Mining Technologies for Achieving Lunar ISRU Objectives

Presented by: Douglas Morrison, President & CEO

Presented to: Space Resources Roundtable, June 6-9, 2023.

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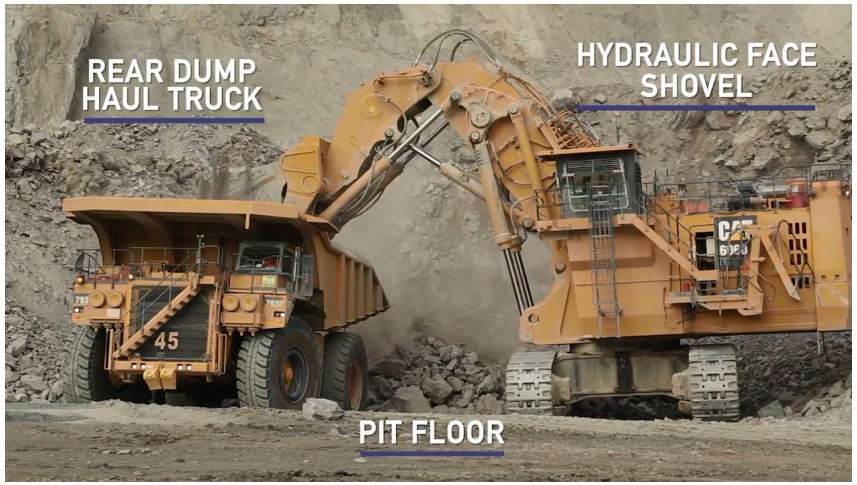
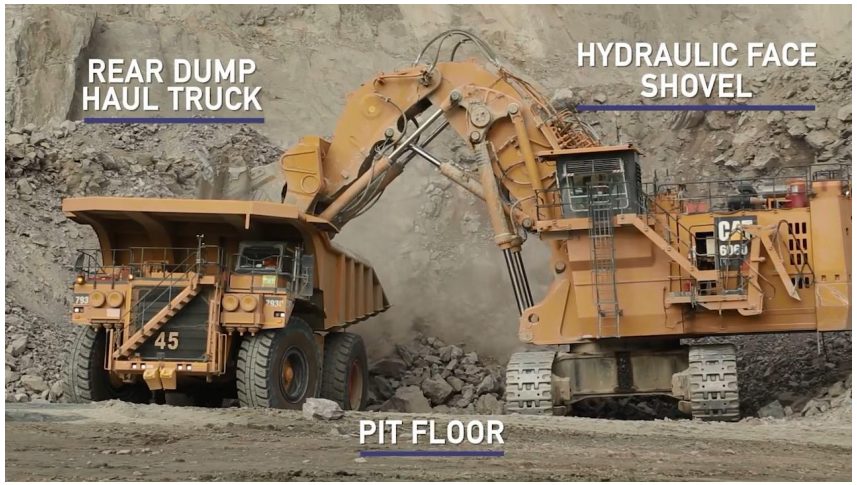
SURFACE MINING – HAUL TRUCKS



