BLUE ORIGIN LUNA-10 AN EXPEDITED APPROACH TO A COMMERCIAL LUNAR SURFACE ARCHITECTURE

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LSIC SPRING MEETING

APRIL 25, 2024

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Three Complementary Multi-Service Systems to Enable Viable Commercial Lunar Surface Infrastructure

Three Multiservice Elements

1. **Lander Infrastructure Node and Host Platform**
2. **Laser and Power Framework for Energy, Communication**
3. **ISRU via Molten Regolith Electrolysis for Construction, Mining and Energy**

Unique Insights

- Blue Origin is internally funding the development and two demonstration missions of the MK1 lander
- 1kW – 100 kW of reliable power is important for ISRU and other fixed assets and mobile elements
- As few as 3 properly situated power nodes near the lunar south pole can provide almost continuous power across hundreds of square km, potentially allowing individual end-user elements to re-allocate mass from energy storage to other functions
- Blue Alchemist ISRU technology, funded by NASA STMD Tipping Point to TRL6, breaks the paradigm of delivering elements from Earth to the Moon.
  - Enables lunar production and delivery of regolith derived materials such as O_2, iron, silicon, aluminum, and construction slag.
- Regolith derived materials can then be used in fabrication of solar panels, wires, radiators, radiation shielding, road surfaces, and delivered as propellants.

Completed Work

- The MK1 lander design completed and first vehicle integration under way under internal Blue Origin funding, flying on early New Glenn mission.
- PowerLight has conducted kilowatt-class laser power beaming TRL4 system demonstrations with the NRL.
  - Integrated transmitter, beam pointing , “safety sleeve”, and receiver technologies
- Honeybee LAMPS vertical solar array technology completed NASA STMD Phase 1 and executing on Phase 2.
- Blue Origin has developed Blue Alchemist ISRU technologies, including demonstrating each stage in the process from initial molten regolith kilns to solar array fabrication, with high fidelity ground demonstration units.

MK1 Can Support Early Demos and Sustained Operations

- **Flight Proven Before MVE –** At least two MK-1 missions will have resolved risk areas prior to Minimum Viable Experiment
- **3 ton Payload –** Will accommodate ISRU technology payloads and 1 kWe transmitted power across 10 km+ to various assets including enabling long-term rover operation in a PSR
- **Flexible Payload Accommodations –** MK1 has multiple interfaces for all foreseeable payloads to address DARPA Thrust Areas as well as NASA objectives
- **MK1 Minimum Viable Experiment Demonstrates MK1 Infrastructure Node –** MVE validates aspects of the MK1 acting as a long-life lunar surface power, communications, and PNT Node in the 2030's

