Helium3 Mining Startup Transportation

Planetary & Terrestrial Mining Sciences Sym

7 May 2013

Business Case for ISRU

Room 201AB, Paper 7899

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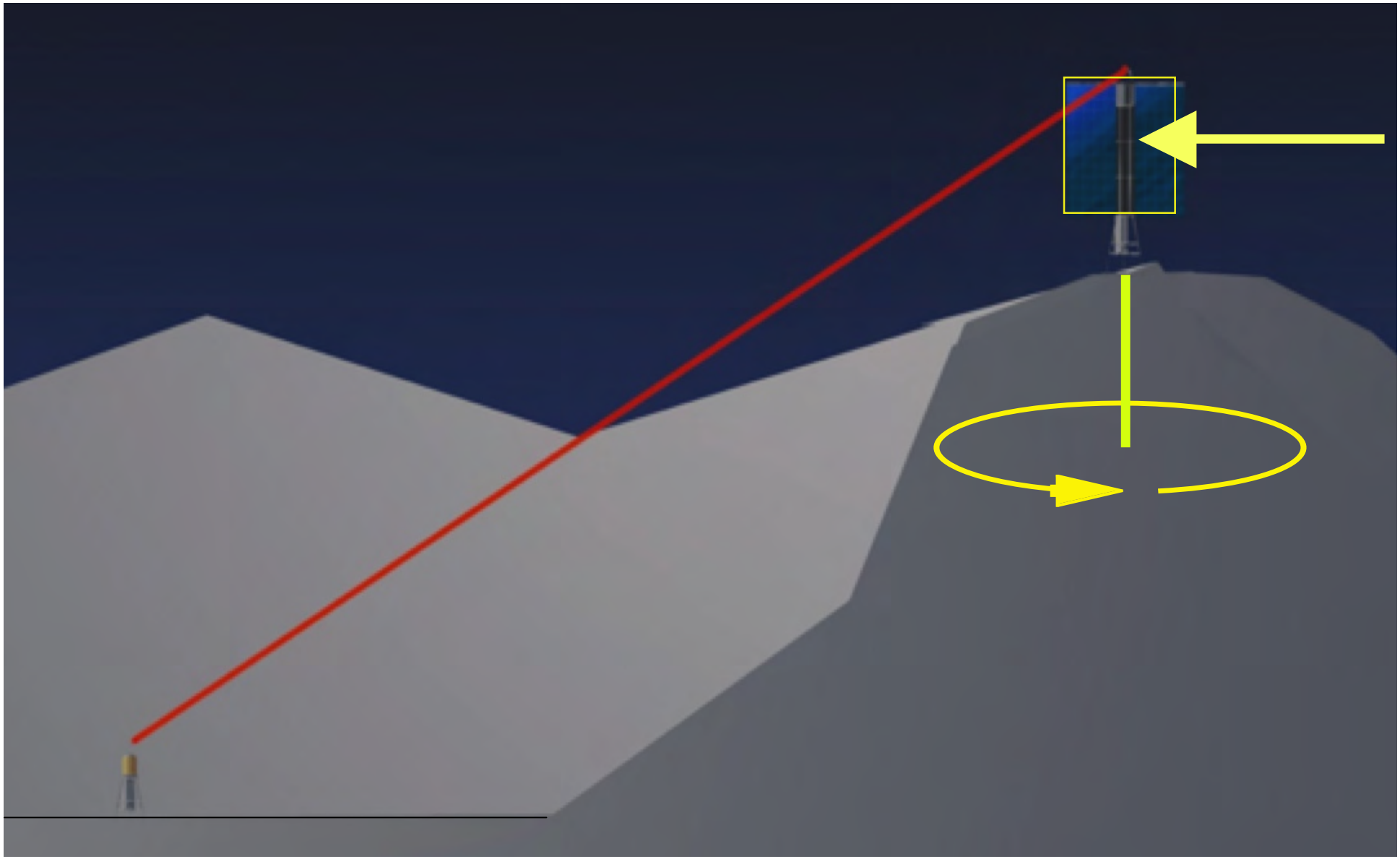
Lunar Transportation Systems, Inc.