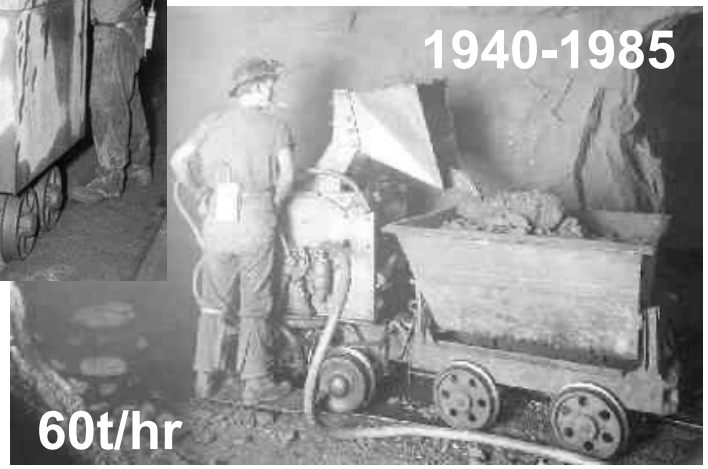
SURFACE & UNDERGROUND HAUL TRUCKS



UNDERGROUND MINING – DRILL & HAUL

Underground Mines - The Prime Directive

Produce Ore, Move Ore, ASAP, at Lower Cost



Underground Mines - The Prime Directive

Produce Ore, Move Ore, ASAP, at Lower Cost

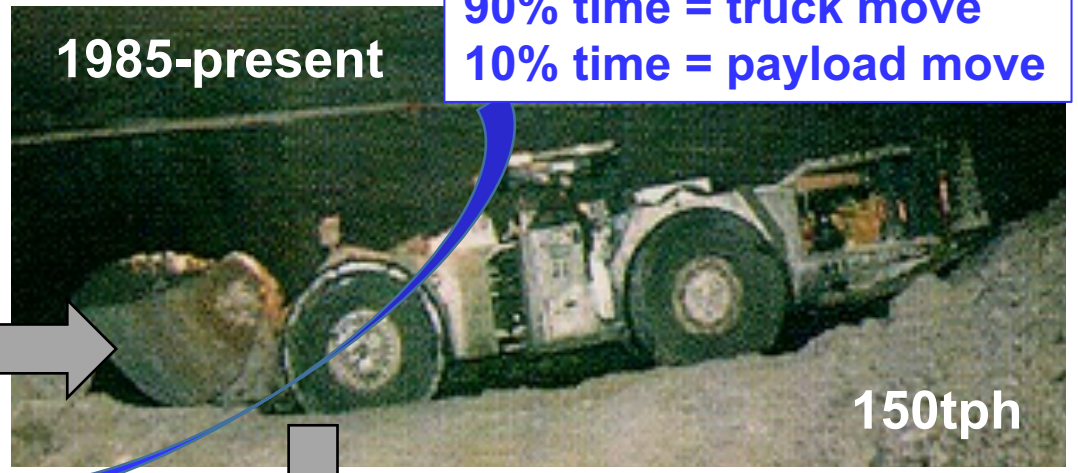
Pneumatic

Diesel/Battery, Electric-hydraulic, Explosives

Underground Mines - The Prime Directive

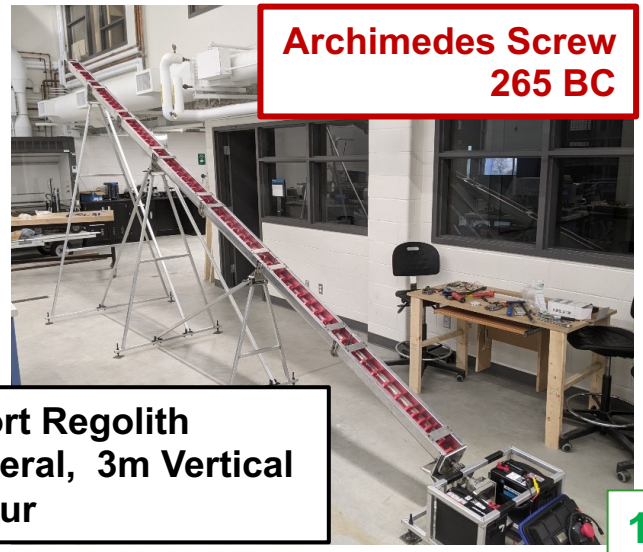
Produce Ore, Move Ore, ASAP, at Lower Cost

CSM Challenge 2011
'Regolith' Transport
Winner: "Luna-Bot"
Laurentian University, Sudbury, Canada.