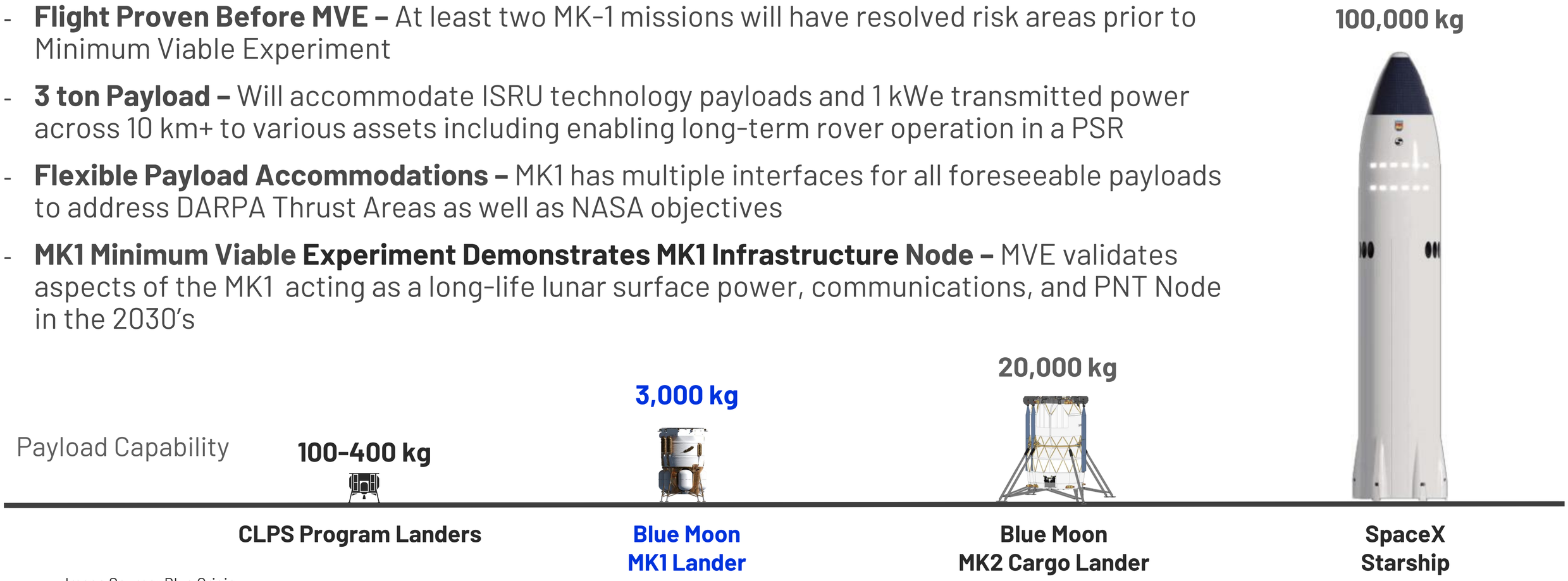

Image Source: Blue Origin

Our MK-1 lander is well sized both to host Minimum Viable Experiment demonstrations and act as a long-term node for lunar surface power, communications and PNT

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Example Lunar Surface Infrastructure Relationships Between LunA-10 Teams

