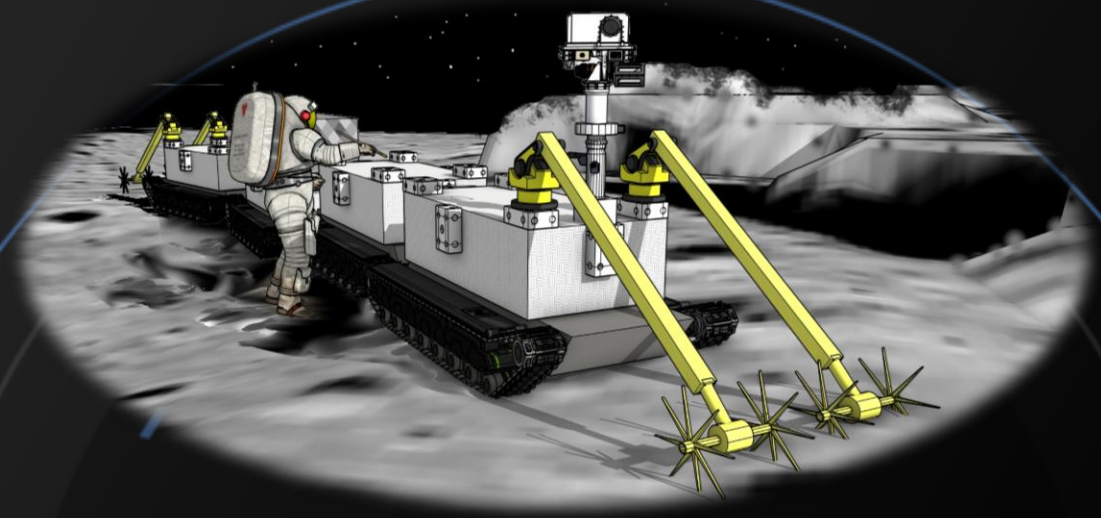


LUNAR HALO

MODULAR ROVER CONCEPT

KENT NEBERGALL
MACROINVENT.COM

ABSTRACT

Modular Rover Technology for Human Outposts

In late 2024, I won a $20K NASA prize for designing a rover that could do science and light industrial work in the moon's permanently shadowed craters. The rover design draws from over 100 years of polar exploration engineering and Mars rover situations. I created a modular solution that could work in nearly any unknown terrain, while being field-maintained by astronauts. The result was called Lunar Halo.

While designed for the moon, this rover concept is ideal for crossing the Martian dust fields that trapped the Spirit rover, climbing the steep slopes that caused Perseverance to backslide, and exploring in lava tubes with poor lines of communication. It can do both exploration and light industrial hauling within and beyond human outposts. It's essentially the sure-footed burro to accompany the pressure-suited prospectors of the new frontier. The rovers are small enough to fit through a human airlock for maintenance but can be locked together into crawler platforms for transporting larger equipment.

NASA "FIND ME ON THE MOON" COMPETITIONS

Low Tech Navigation

- 10 prizes, $5K maximum
- Low-tech navigation for astronauts.

Shackleton Sampler

- 3 prizes, $20K maximum
- Bring samples back from Shackelton Crater reliably.

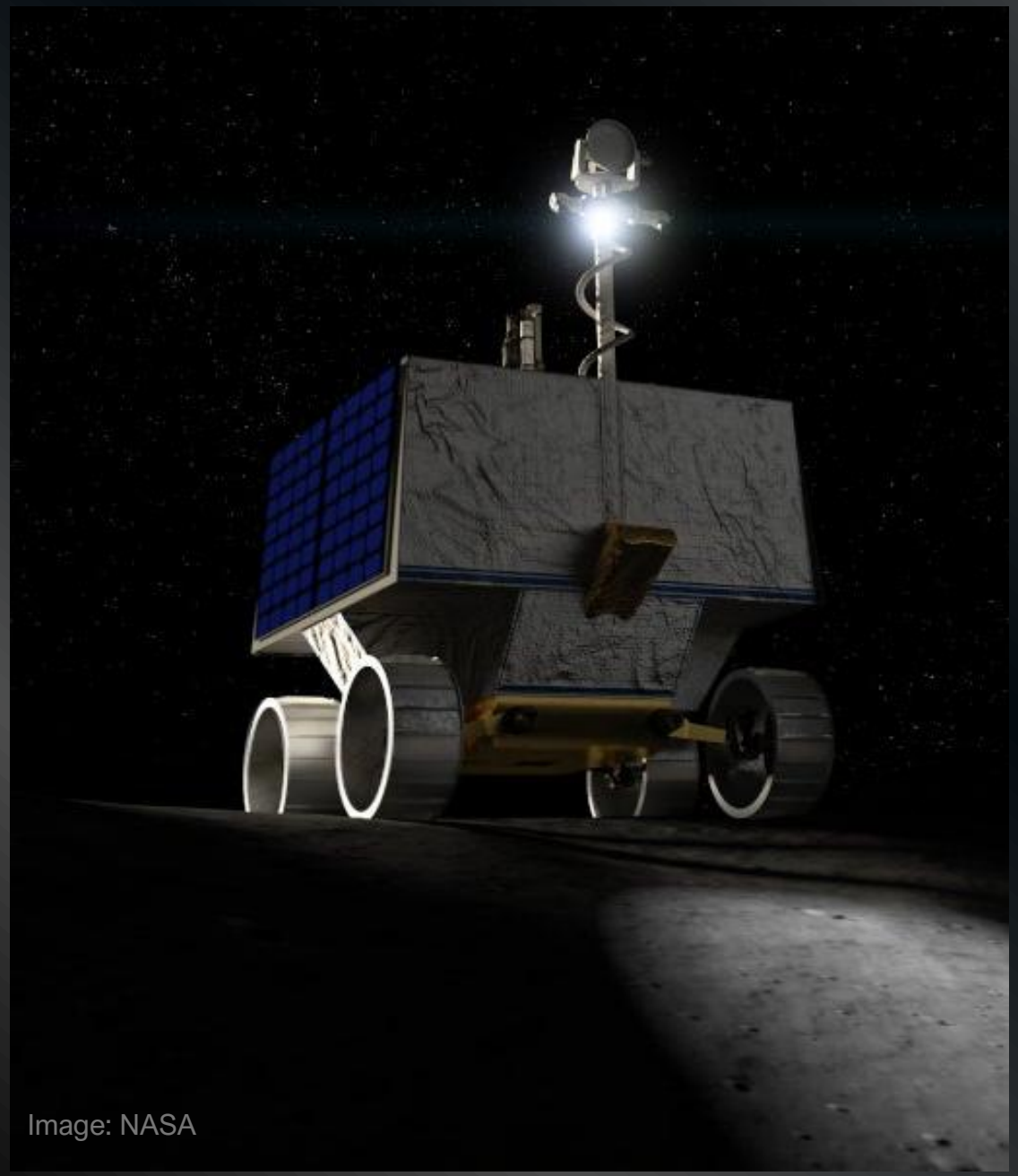
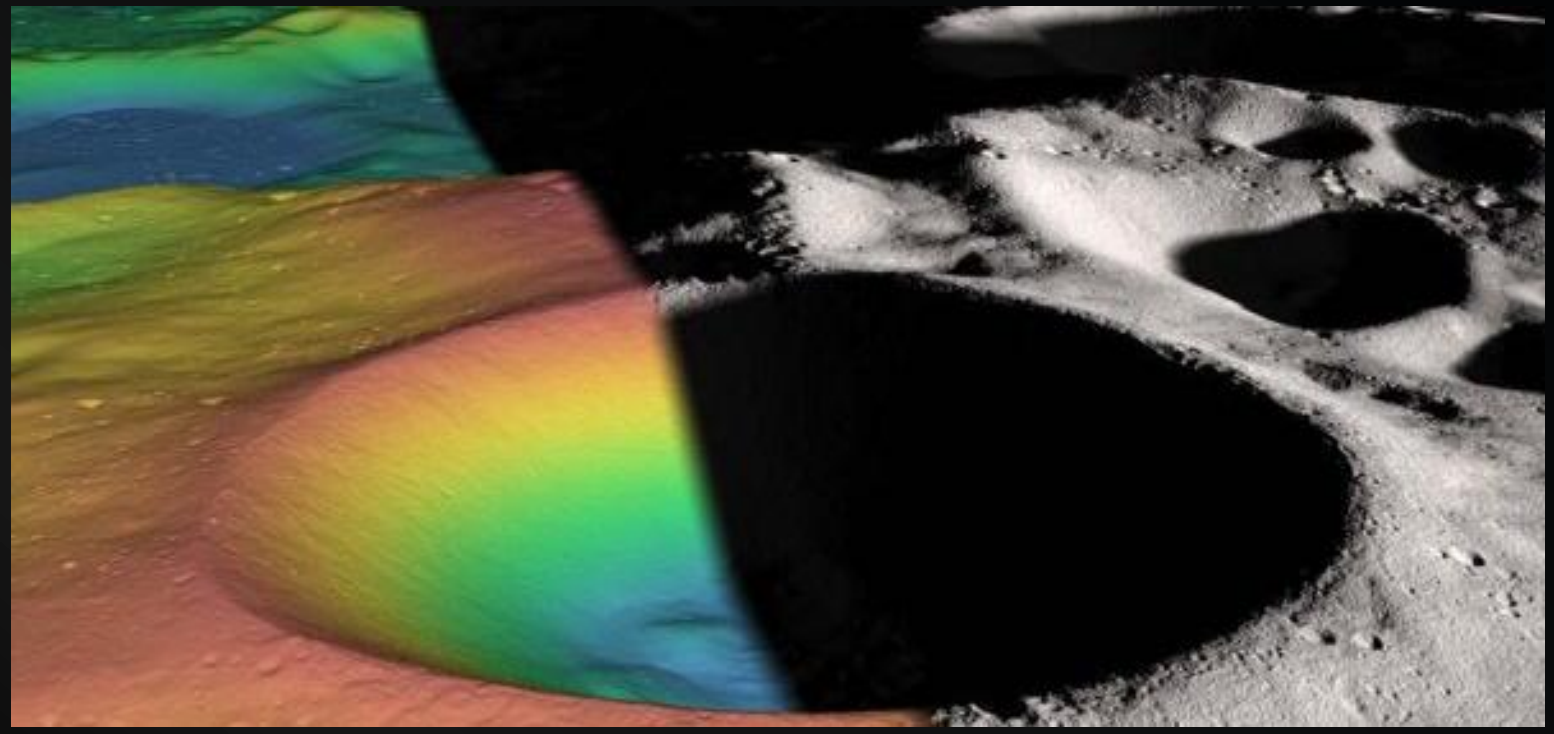


