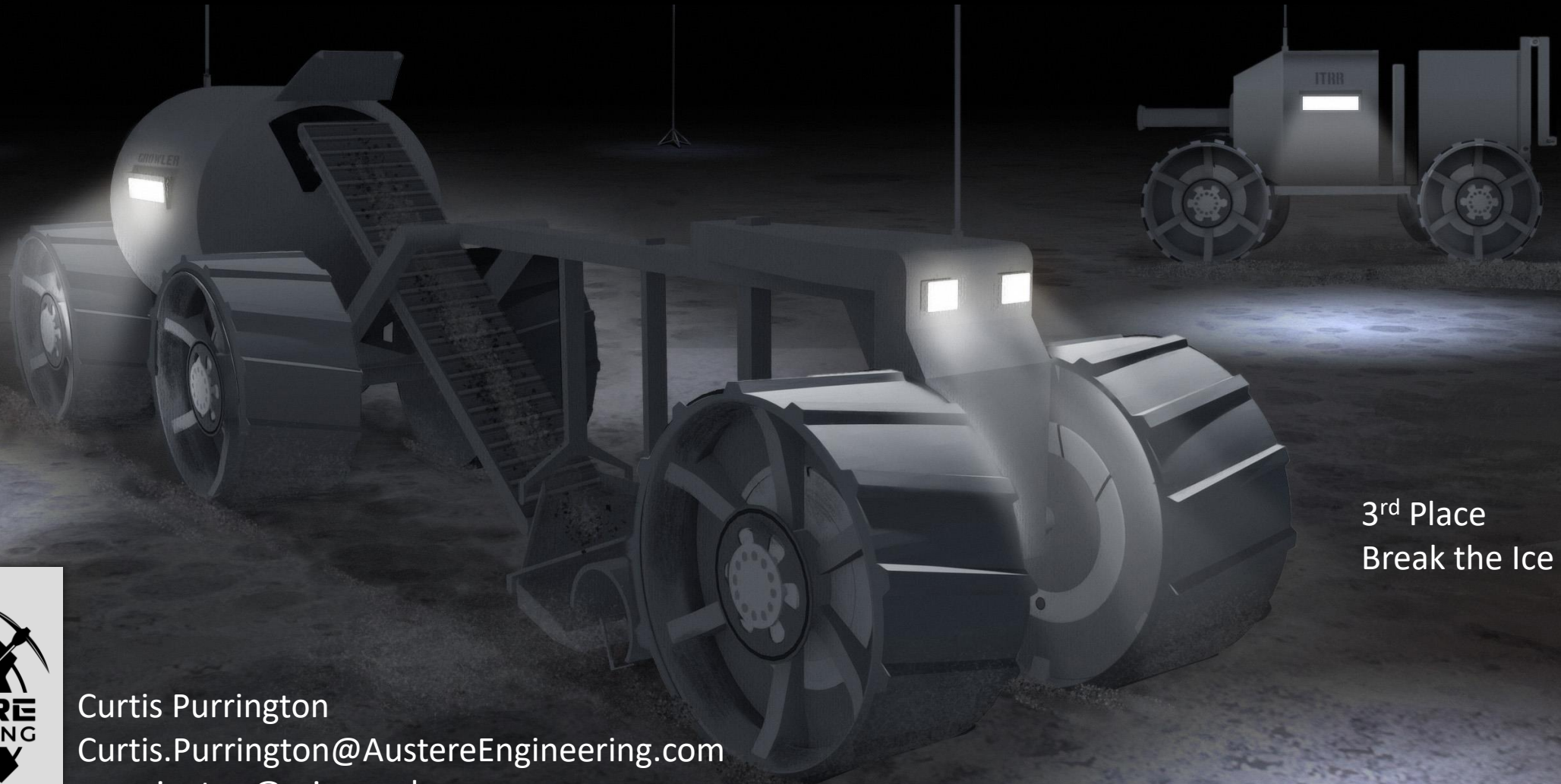
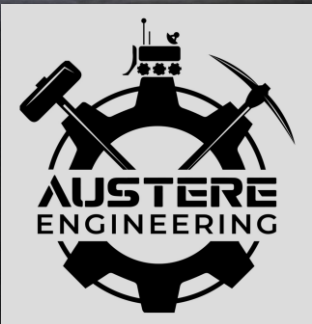


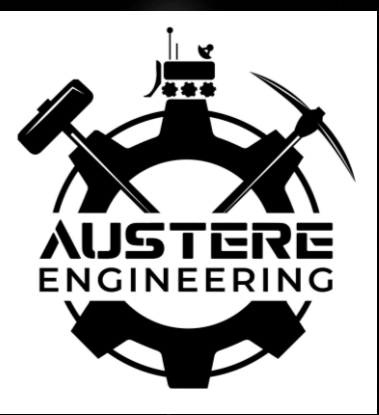
GROWLER – Grading and Rotating for Water in Lunar Excavated Regolith



3rd Place
Break the Ice Challenge



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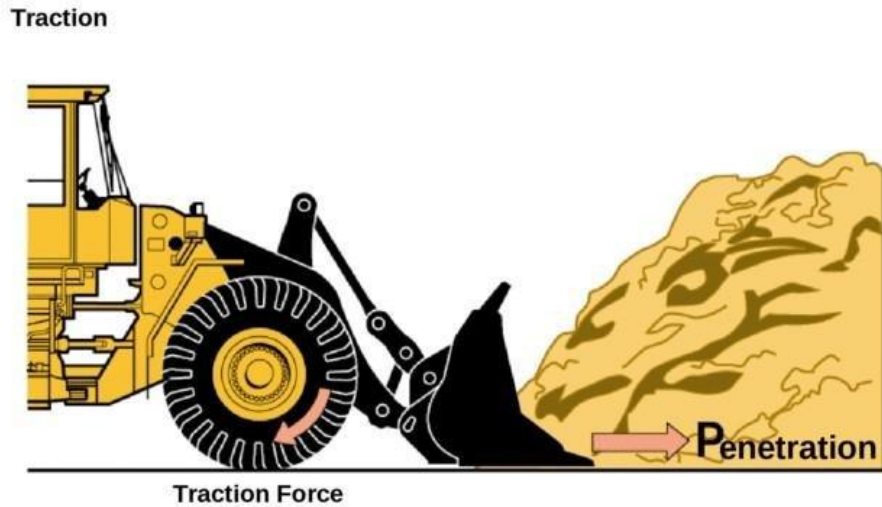
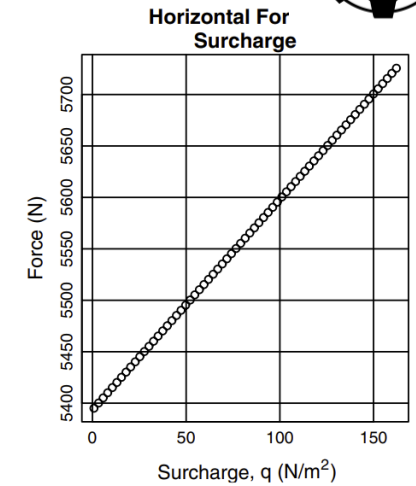
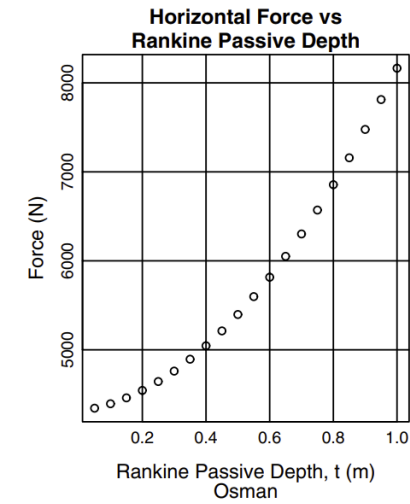