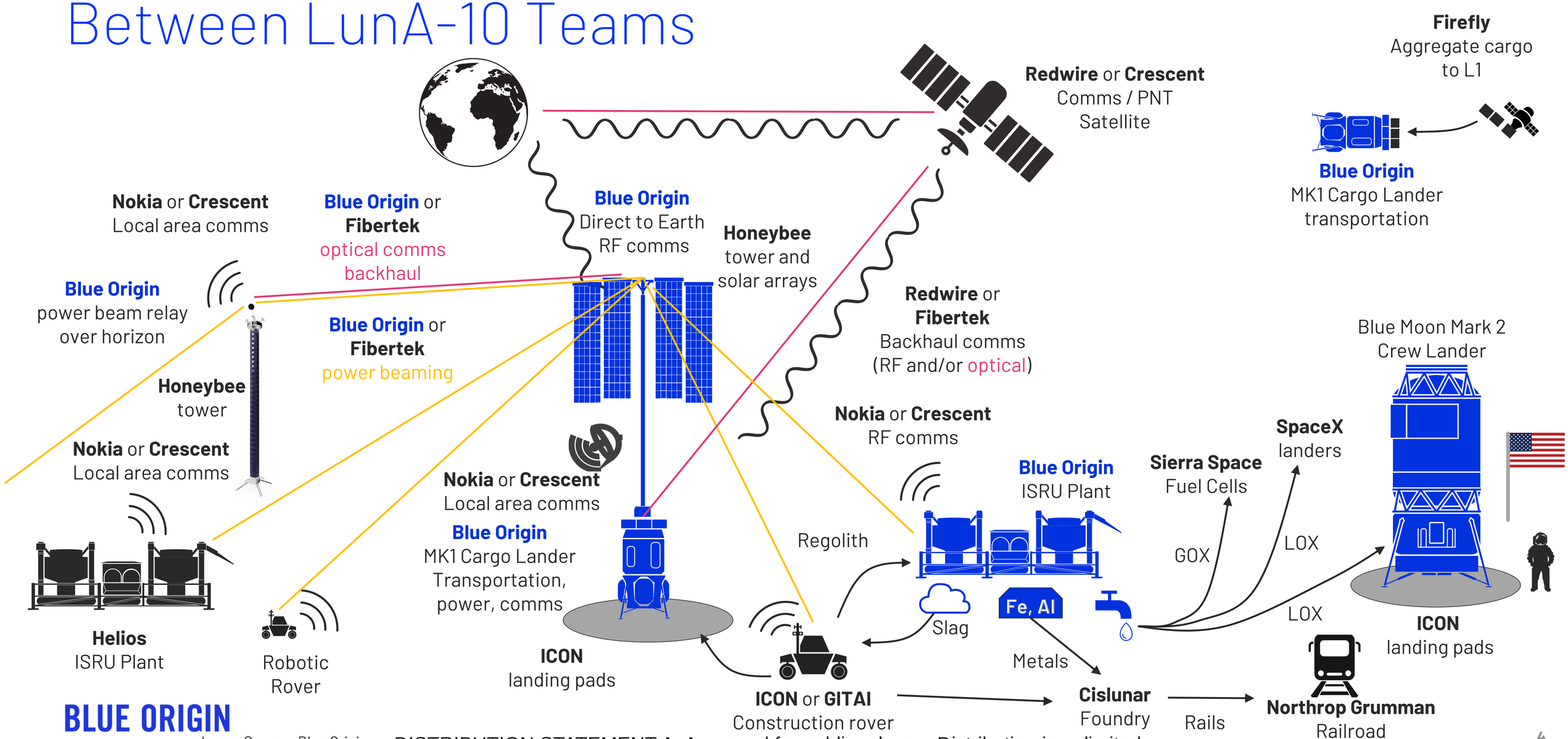

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Image Source: Blue Origin

Infrastructure Concept - 2035

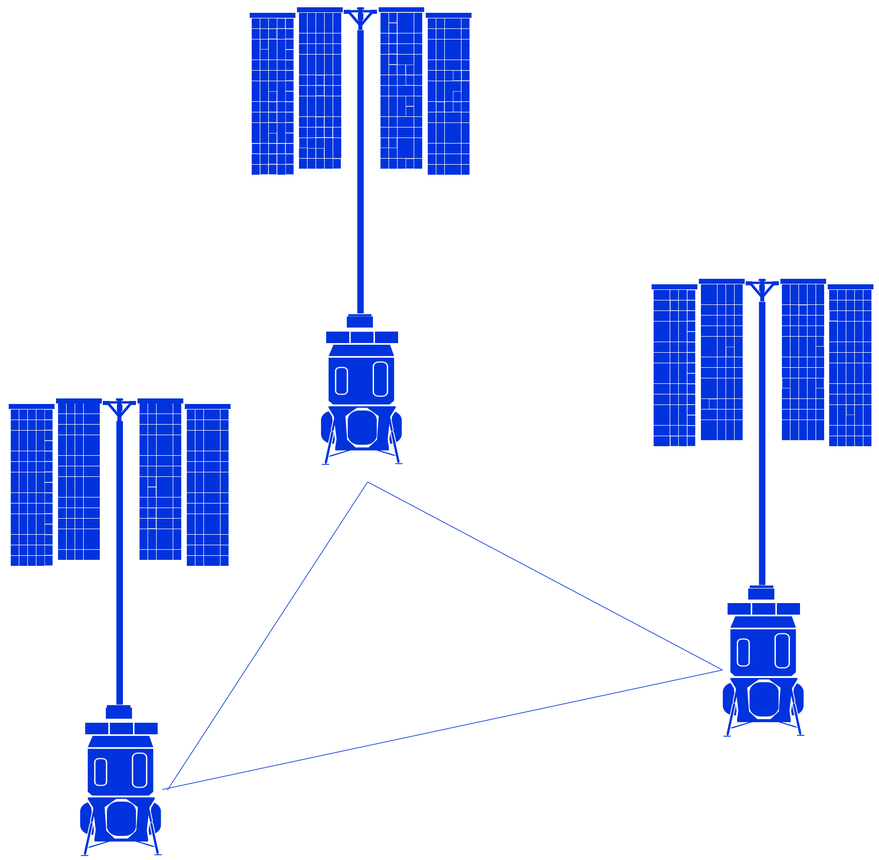
1) Power & Communications Utility service, 2) Cargo delivery service, 3) Materials Supply