90% time = truck move
10% time = payload move

15% time = equip. move
85% time = payload move

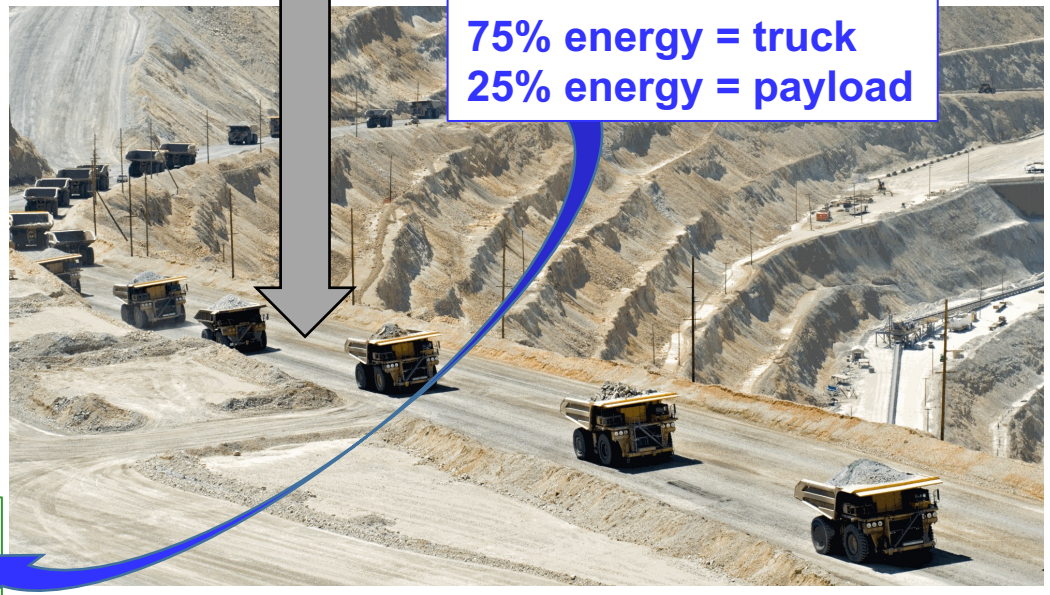


Archimedes Screw
265 BC

OVER THE DUSTY MOON CHALLENGE
COLORADO SCHOOL OF MINES
LOCKHEED MARTIN

Winner:
Laurentian University, Sudbury, Canada.
10kg in 11 minutes.

Transport Regolith
10m Lateral, 3m Vertical
10kg/hour



75% energy = truck
25% energy = payload

15% energy = equip. move
85% energy = regolith move

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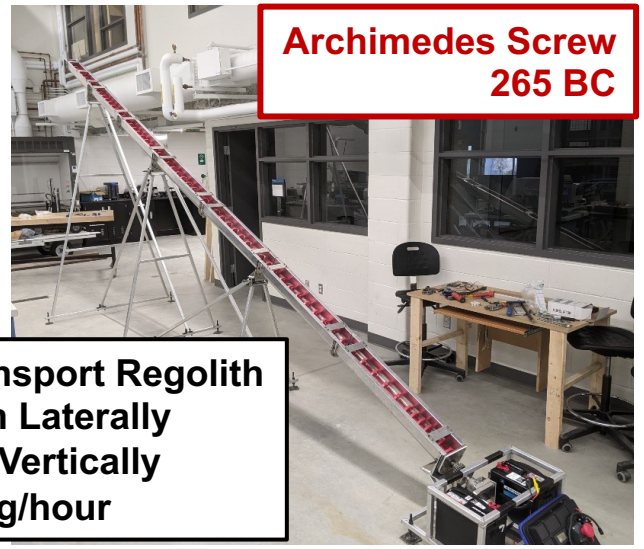

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3 x more ore @ 20% energy = 15 x effective

