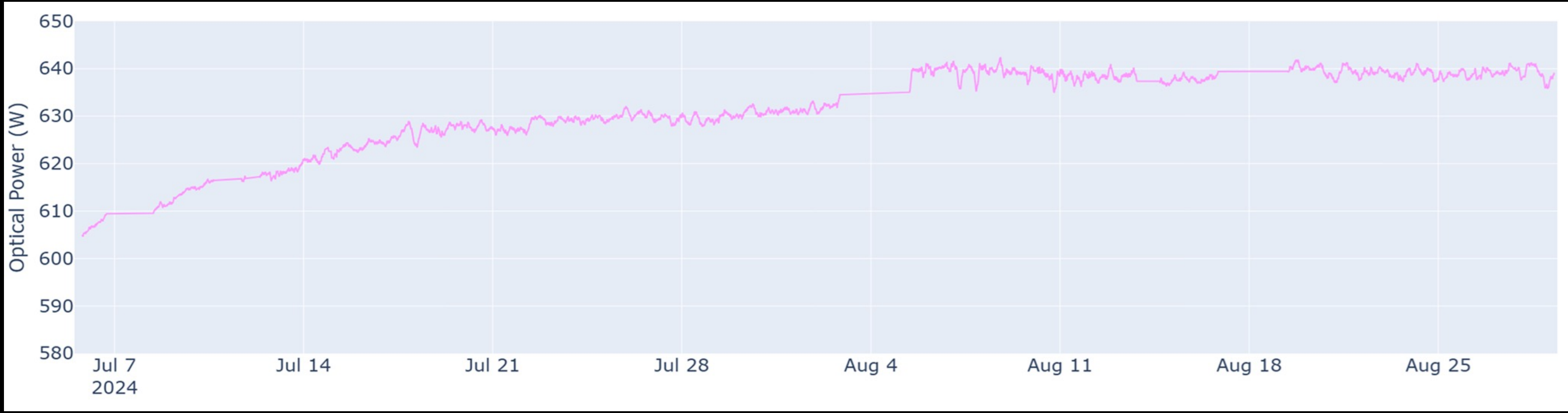


Laser performance as a function of TID up to 17.8 krad

Lifetesting

2 – Laser Testing

- Lifetesting was conducted after TID testing and saw an increase in optical output to nearly pre-TID levels; a behavior attributed to annealing of the laser fiber
- 1,095 hours of active beaming corresponds to over 3.5 years of beaming, assuming CONOPs of 4 minutes of beaming per 2-hour lunar orbit