Our concept may provide an infrastructure for the following services through a mesh network of landed assets:

1) Deliver cargo to lunar surface
2) Establish infrastructure node and host platform for other customer hardware
3) Provide day/night wireless power via laser power beaming to offboard users
4) Provide day/night wired power to hosted and adjacent users
5) Provide regolith-generated O_2, slag, and metals
6) Provide backhaul comms Direct to Earth and over surface

Blue's notional initial demonstration system demonstrates one node

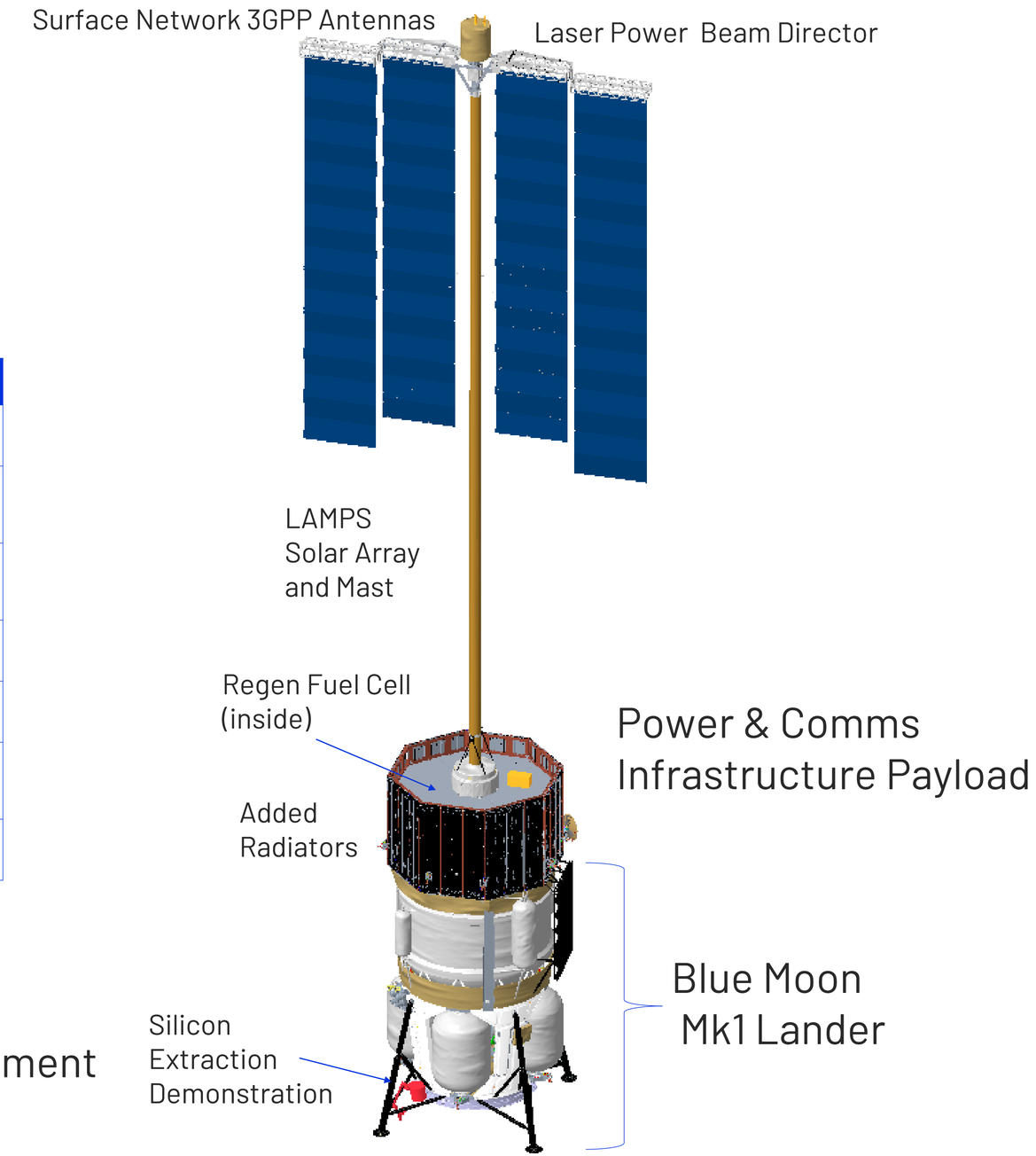
- Mk1 Cargo Lander
- Power & Communications Infrastructure Payload Kit
  - Vertical Solar Array Technology (VSAT)
  - Power Storage System for overnight power
  - Laser Power Beaming
  - Radio and/or Optical. Comms
  - Power Conditioning
- Silicon extraction ISRU experiment using Molten Regolith Electrolysis (MRE)