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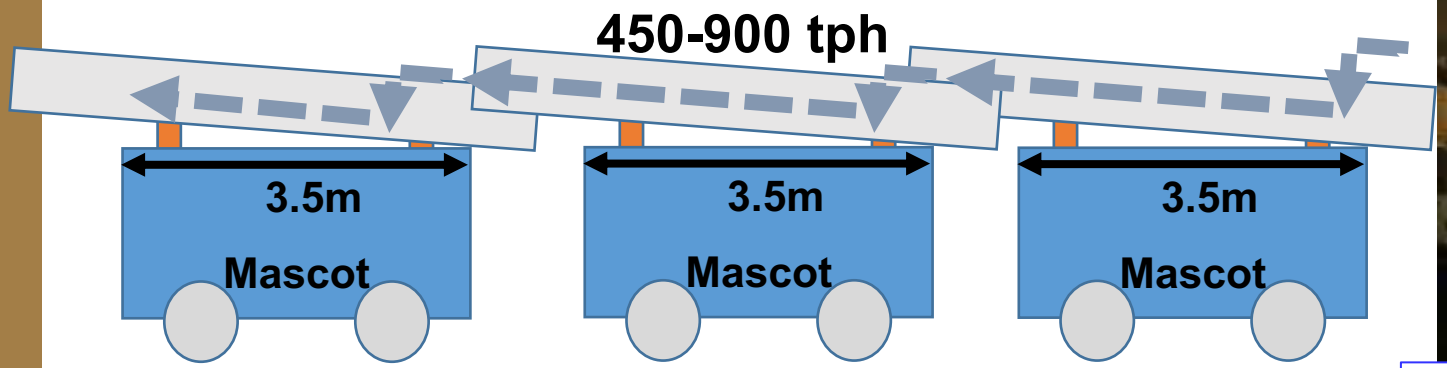

Mobile, Autonomous, Steel, Coarse Ore Transport

3 x more ore @ 20% energy = 15 x effective

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Underground Mines - The Prime Directive

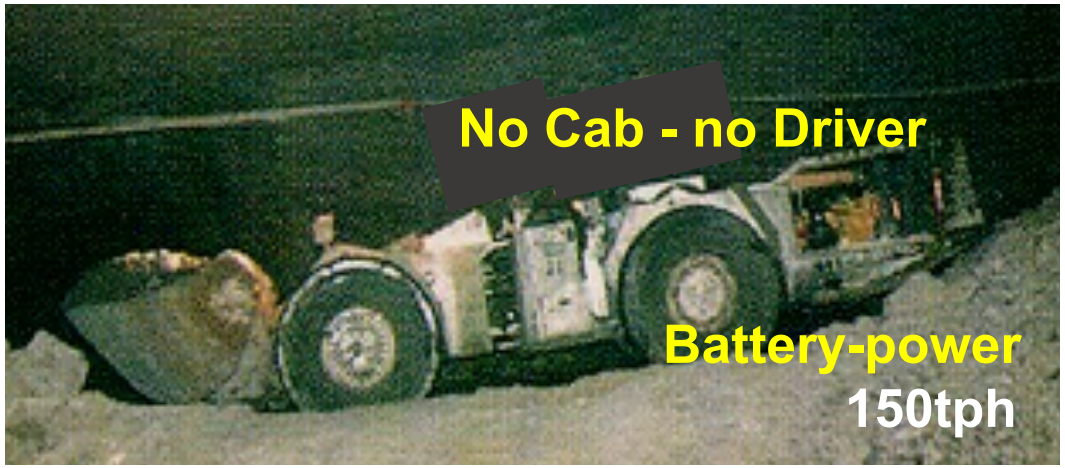
Produce Ore, Move Ore, ASAP, at Lower Cost

Automation:

Keep Equipment Design (diesel or BEV)
Reduce Direct Labour
Keep Maintenance Labour
Keep Batch Process Inefficiencies

10-hour shift x 150tph = 1,500tps (3,000 tpd)

6 times more ore
Production = (6/0.2) = 30 x more effective.
Productivity irrelevant on the Moon.
Lift-off 15-30 x smaller, lower mass units.