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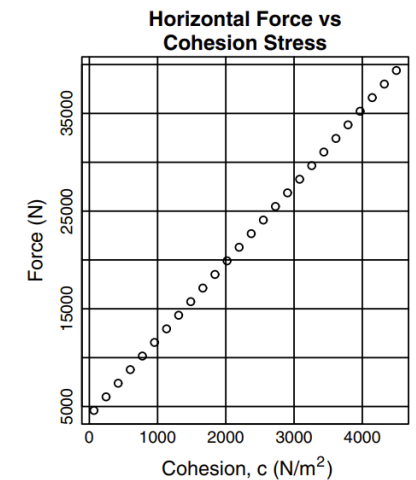
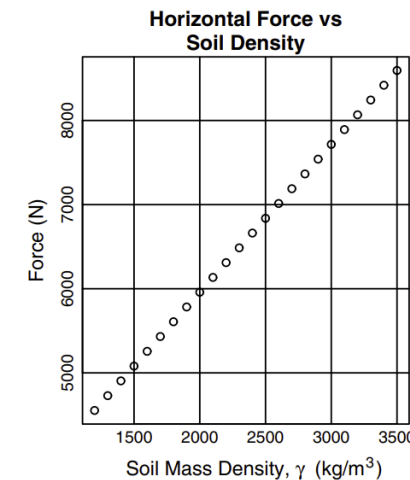
Is it hard to dig on the moon?



NASA: Apollo 17 landscape

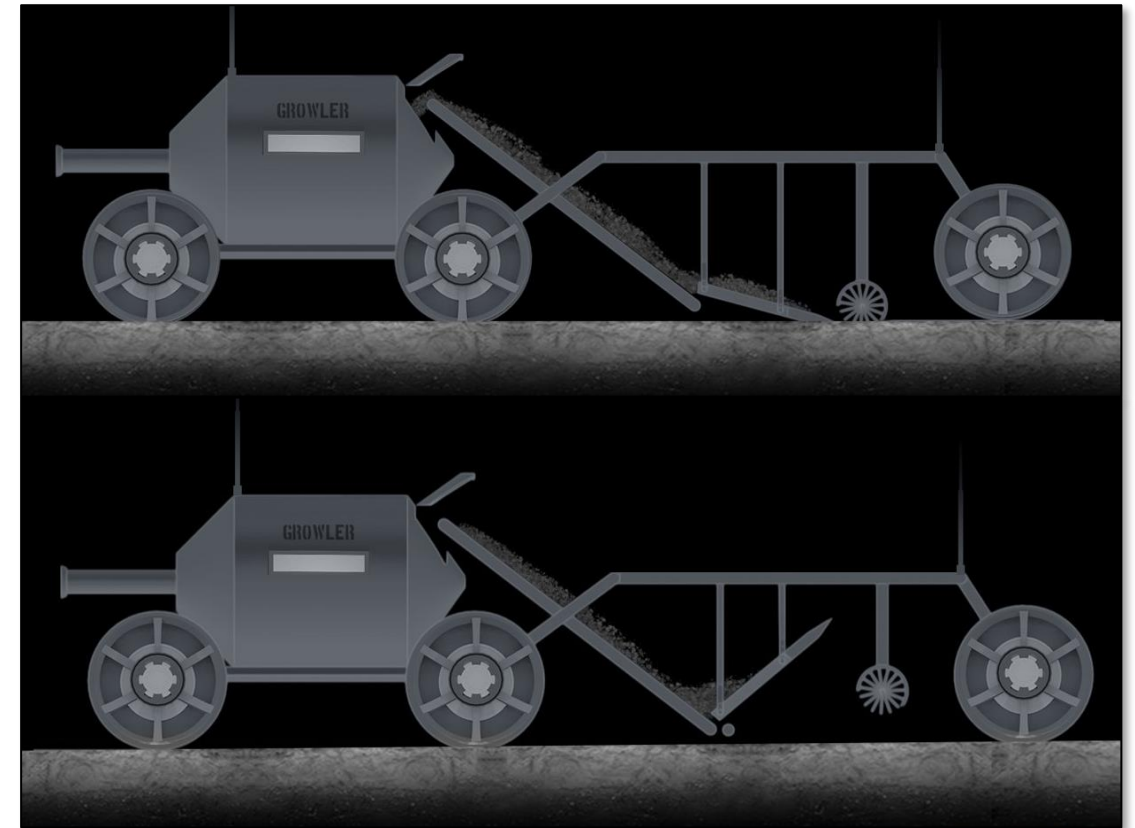
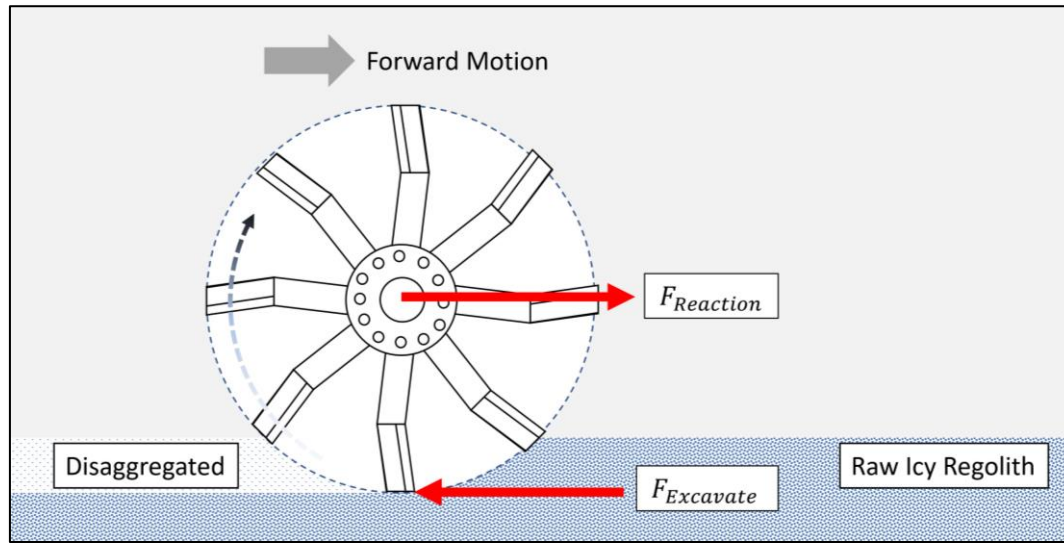