System Configuration

INITIAL DEMONSTRATION SYSTEM

Features	Capability
Solar Array	> 10 kWe
Mast	20 m mast on ~10 m lander (total 30 m above surface)
3GPP Telecom Service	25 Mbps bps up to > 10 km range, max range ~100 km
Regen Fuel Cell Augmentation Kit	1.5 MWh, 7.8 kW_e over 192 hrs
Laser Power Transmitter	~1 kW_e delivered to 10+ km,
Silicon Extraction Experiment	Demonstrate production of silicon from regolith
Heat Rejection Augmentation Kit	Added Radiator area for payload power



This is a study concept, not a product development commitment

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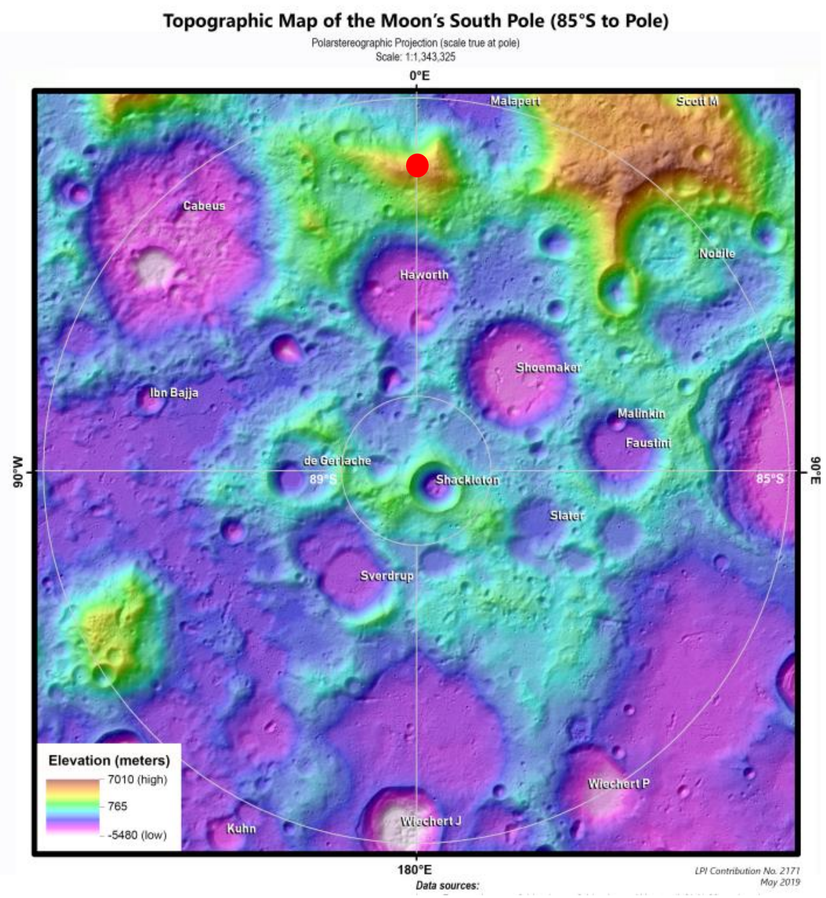
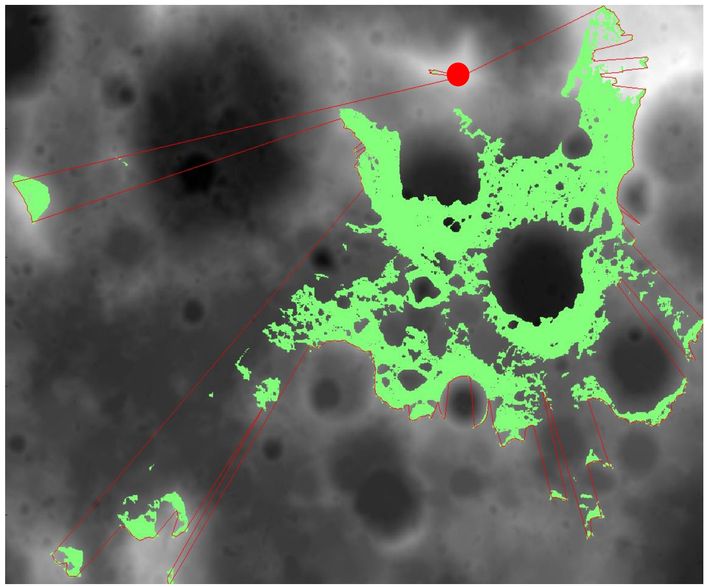
Image Source: Blue Origin