Image: NASA

WHY SO DIFFICULT?

SHACKELTON CRATER

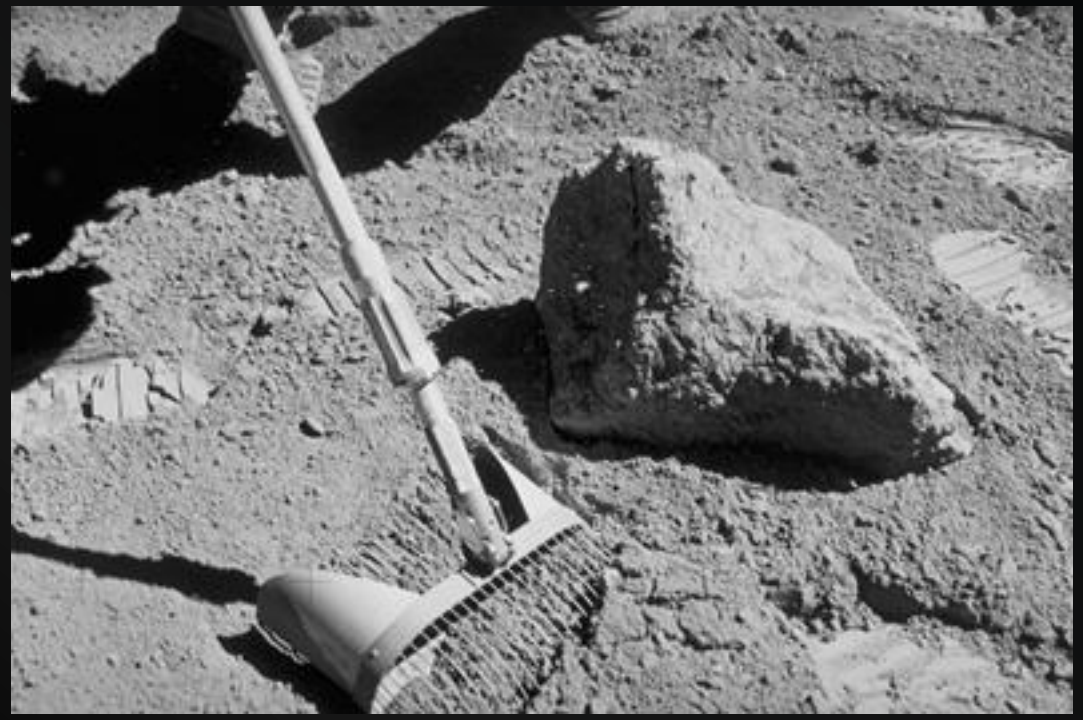


5 km slopes at a step grade – “Medium” ski slope equivalent

+ No light for billions of years. Pluto-like temperatures

Absolutely unknown geomorphology

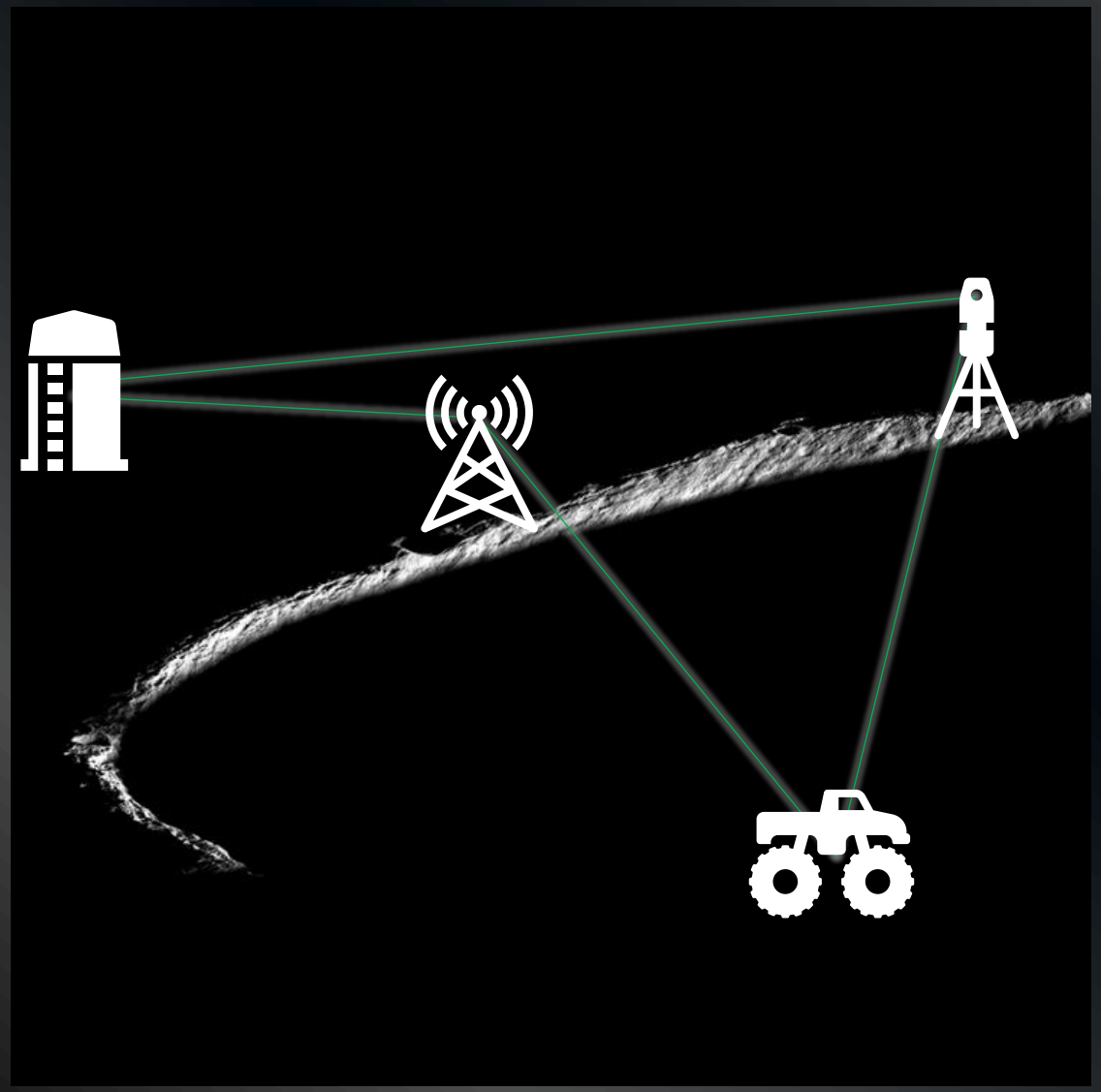
LUNAR REGOLITH



Worst properties of metallic grit, shattered glass, and ceramics with no erosion, so everything is sharp and embeds in surfaces, equipment, seals, etc.

