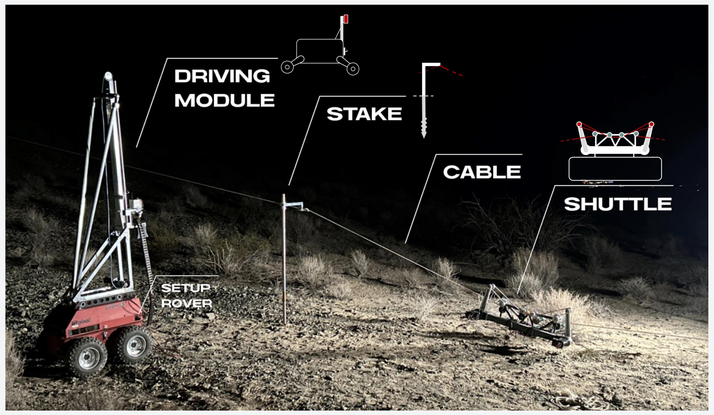
Lunar Architecture for Tree-Traversal In-service-of Cabled Exploration

California Institute of Technology

LATTICE OVERVIEW

Steep slopes, avalanches, and lunar dust are all obstacles to a permanent presence on the Moon. To overcome these challenges, we developed LATTICE, a lightweight, versatile, and long-lived robotic cableway-based infrastructure system to carry any cargo into and out of lunar craters full of vital resources. Cableways succeed on the steep slopes, while surface vehicles struggle with them. Cableways also scale indefinitely, allowing for a large, terrain-agnostic transportation network. LATTICE advances the state of the art for accessing extreme lunar terrain, transporting mass, energy, and information in one cohesive system.

EARTH PROTOTYPE



LATTICE system in Lucerne Valley

SCALING LAWS

$T_{cable} < W_{shuttle} L_{span} / 4H_{max\ droop}$ ← *Limited by Shuttle actuator torque density*

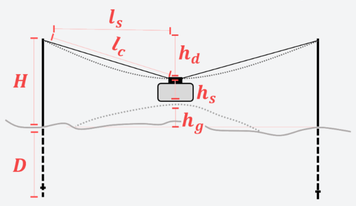
$M_{stake} \propto H_{stake} R^2_{stake}$ ← *Lim. by deployment vehicle size (spool)*

$W_{shuttle} L_{span} \propto R^3_{stake}$ ← *Lim. by lander, driving mechanism*

Cantilever beam moment capacity

$M_{system} \propto L_{total\ span} / R_{stake}$

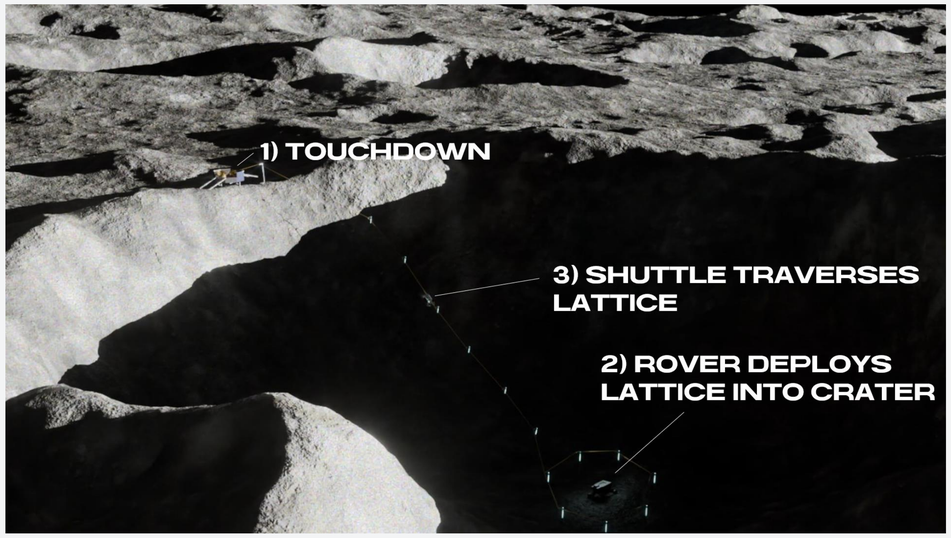
$\propto L_{total\ span} (W_{shuttle}^{2/3} / L_{span}^{1/3})$



KEY TAKEAWAY

Architecture Favors:
- Wide, Short Stakes
- Long Spans
- High Tension
- Many Lightweight Shuttles w/ High Torque Density

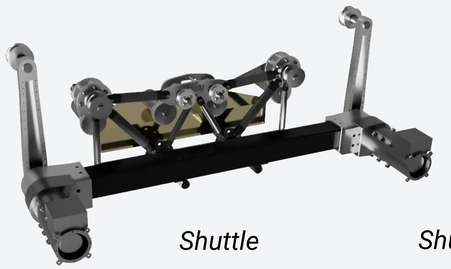
CONOPS



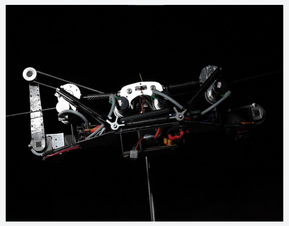
Component Test	Description	Conditions	TRL	Results
Stake	Side loads on stake in ground, removability	Lucerne Valley	4	Withstands cyclic 2.5 kN base side load with little ground deflection
Driver	Ability to drive a stake into the ground	Lucerne Valley	4	Driver can drill a stake up to 75 cm into ground, drawing less than 5 W
Shuttle	Ability to tension and lift off ground to traverse slopes and cross stakes	Lucerne Valley	4	Shuttle tensions and lifts self off ground, traverses >20° slopes, and crosses stakes

SHUTTLE

Shuttle travelling on cable with payload

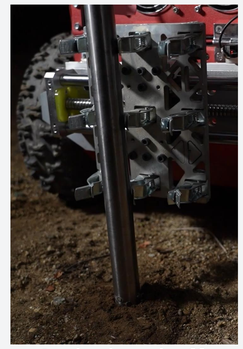


Shuttle

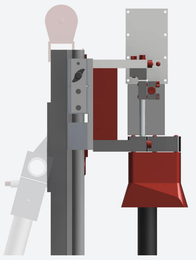


Shuttle performing stake transition and switching arms

DRIVER



Stake hand-off

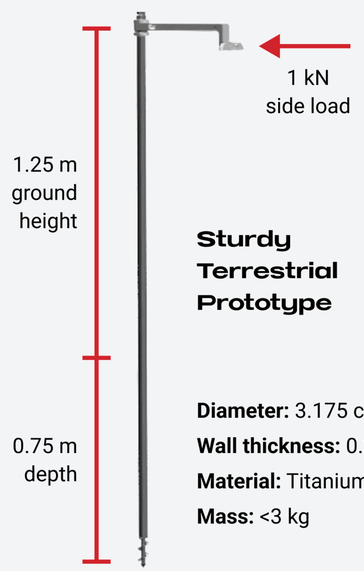


Driving mechanism

Driving stake into ground

STAKE

Partially driven



Sturdy Terrestrial Prototype

Diameter: 3.175 cm
Wall thickness: 0.32 cm
Material: Titanium
Mass: <3 kg

Stake schematic

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Shuttle Lead & Deputies: Malcolm Tisdale, Yao Huang, Matteo Kimura **Stake Lead:** Calle Junker
Advisors: Prof. Soon-Jo Chung Dr. Issa Nesnas Prof. Charles Elachi Prof. Paul Dimotakis Dr. Jason Kastner Mr. Steve Wall Prof. Michael Mello