Autonomization:

Change Equipment Design
Eliminate Direct Labour
Reduce Maintenance Labour
Increase Process Efficiency

10-hour shift x 900tph = 9,0000tps (18,000tpd)

Underground Tech – for Lunar ISRU

Simple, Robust, Effective & Autonomous. & Historical

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Winner:
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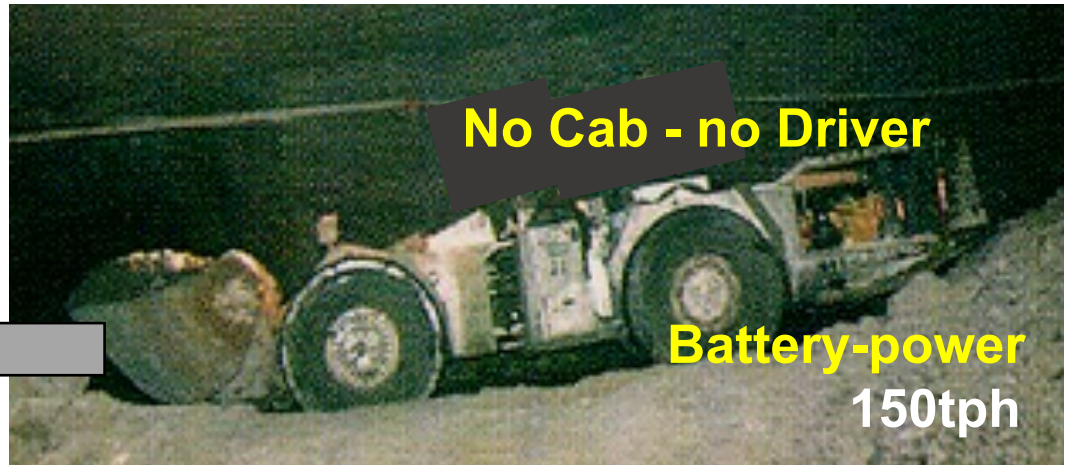

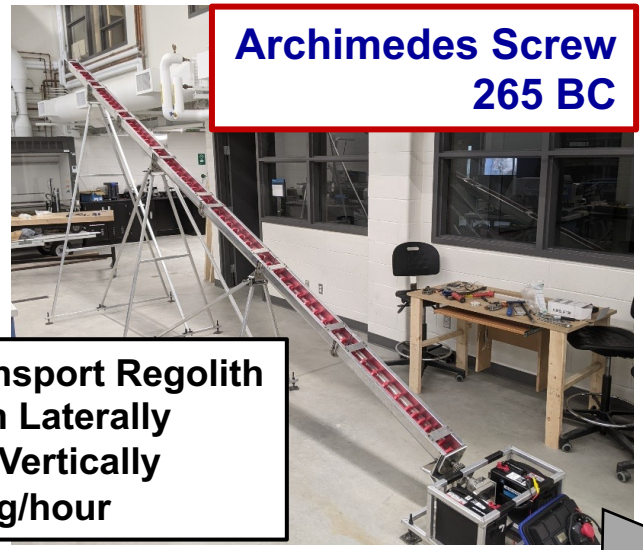

Transport Regolith
10m Laterally
3m Vertically
10kg/hour

OVER THE DUSTY MOON CHALLENGE
COLORADO SCHOOL OF MINES
LOCKHEED MARTIN

Winner:
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10kg in 11 minutes.