Wheel Loader Buckets & Digging Forces, (Ozgodan, 2019)



Digging and pushing lunar regolith: Classical soil mechanics and the forces needed for excavation and traction (Wilkinson, 2007)

Increasing Traction, Decreasing Penetration



Increasing Traction Force

1. 6x Wide Wheels
2. Rotary Tiller – Forward Reaction Force

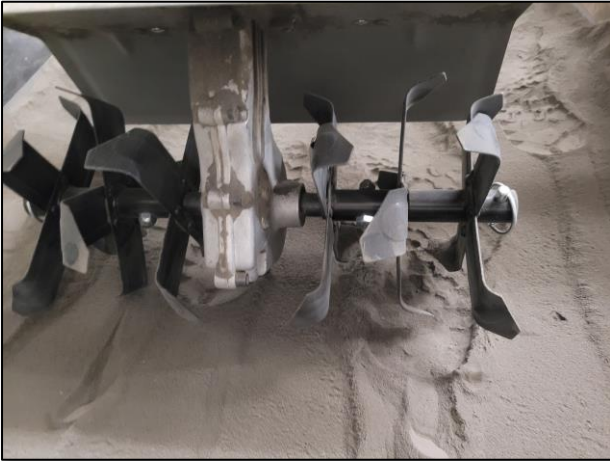
Con ops– Reducing Penetration Forces

1. Depth – Excavated at 5cm
2. Surcharge Pressure – Low gravity, articulating bucket

Rotary Tiller – Reducing Penetration Forces

1. Soil Density – Rotary Tiller reduces the density to 1.2 g/cm^3
2. Cohesion Stress – Rotary Tiller Disaggregates, reducing grain cohesion

Early Rotary Tiller Experiments

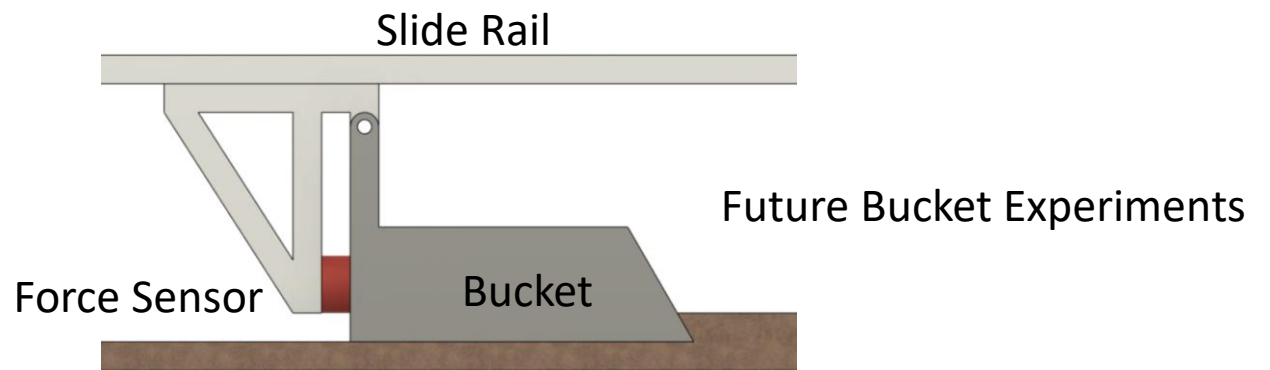


Colorado School of Mines
Lunar Test Bed

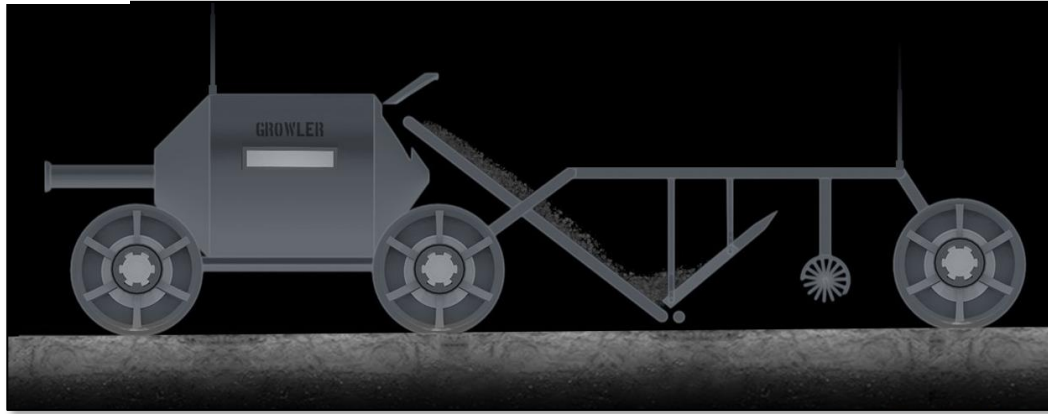
| | | |
|------------------|----------------------|----------------------|
| | Initially Density | Rotary Tiller |
| Density Decrease | 1.5 g/cm^3 | 1.2 g/cm^3 |
| | 1.8 g/cm^3 | 1.2 g/cm^3 |

| | | |
|---------------------------------|----------------------|---------------------|
| Penetrometer Pressure Decreases | 24 kg/cm^2 | 4 kg/cm^2 |
| | Depth: 0.25in | Depth: 1in |