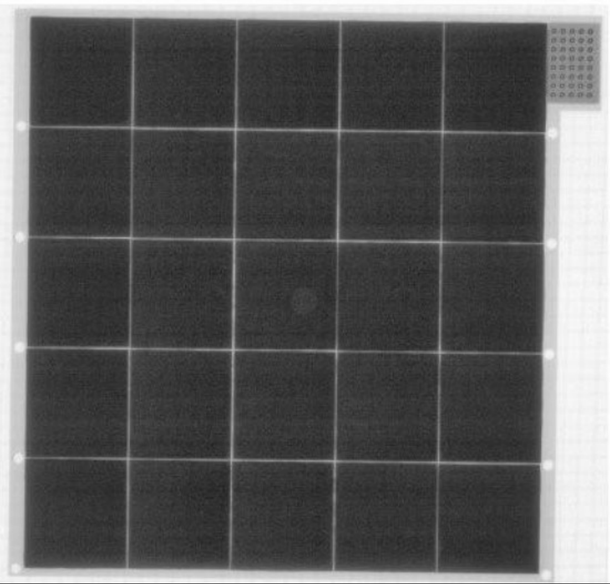


Optical power over the course of 1,095 hours of lifetesting at 25ºC

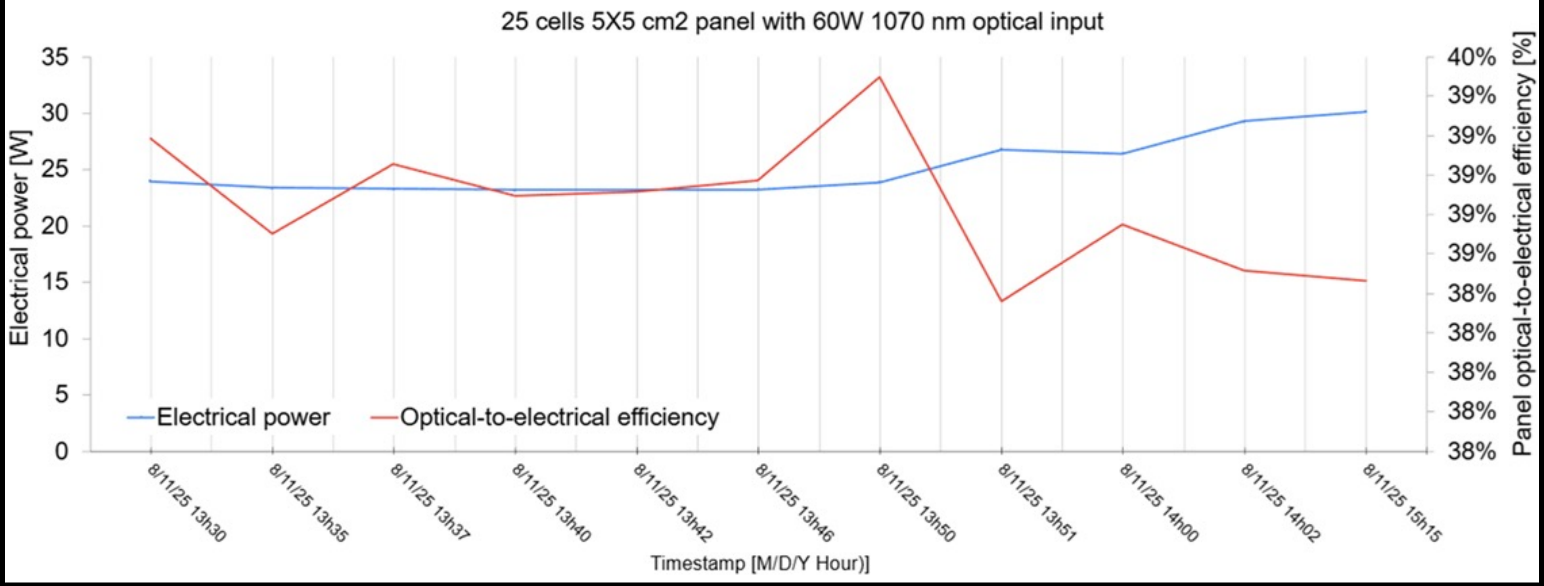
Efficiency

3 – Receiver Testing

- A 5x5 receiver cell array, composed of 25 InGaAs cells, is used as the receiving side of Volta's power transfer architecture
- Testing showed optical-to-electrical conversion efficiencies up to 39%



X-ray image of a 5x5 receiver cell array

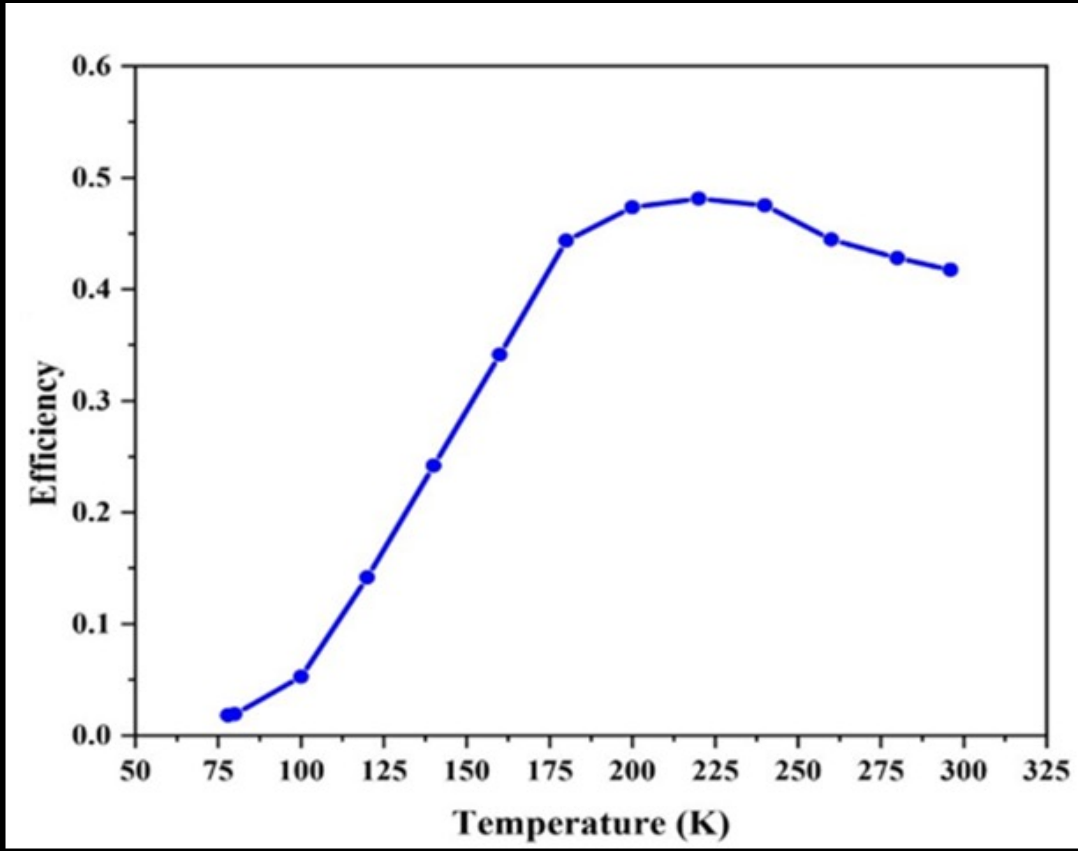


Optical-to-electrical power generation and conversion efficiency

Thermal

3 – Receiver Testing

- Temperatures on the surface of the moon can reach as low as ~40K during lunar night or in permanently shadowed regions
- Thermal testing was performed on an individual receiver cell over a range from 75K to 300K
- Peak efficiency of ~45% was observed at ~225K



Optical-to-electrical conversion efficiency as a function of cell temperature

4 – Findings & Future Work

- This testing has allowed us to:
  - Develop a much greater understanding of the thermal effects of high-power beaming in a space environment
  - Demonstrate that our laser hardware will withstand the mechanical and radiation environments required to enter deep space
  - Confirm that our laser hardware is capable of a multi-year mission duration
  - Characterize receiver array performance over a range of representative lunar surface temperatures
- The next iteration of this hardware, a higher power laser and larger receiver array, are already in design with an environmental test campaign planned for Q4 2026

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