Viewshed from Utility Site at Malapert

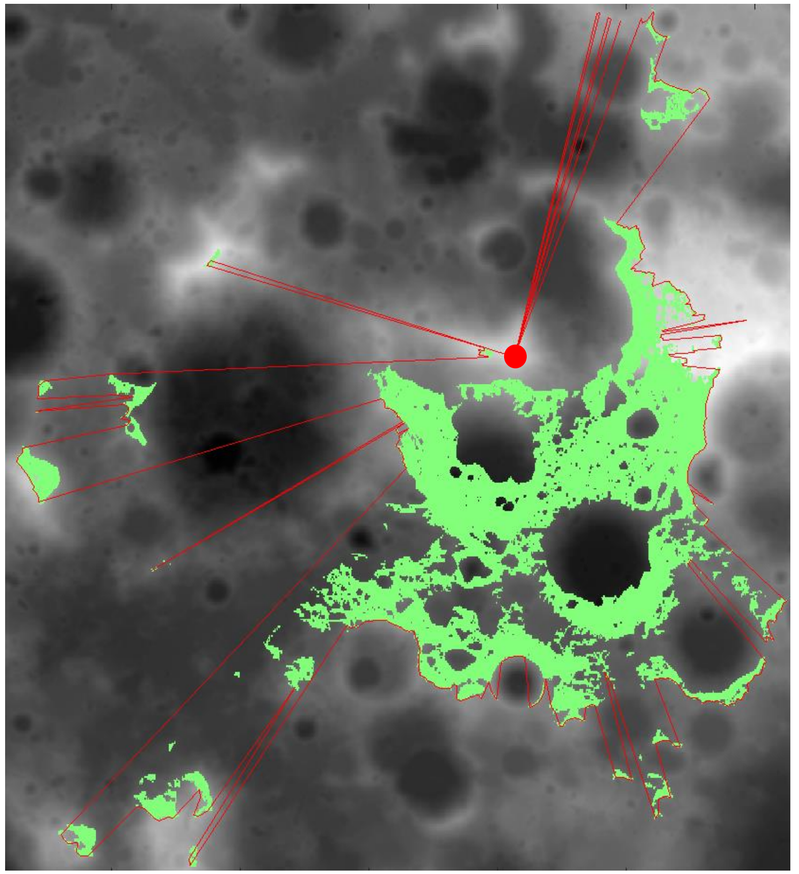
Unlike on a theoretically smooth sphere, in mountainous terrain increasing the tower height doesn't (much) extend the max distance, instead it fills in gaps in the mid-field