83% Reduction in penetrometer pressure



Excavation Rates



Vehicle Speed: 0.45m/s (1 mph)
Excavating at Depth: 5cm
Bucket width: 1.5m

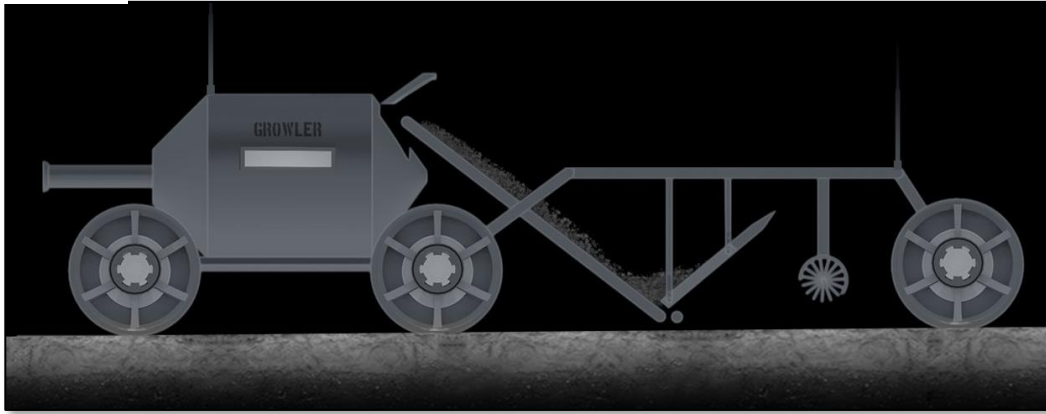
Excavation Rate
1000kg/10mins

Break the Ice Challenge

Objective 1. Excavate Icy Regolith Complete

Objective 2. Process the ice and deliver the ice outside of the PSR

Excavation Rates



Vehicle Speed: 0.45m/s (1 mph)
 Excavating at Depth: 5cm
 Bucket width: 1.5m

Excavation Rate
1000kg/10mins

Excavation
6000kg/hr

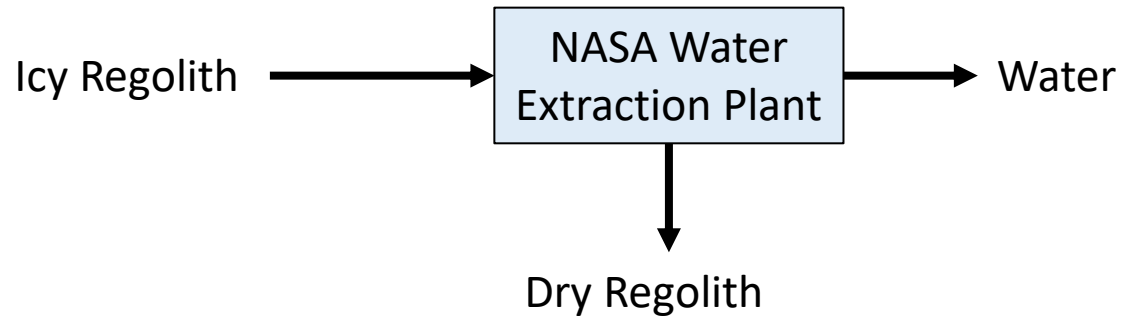
≠

Icy Regolith Processing
100 kg/hr

Excavation
6000 kg/hr

>>

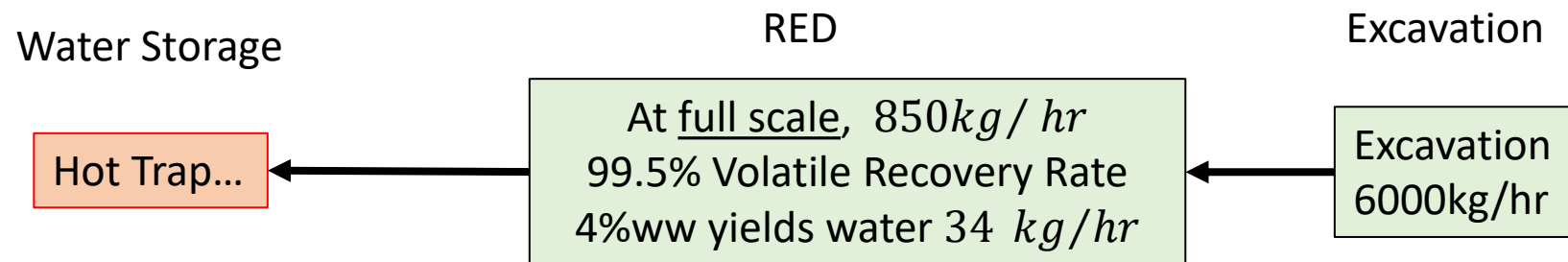
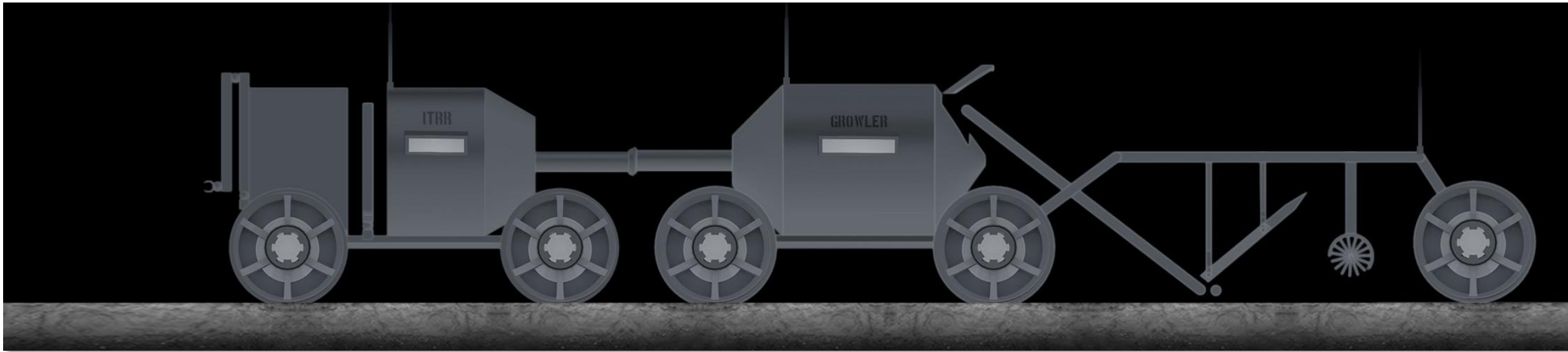
Icy Regolith Processing
100 kg/hr



60x Water Extraction Plants!