MODULARITY

DESIGNED FOR PRACTICALITY



COMMUNICATIONS AND NAVIGATION

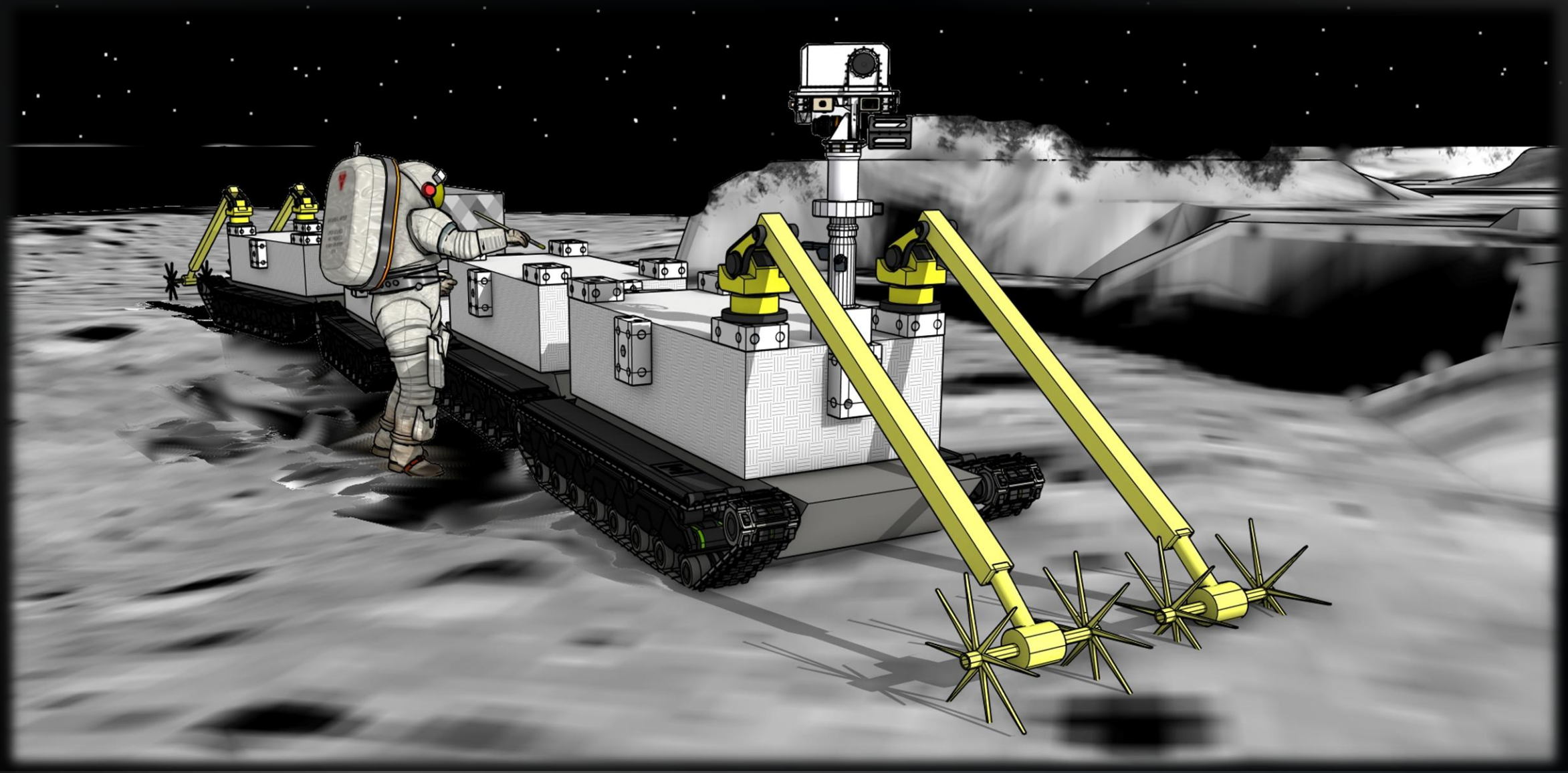
Primary – Laser to relays at the top. Also traditional S or K band comms.

Secondary – strobe coding like your living room IR remote.

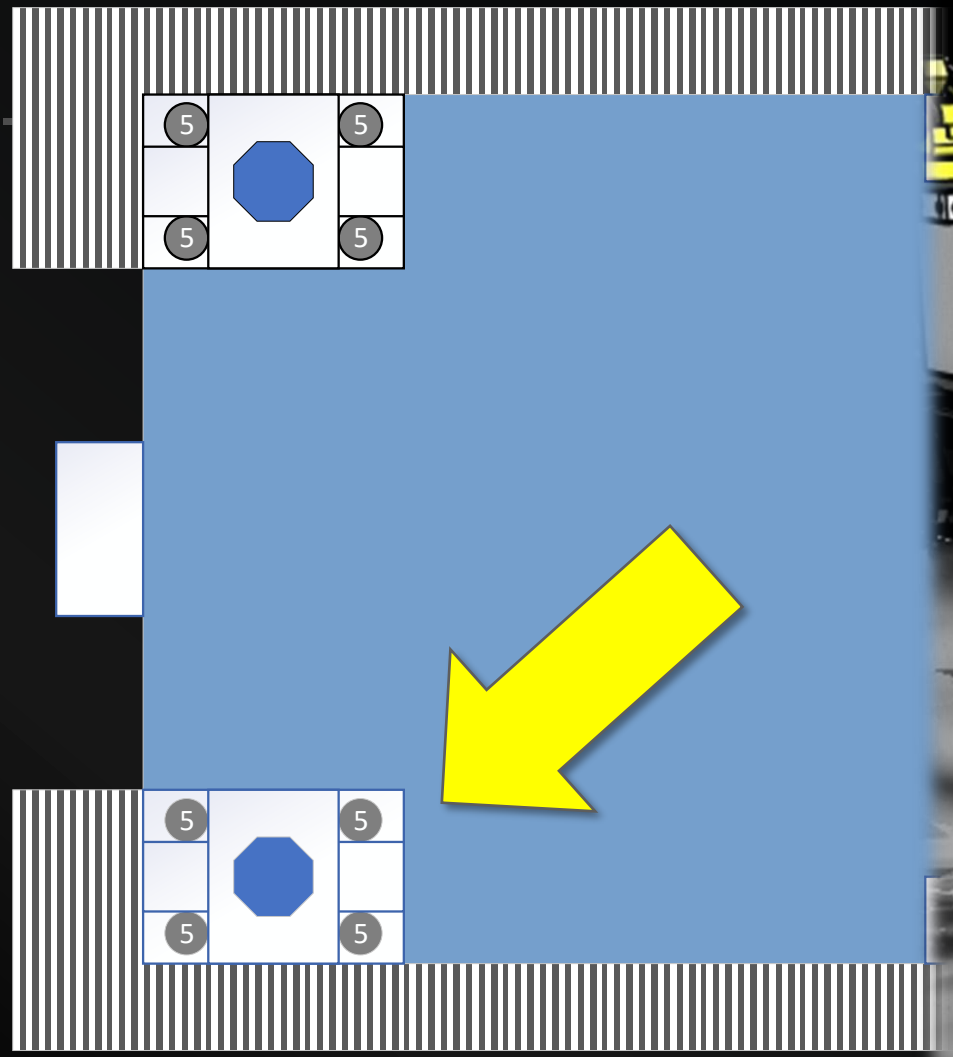
Backup – AM and FM frequency radio, also for Navigation backup