30 m tower to user 1 m above terrain

Source: Blue Origin



100 m tower to user 1 m above terrain

Source: Blue Origin

Max line-of-sight transmit distance for laser or RF is ~250 km
But most of the viewable area is <75-100 km

Source: Stopar J. and Meyer H. (2019) *Topographic Map of the Moon's South Pole (85°S to Pole),* Lunar and Planetary Institute Regional Planetary Image Facility, LPI Contribution 2171,

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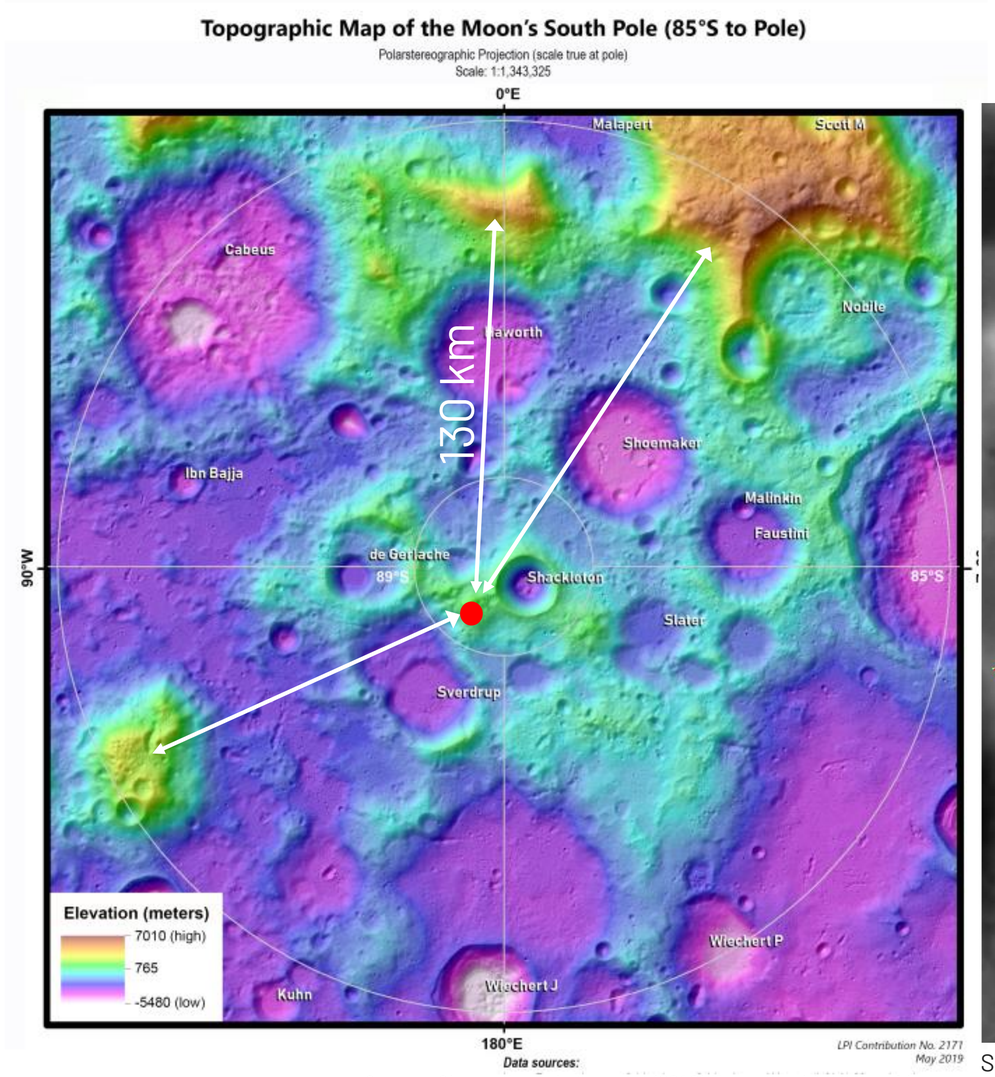
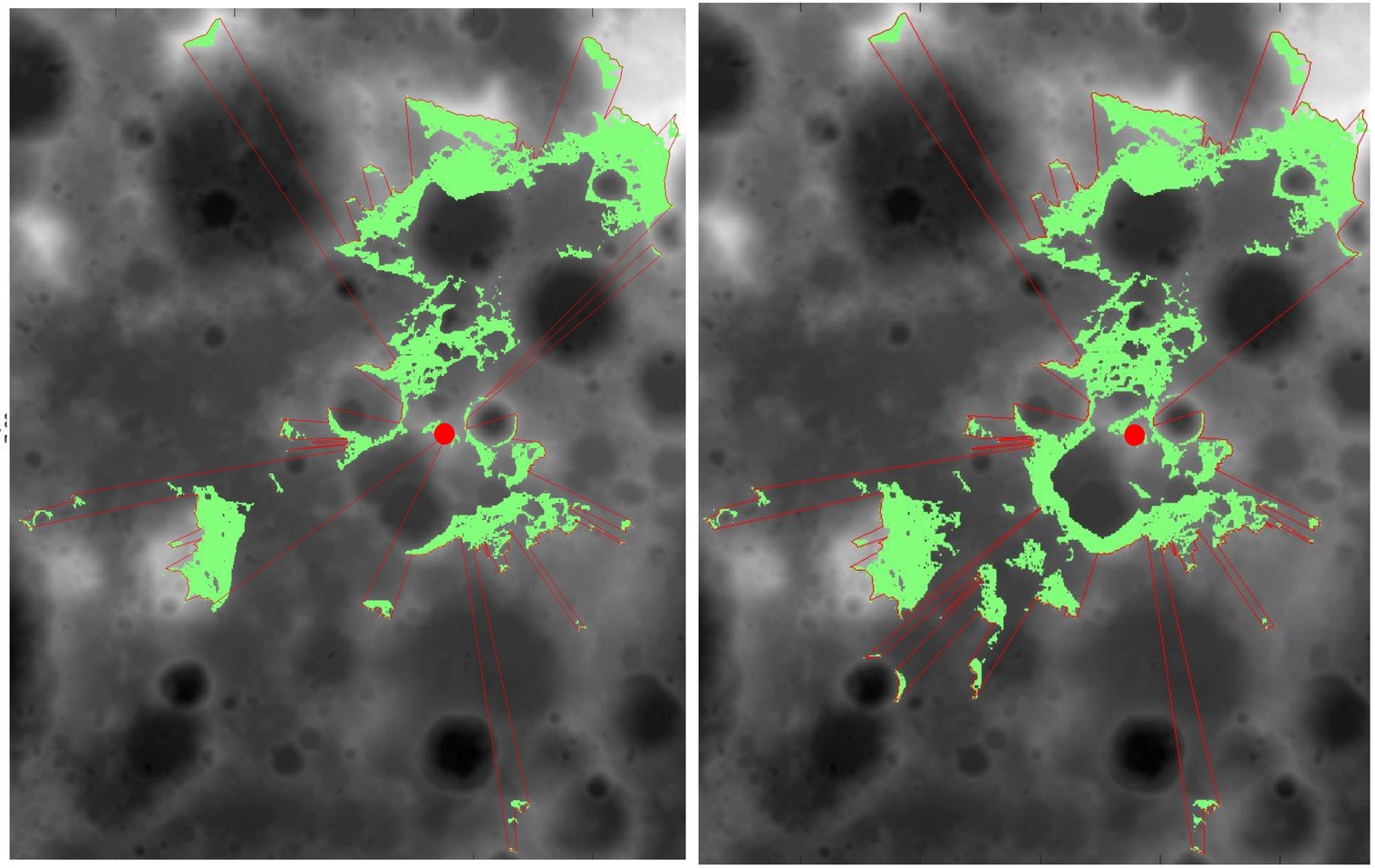
Viewshed from Utility Site at South Pole



Region with line of sight from point on the Shackleton Connecting Ridge

30 m tower to user 1 m above terrain

100 m tower to user 1 m above terrain



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The Blue Origin Mark 1 lander can deliver the basic building block of lunar power, telecom, and resource infrastructure