Extract water through a Rotary Extraction Drum (RED)

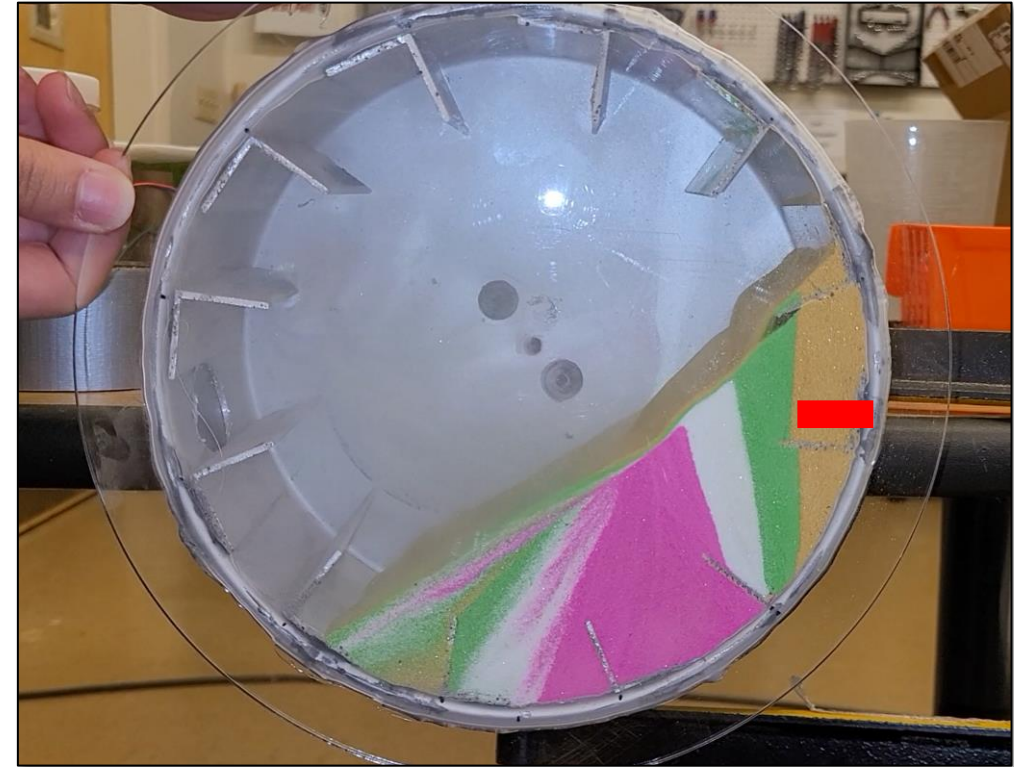


Allows GROWLER to be scaled down

Extract water through a Rotary Extraction Drum (RED)



Starting Position: 0°




Rotation: 90°

1. Estimated Revolution – 1hr/revolution
2. All material cycles – every 150 degrees
3. Full Revolution – 2.4x Material Turnover


Water 34 kg/hr
38mT Water/1st Year



Rotary Extraction Drum (RED)



Water Extraction Series - Extracting Water from lunar Icy Regolith
51 views • 1 month ago

 Austere Engineering

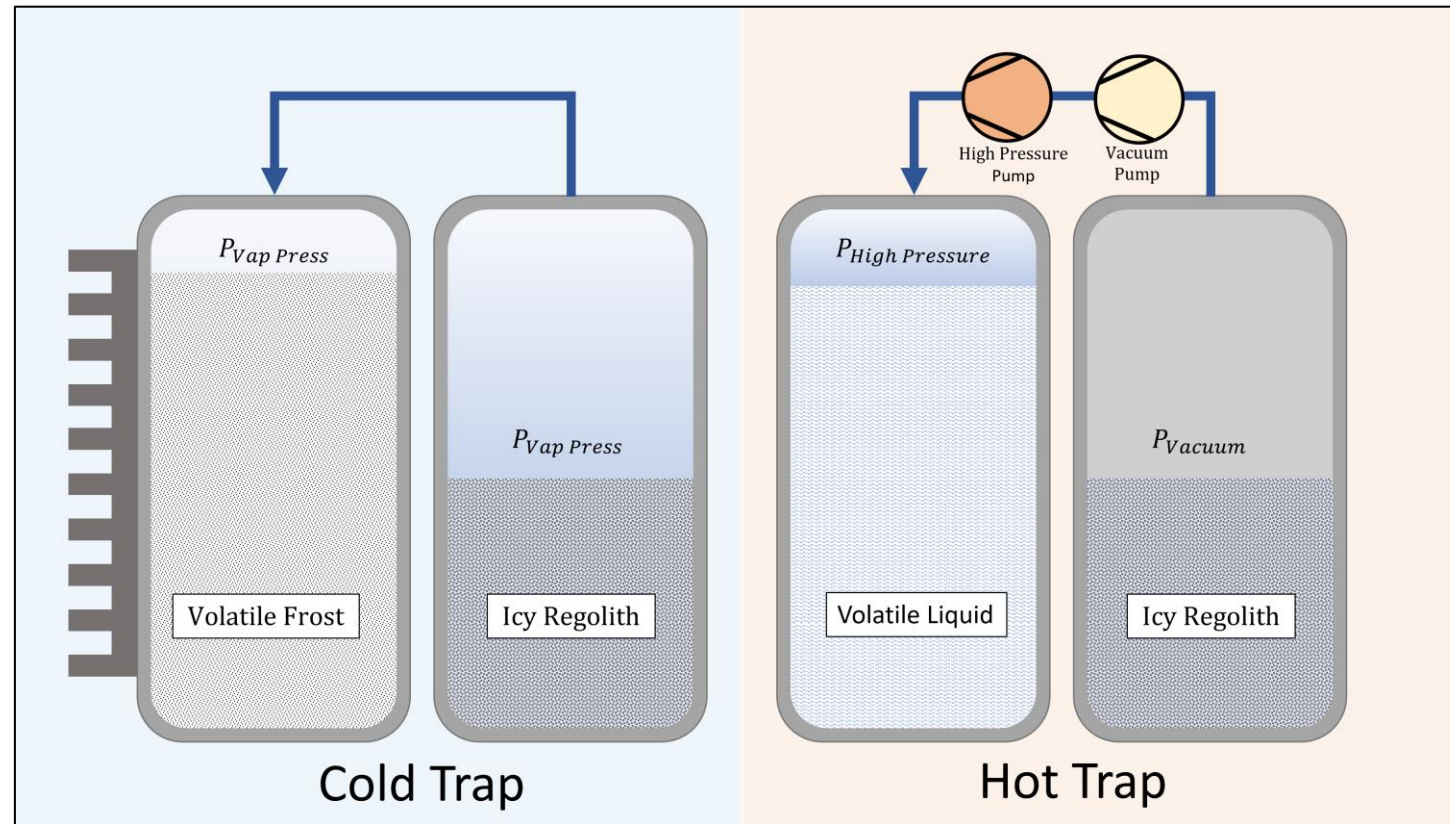
This will be the first video in a series covering aspects of water extraction on the moon. The technology currently ...