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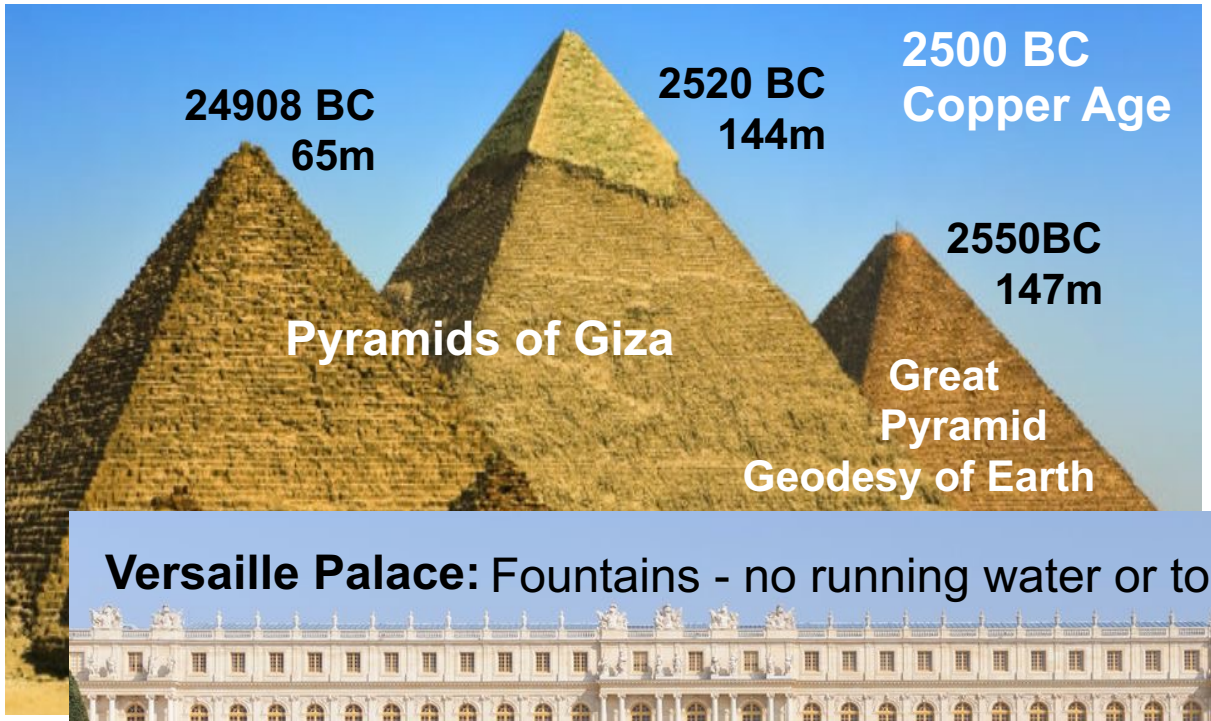
Underground Tech – for Lunar ISRU

Simple, Robust, Effective & Autonomous. & Historical Resource-constrained Environment



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Historical & Underground Tech for Lunar ISRU.

Autonomous
+ Low-energy
+ Modular Designs

Surface Radiation & Regolith: Health & Consumables impacts, & Equipment-wear impacts?

Operational Targets:

1. Re-usable Landing-Lift-Off Facility (RLLOF) - bedrock.
2. Clear Regolith & Groom Level Surface + Deflection/baffle Barriers.
3. Safe, Secure Habitable Facility & Consumable Stockpile Storage.
4. Travel Emergency Refuge Stations: atmosphere, water, food & heat. (Polar Expeditions)

Historical Tech. & Lunar Applications

Non-mining tech.
Modular Autonomous Units.
Simple, Robust, Effective.
Low-risk Innovations (renewed).
Easily Autonomized (simple).

CEMI & Client targets:

1. Overland Transport System
2. Regolith/Ice Harvester, Sorting & Packaging
3. Single Drill: any length & orientation
4. Multiple Drill Capability: 3-stage system
5. Bedrock Grooming, Trenching & Tunnelling
6. Sub-surface Habitation & Access, corridors, bedrooms, common room, consumable storage, vehicle storage.)

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Mining Technologies for Achieving Lunar ISRU Objectives

Summary & Conclusions

1. Modern Earth-model Mining Tech: massive, energy-inefficient & high maintenance.
2. The Lunar Surface: Remote, Hostile (reg. & temp.) & Resource-constrained (night).
3. High-efficiency Mining Technologies: reduce size and mass for Earth Lift-off.
4. Historical Mining Techniques: simple, robust, energy-effective (electric & autonomous).
5. Non-mining Sectors are also sources of Lunar-model Technologies.
6. Utilization & Processing: Lunar Resources, not current Earth-analogue models.

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