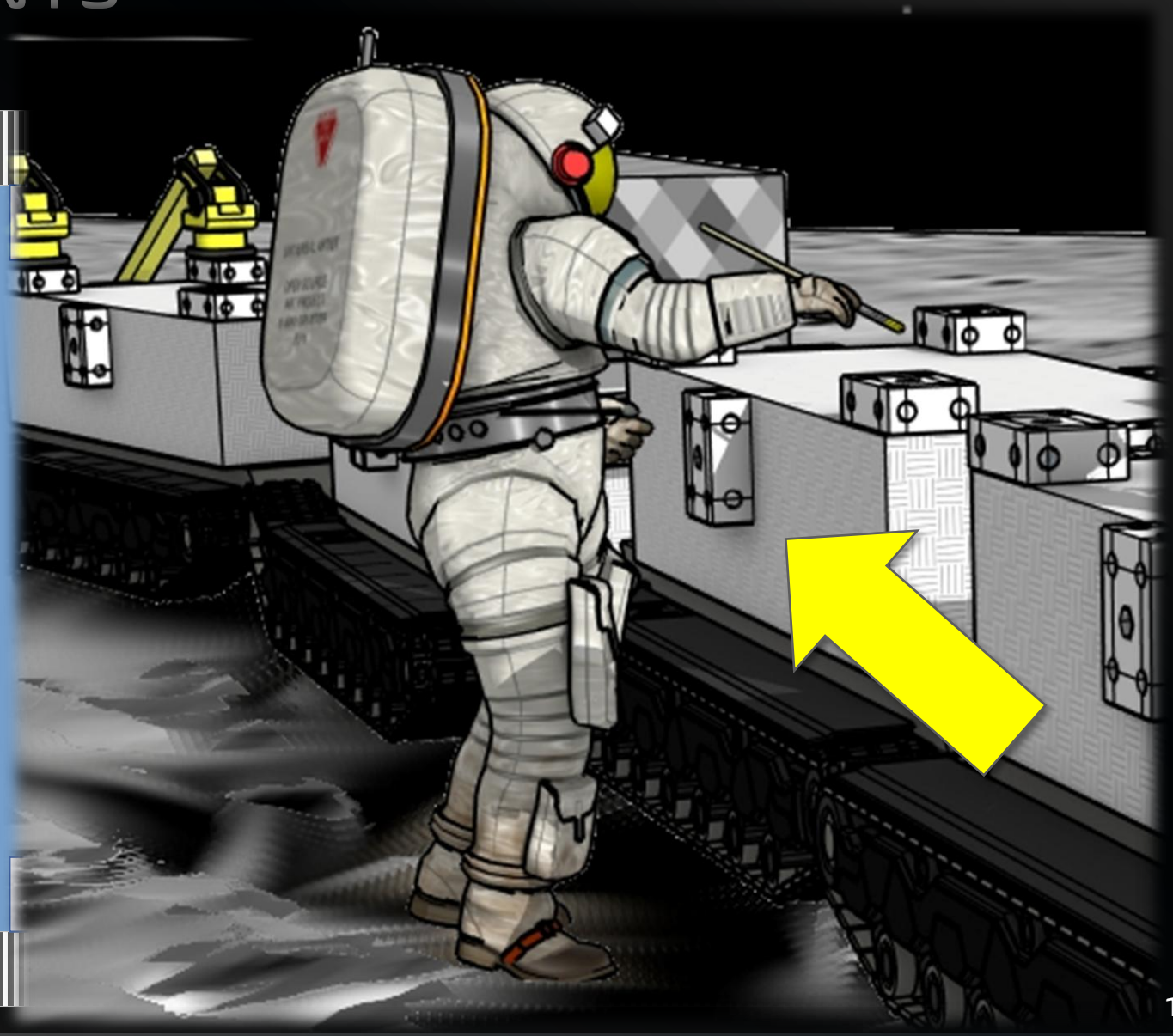
All elements are mesh networked.