2:57

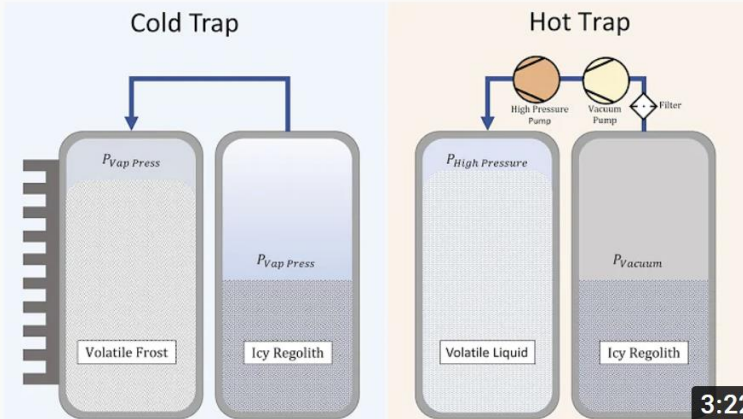
Water Extraction Series - Extracting Water from lunar Icy Regolith

Water Storage 'Hot Trap'

| Property | Cold Trap | Hot Trap |
|-----------------|--------------------------------|------------------------------------|
| Storage Rate | 0.22 <i>kg/hr</i> | 20 <i>kg/hr</i> (40 <i>kg/hr</i>) |
| Product Density | 50-400 <i>kg/m³</i> | 997 <i>kg/m³</i> |
| Post Processing | Solid (Frost) | Liquid/Vapor |



Water Storage 'Hot Trap'




The diagram illustrates two water extraction setups. The 'Cold Trap' setup consists of two vertical cylindrical vessels. The left vessel is labeled $P_{Vap Press}$ and contains 'Volatile Frost'. The right vessel is also labeled $P_{Vap Press}$ and contains 'Icy Regolith'. A blue line connects the top of the left vessel to the top of the right vessel. The 'Hot Trap' setup also consists of two vertical cylindrical vessels. The left vessel is labeled $P_{High Pressure}$ and contains 'Volatile Liquid'. The right vessel is labeled P_{Vacuum} and contains 'Icy Regolith'. A line connects the top of the left vessel to a 'High Pressure Pump', which is connected to a 'Vacuum Pump' and a 'Filter'. A '3:22' timestamp is visible in the bottom right corner of the diagram area.

Cold Trap

Hot Trap

Water Extraction Series - Cold vs Hot Traps

5 views • 2 days ago

 Austere Engineering

Austere is currently exploring methods to increase the storage believe ...

New

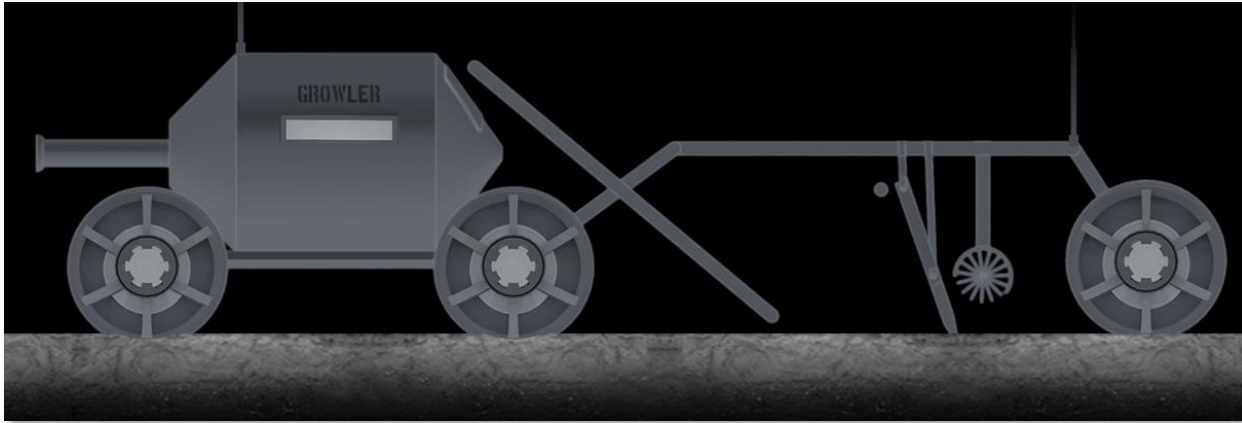
Water Extraction Series – Cold vs Hot Traps

Hot Traps

1. Moving Parts
2. More Energy Efficient
3. Less time Consumption
4. Produces a product that's ready for further processing