MODULAR HARD POINTS

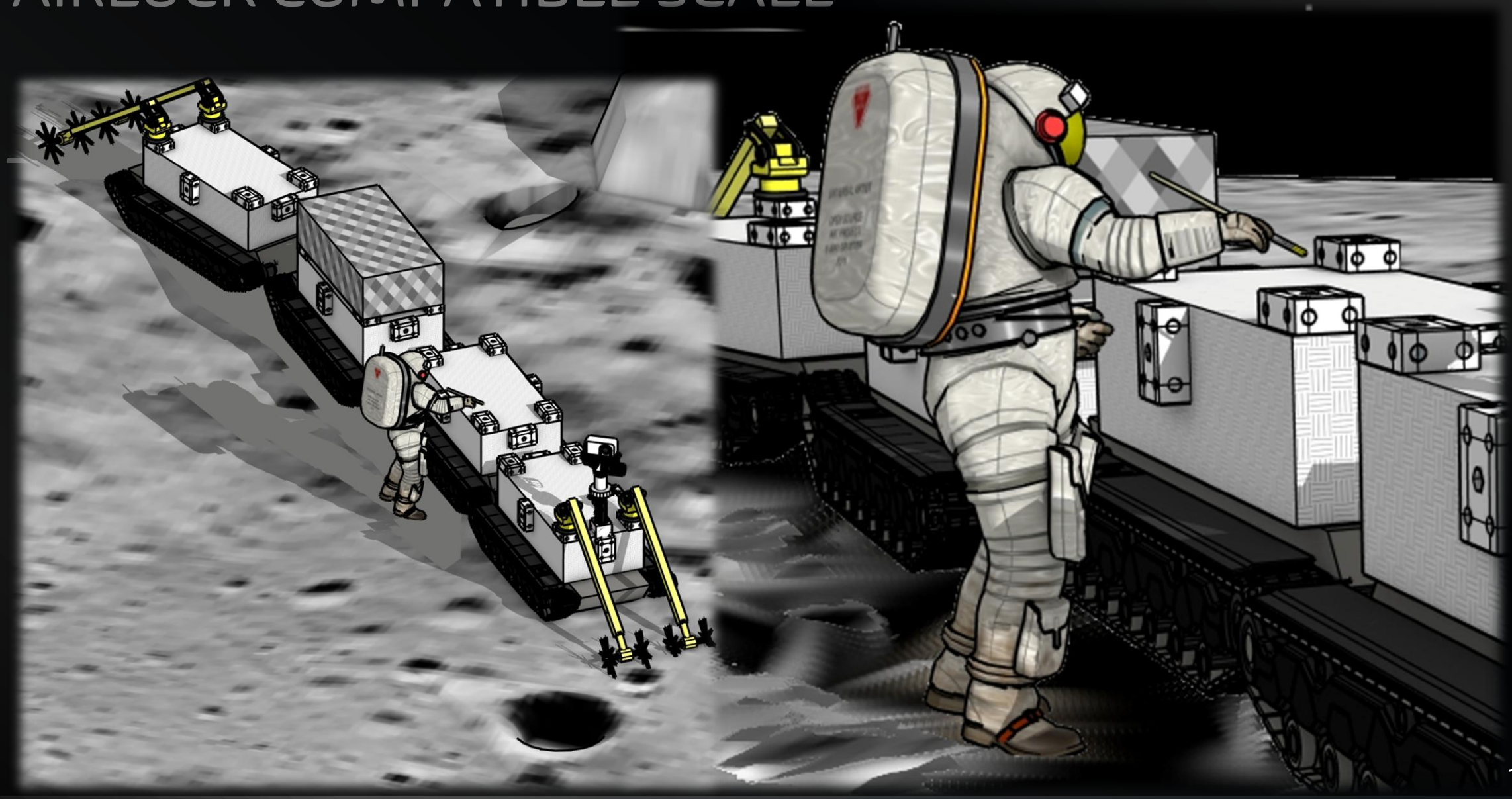


MODULAR HARD POINTS



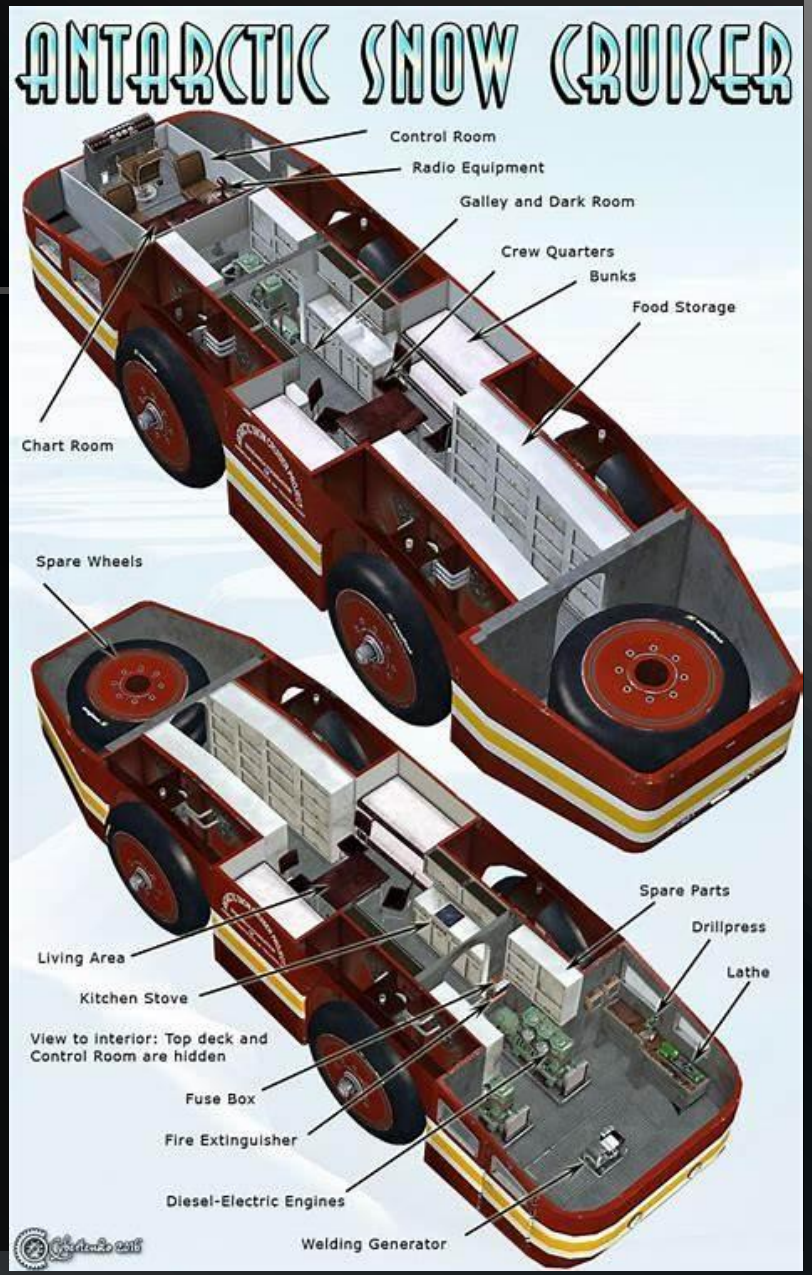


AIRLOCK COMPATIBLE SCALE



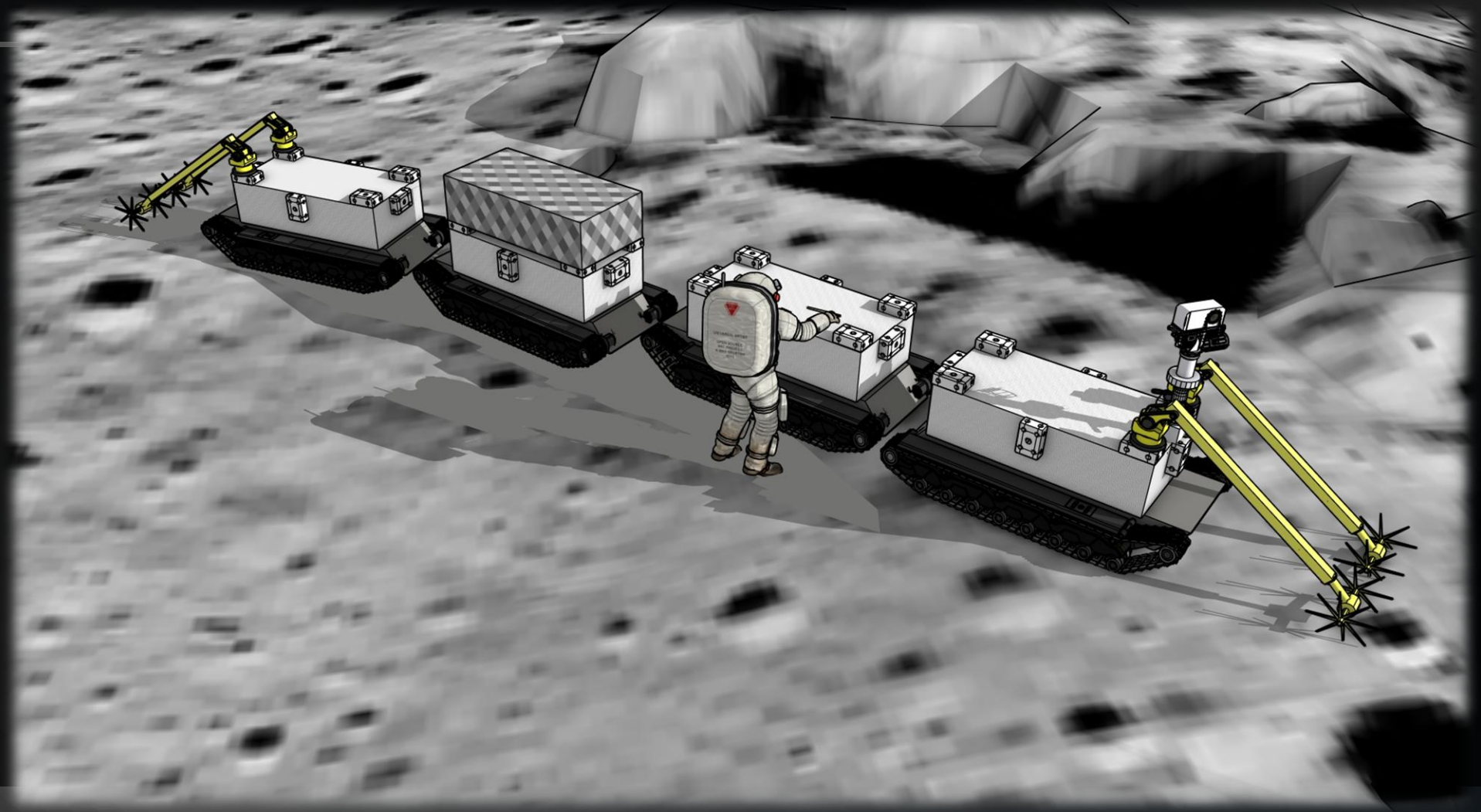
POLAR PROBLEMS REQUIRE POLAR SOLUTIONS

PROBLEM – WHEEL LOADING

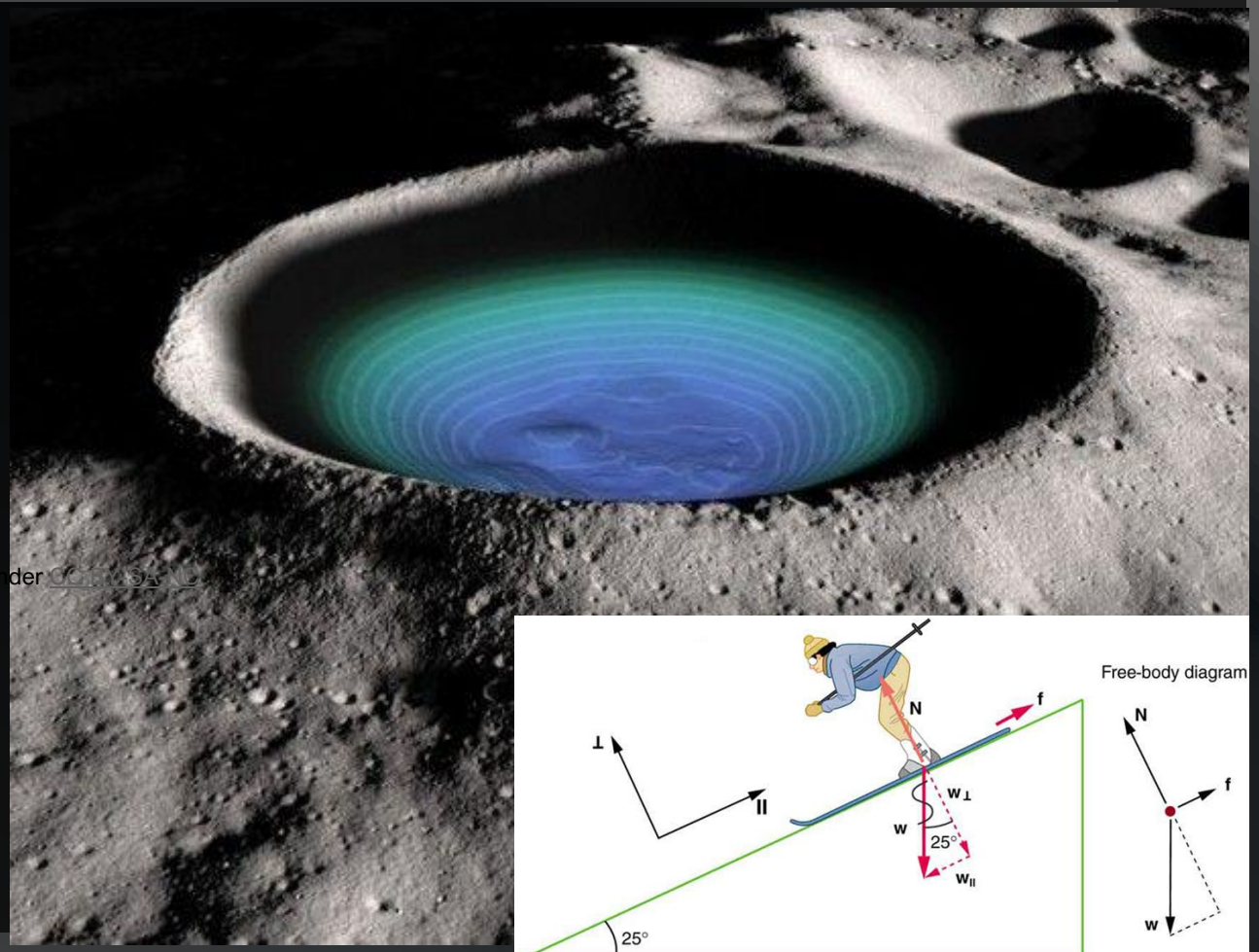


SOLUTION: LETOURNEAU LAND TRAINS

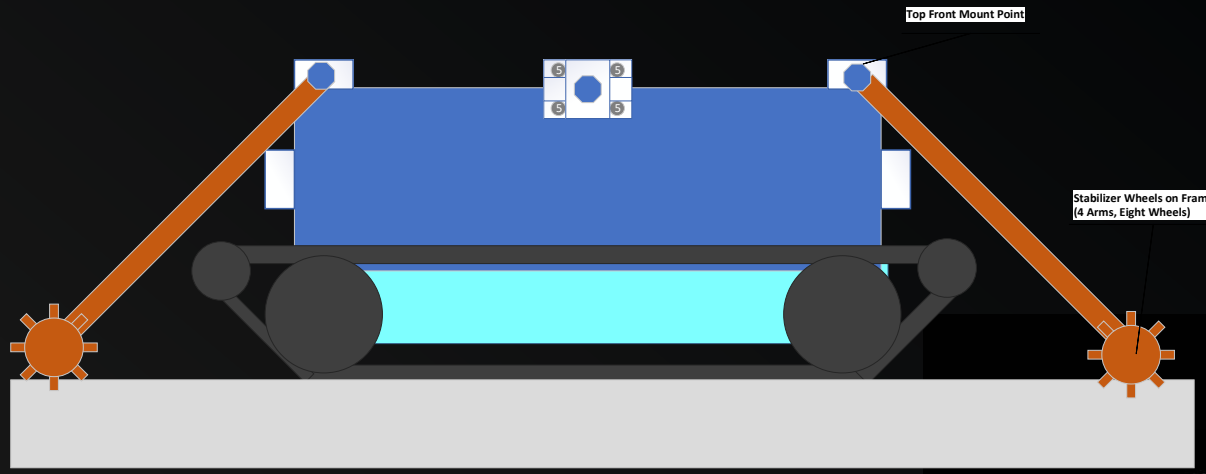
LUNAR HALO LAND TRAIN

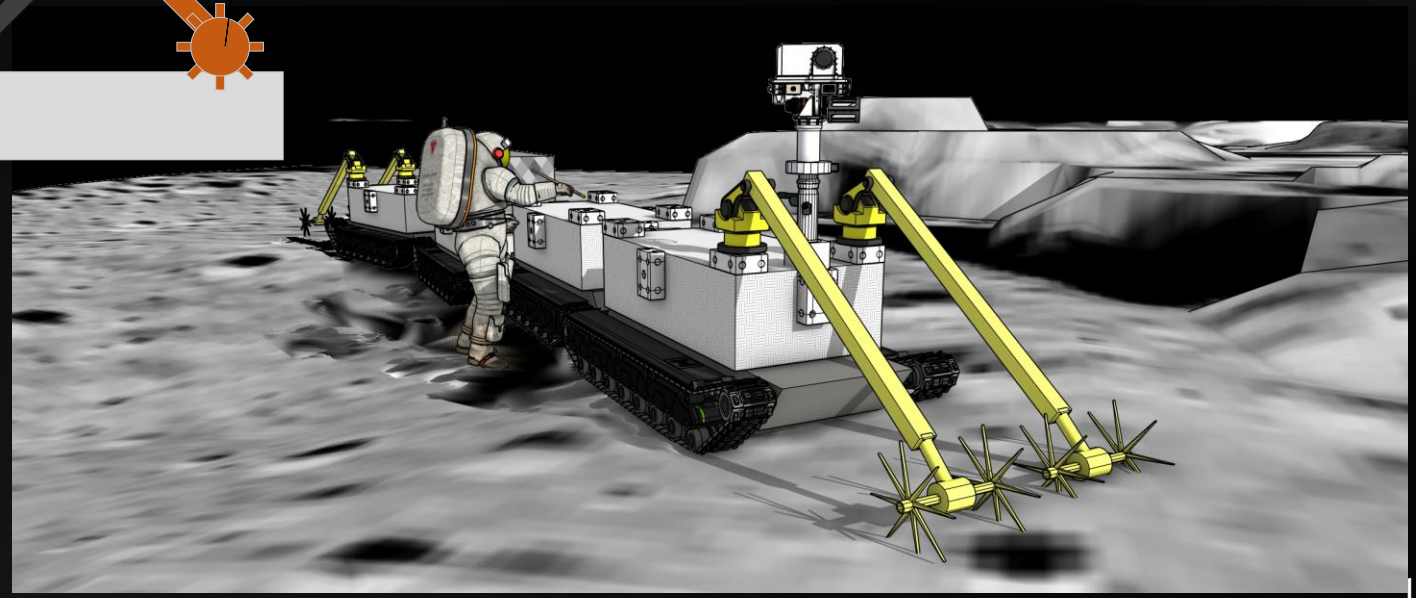


PROBLEM: SKI SLOPES IN ABSOLUTE DARKNESS

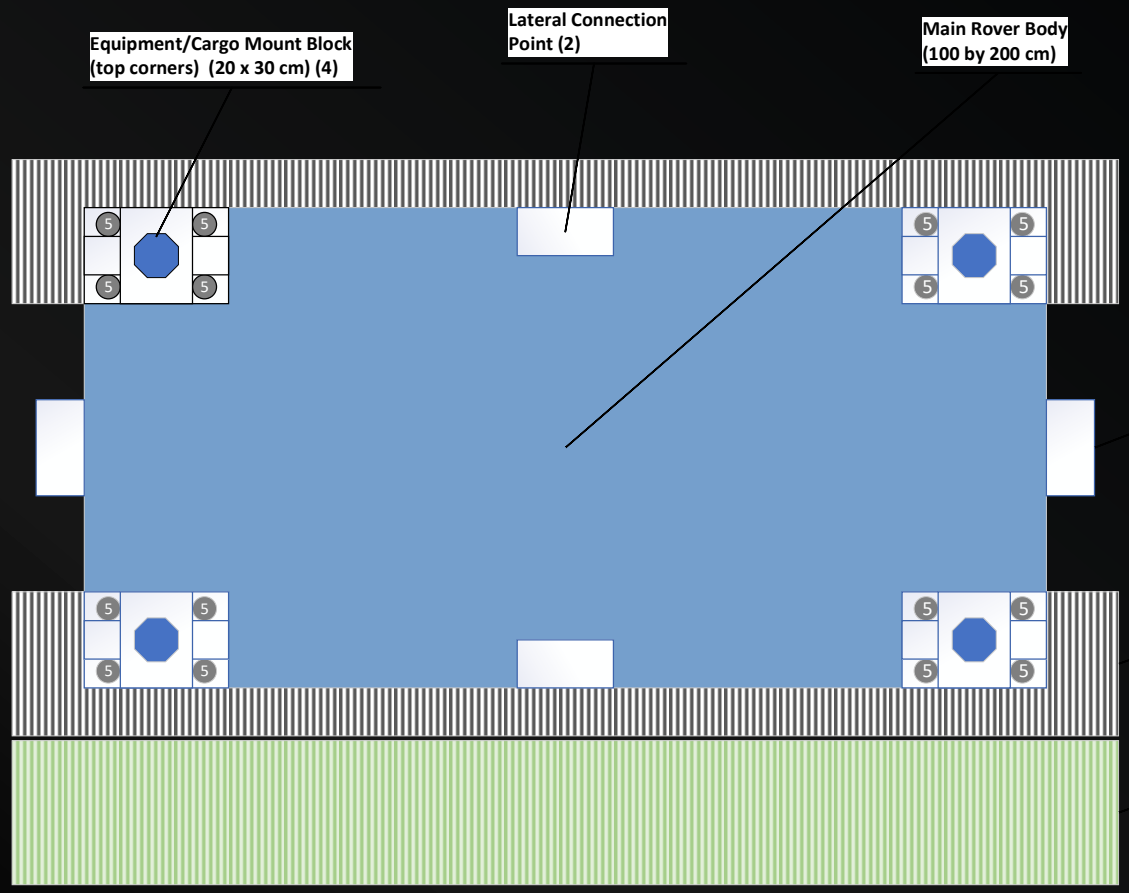


SOLUTION 1: OUTRIGGERS

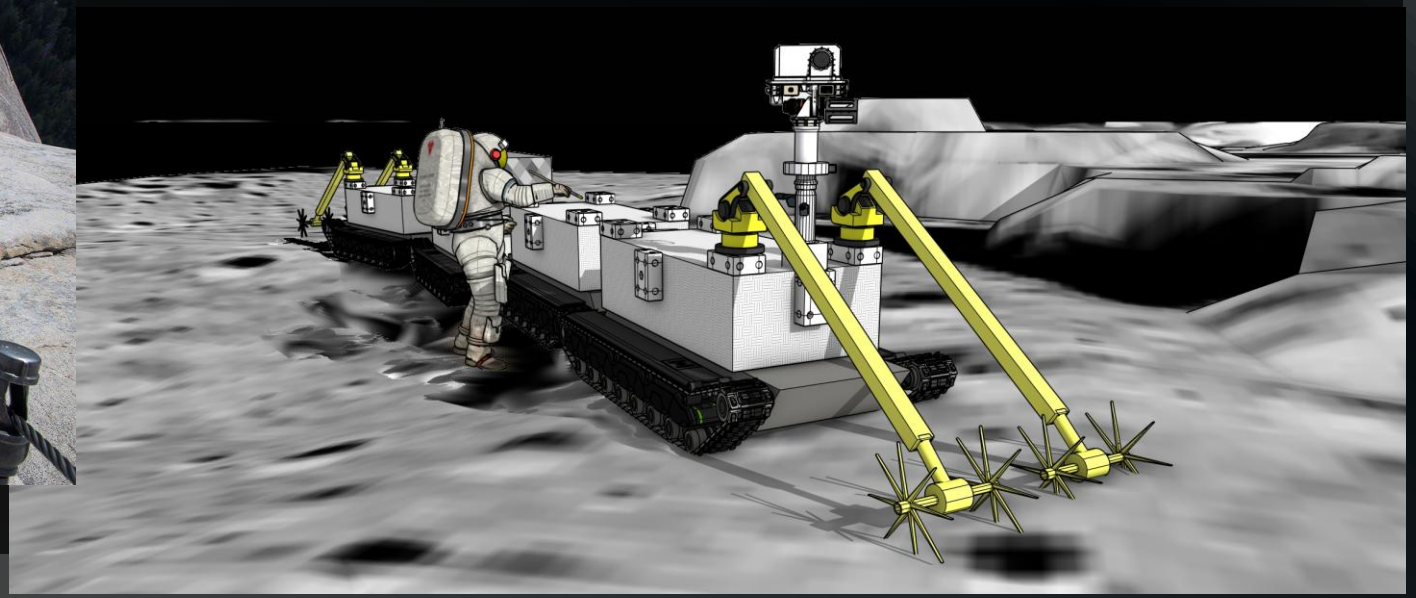