GROWLER - Road Production



Future Attachments
Fork Lift
Excavator Arms

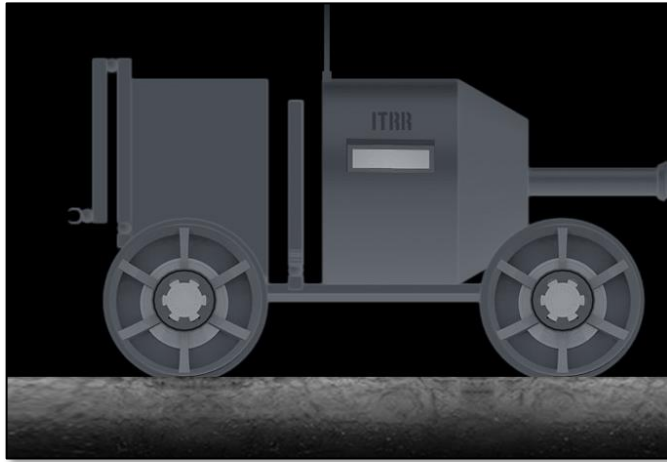




Maintenance on the Moon



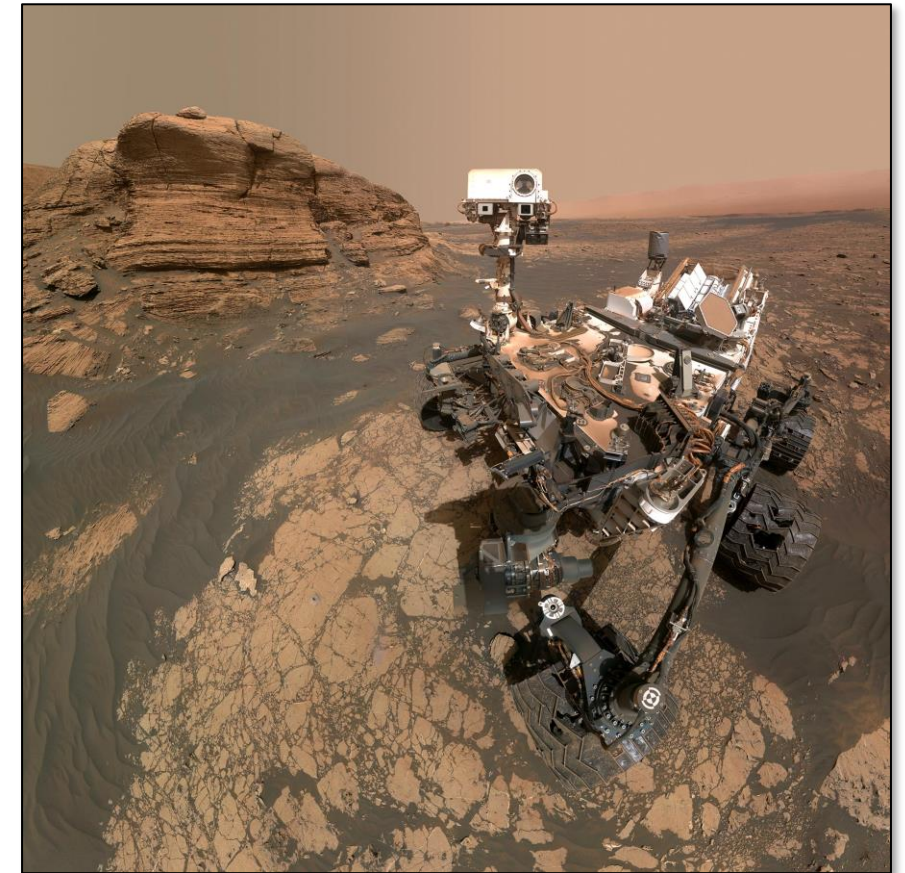
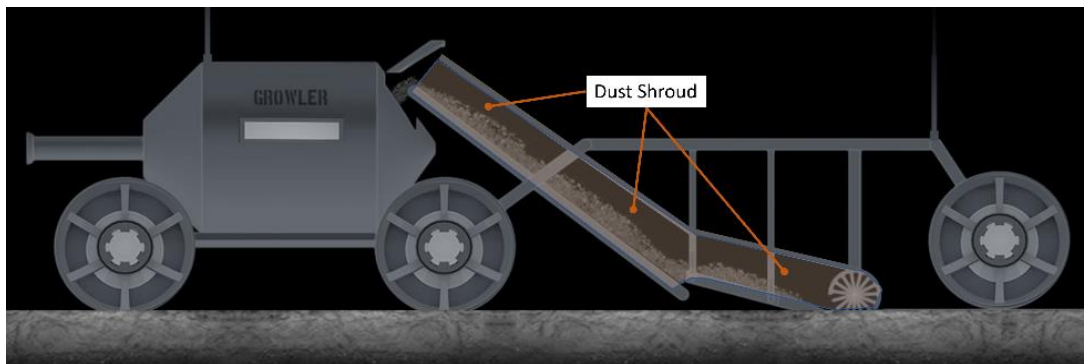
Ice Transportation and Maintenance Rover (ITMR)



- 1x Aft 6m Robotic Arm
- 2x Lateral 6m Robotic Arms

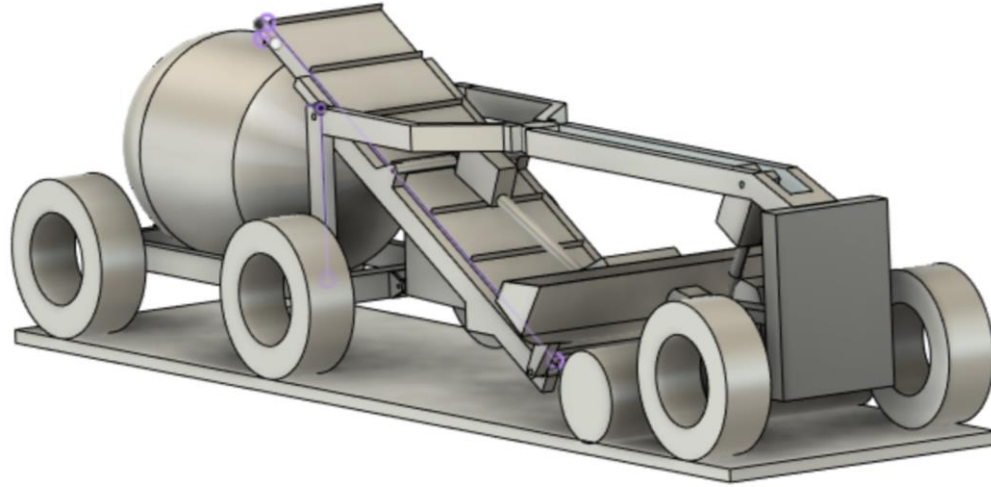
Terrestrial Mines total Expenses:
11% Maintenance

GROWLER – Dust Shroud



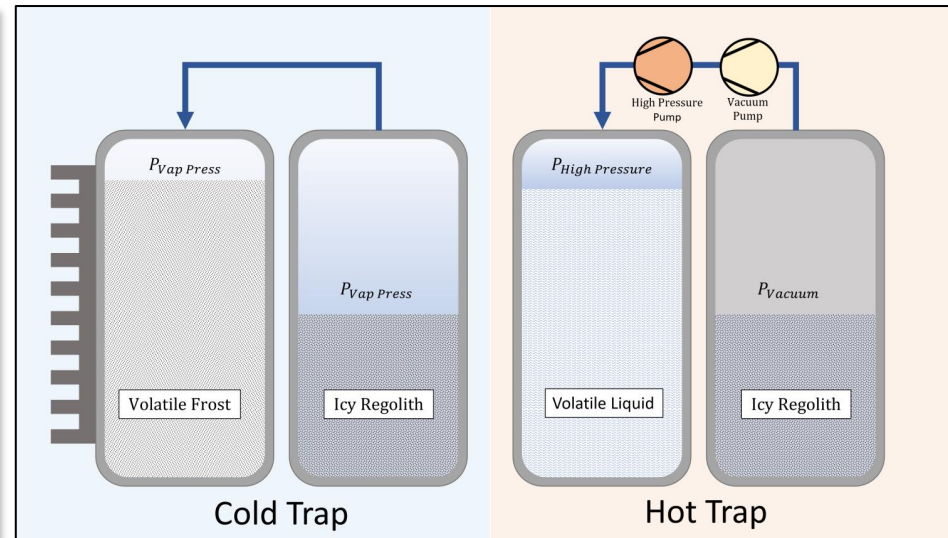
NASA Curiosity

Path forward - Prototypes



GROWLER – Volatile Production
2.4m x 0.6m x 1m – Prototype

4.5m x 1m x 1.5m – Full Scale





Testing Facilities

Lunar Test Bed (CSM)

Rotary Tiller

Bucket Mechanics

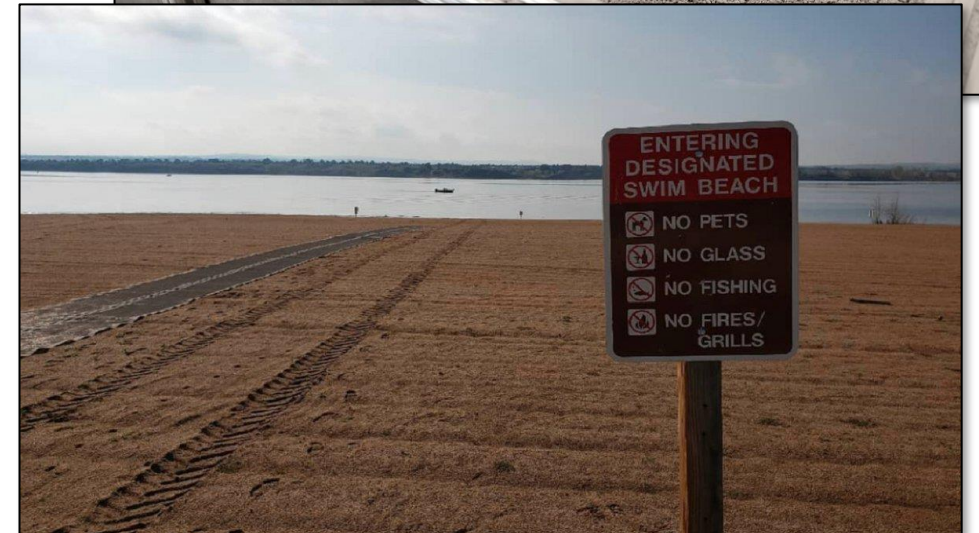
Chatfield State Park (Park Rangers)

Large Scale Excavation

Vacuum Chambers (CSM)

Rotary Extraction Drum

Hot Trap



Q/A



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Total System

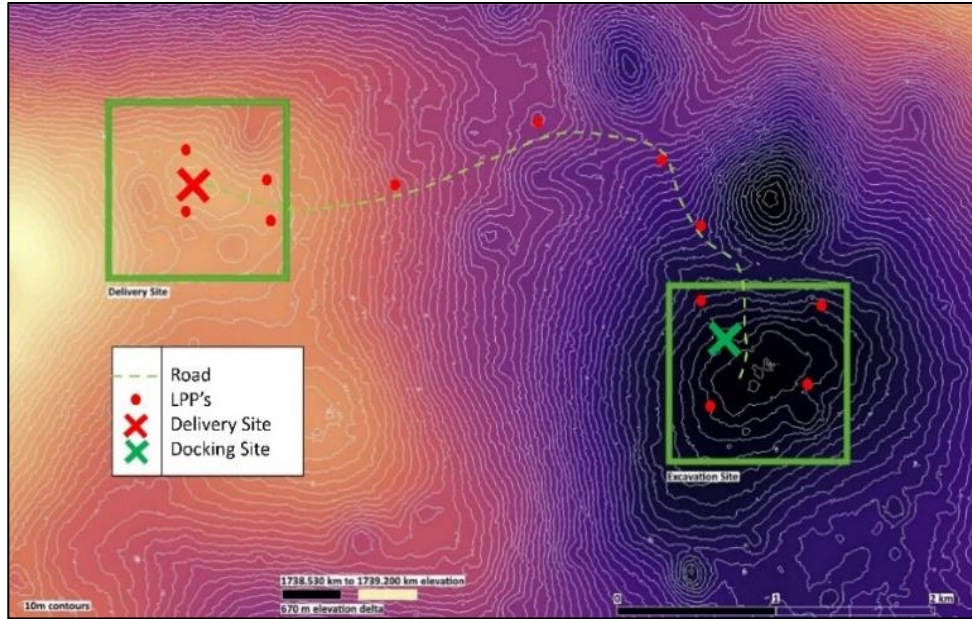
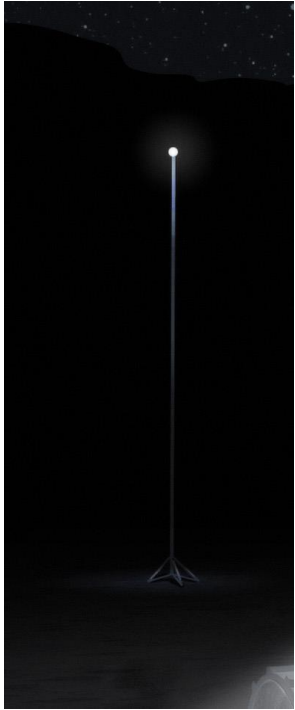
38mT/year – Ice Delivered
950mT/year – Icy Regolith Excavated
3x GROWLERS
2x ITMR's
12x Lunar Locating Posts
58% of total energy consumed



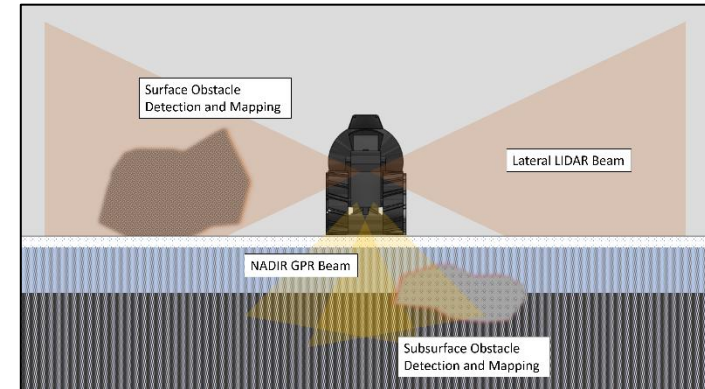
Navigation on the Moon



GROWLER – Lunar Locating Post



GROWLER – Obstacle Avoidance



Lunar Locating Posts – (LPP's)

Low Power – Still partially functional no power
3x LPP's visible from any where in the AO