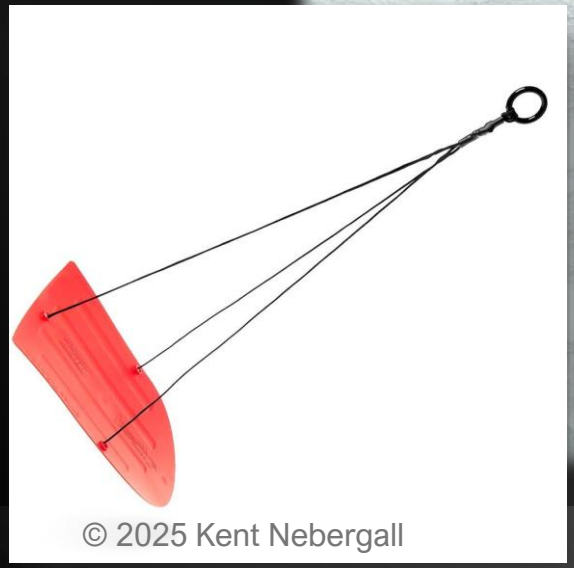
SOLUTION 2: EXTENDED CATERPILLAR TRACKS

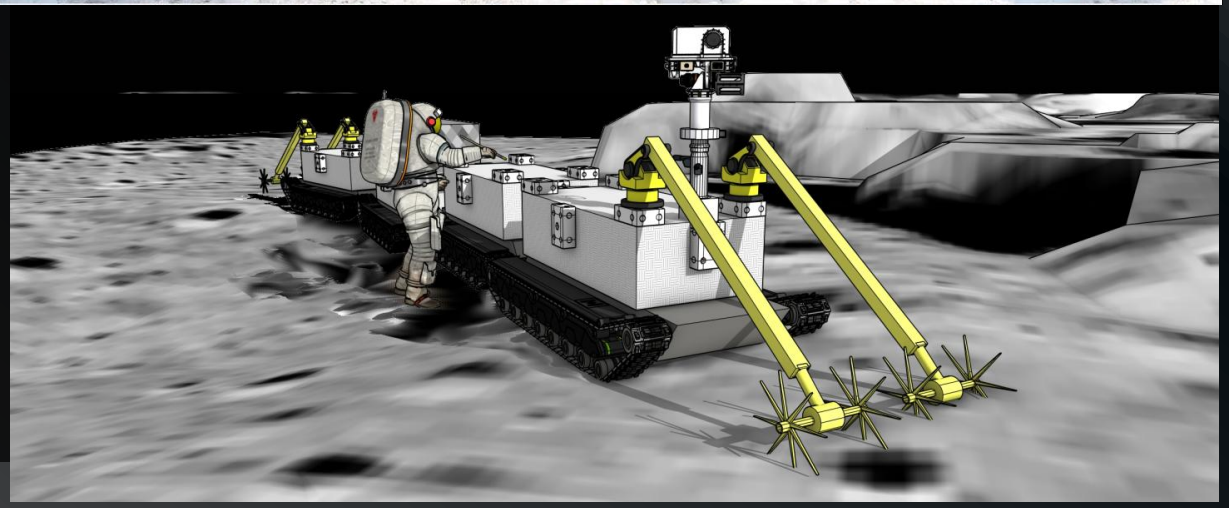


SOLUTION 3: ANCHOR CABLE

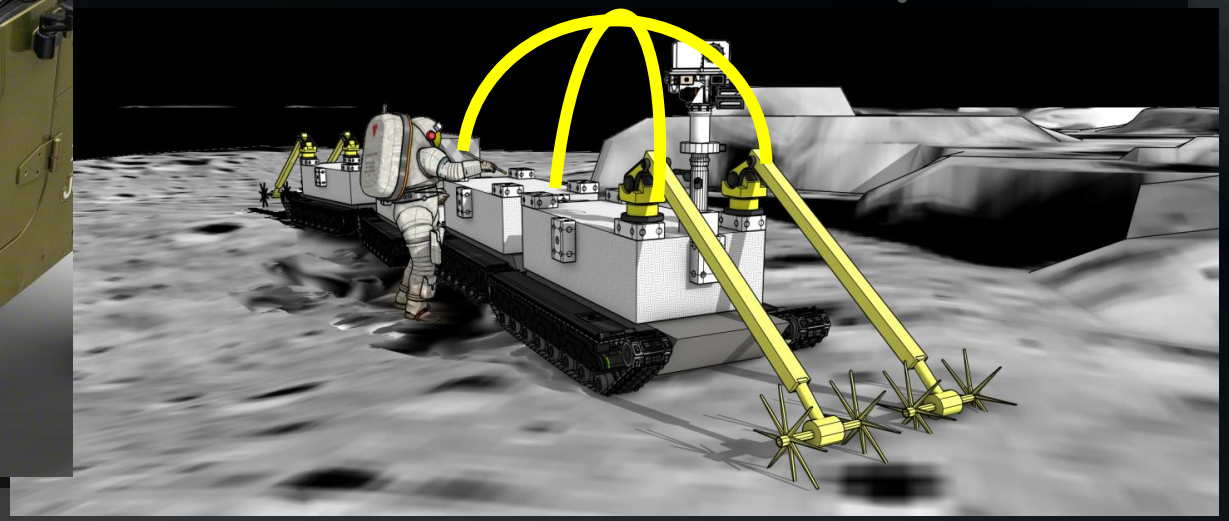


SOLUTION 4: DRAG LINE AND DROP BRAKES





SOLUTION 5:
A ROLL CAGE OVER INDIVIDUAL ROVERS



OTHER SYSTEMS

ADAPTING FOR MARS

SCANNING YOUR TRACKS FOR MINERAL DEPOSITS

DUAL USE FOR MARS

SYSTEM	MOON	MARS
Modular Cargo Hauler	• "Pack Mule" Tasks for Crew • Cryogenic Terrain Sampling	• Pack Mule Tasks for Optimus • Battery/Solar Farm Construction
Deep Dark Exploration	• Shackelton Crater • Lunar Lava Tubes	• Martian Lava Tubes • Water-Formed Caves?
Modular Science Equipment	• Crew tended equipment Swaps	• Robotic Equipment Swaps
Construction Work	• Pavement Creation with Microwave Trailer	• Pavement Creation with Stabilization Cement
Other Uses	• Crew Rescue/Transport	• Test Roads for Sand Traps

TECHNOLOGY READINESS LEVELS

TRL	TRL Definition	Components
1	Principles known	• Cryogenic geomorphology and impact on mission design
2	Tech proven	• Magnetic tread drive • Dynamic terrain self-driving • Grinding wheel bearings
3	Proof of Concept	• Fuel cells/batteries
4	Breadboard in lab	• AI digital twin in lunar conditions with refinement of designs
5	Breadboard in environ.	• Meshnet communications
6	Subsystem in environment	• Land Trains, extended treads for “snow groomers”. • Pilot wheels • FM/VOR/DME and AM/ADF communications and Navigation
7	Prototype in space	• Data/power/structural mounts (ISS power data grapple fixtures)
8	Flight qualified	• Lunar driving AI (commercial moon landers, VIPER)
9	Flight proven	• Laser communication (LADEE, Starlink, etc.) • ChemCam, multi-spectral geology cameras, strobes, star trackers, etc. • Self-driving (Perseverance) • Remote driving on moon (Lunokhod)

THANK YOU

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