Introduction

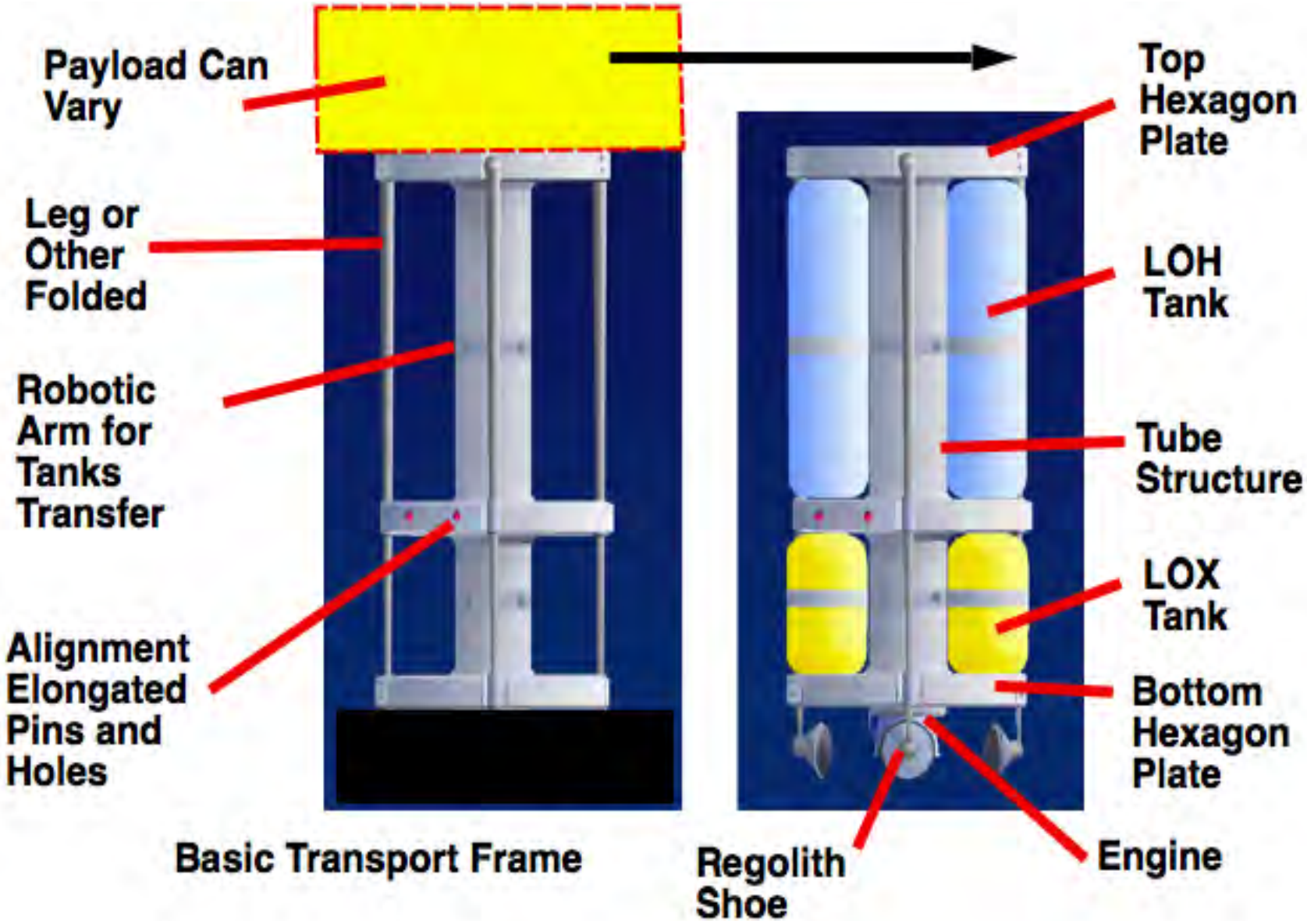
- LTS has Vehicle Concept & Commercial Business
- Raise Capital & Innovation to START Trade Route
- Entrepreneurs Explore Future Markets, Cut Costs & Increase Market Share, to make $ & More Effective
- After 42+ years it is Time to Mine the MOON
- Helium3 is $6-15B/ton, Mined & a Trade Route
- Trade Routes Transport Value in both Directions
- Mankind now Expands into the Near Universe
- Our Government Stimulates other Industries

Mining Lunar Cold Traps



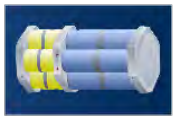
Reduce the Cost of Commercial Transportation

& Construction Methods



1

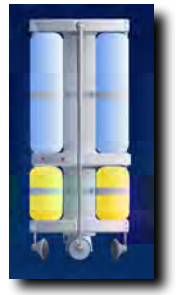
Propellant
Transporter



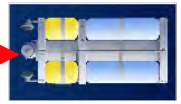
2

Propellant
Dispenser

3



Lunar
Lander



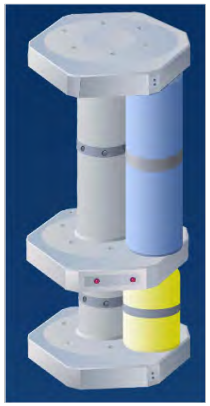
Low Lunar
Orbit

Lunar Lander

Empty Spacecraft Mass - 1 metric ton
Propellant Mass - 5 metric tons
Total Mass - 6 metric tons
Spacecraft Size - 5.0 m height; 2.7 m diameter
Payload Mass - Up to 10 metric tons
(transferred in LEO)
Launch Vehicle to LEO - Delta II Heavy class

Lunar
Lander

LLO



Mission Profile 1 - LEO to Lunar Surface Direct - 800 kg
Mission Profile 2 - LEO to L1, Refuel, to Lunar Surface - 3.2 tons
Mission Profile 3 - LEO to MEO, Refuel, to L1, Refuel, to Lunar orbit, Refuel, to Lunar Surface - 10 tons

Payload
Dispenser

4

L1

Propellant
Transporter

MEO

A Propellant Depot increases our Payload Capacity

Autonomous Rendezvous and Soft Berthing

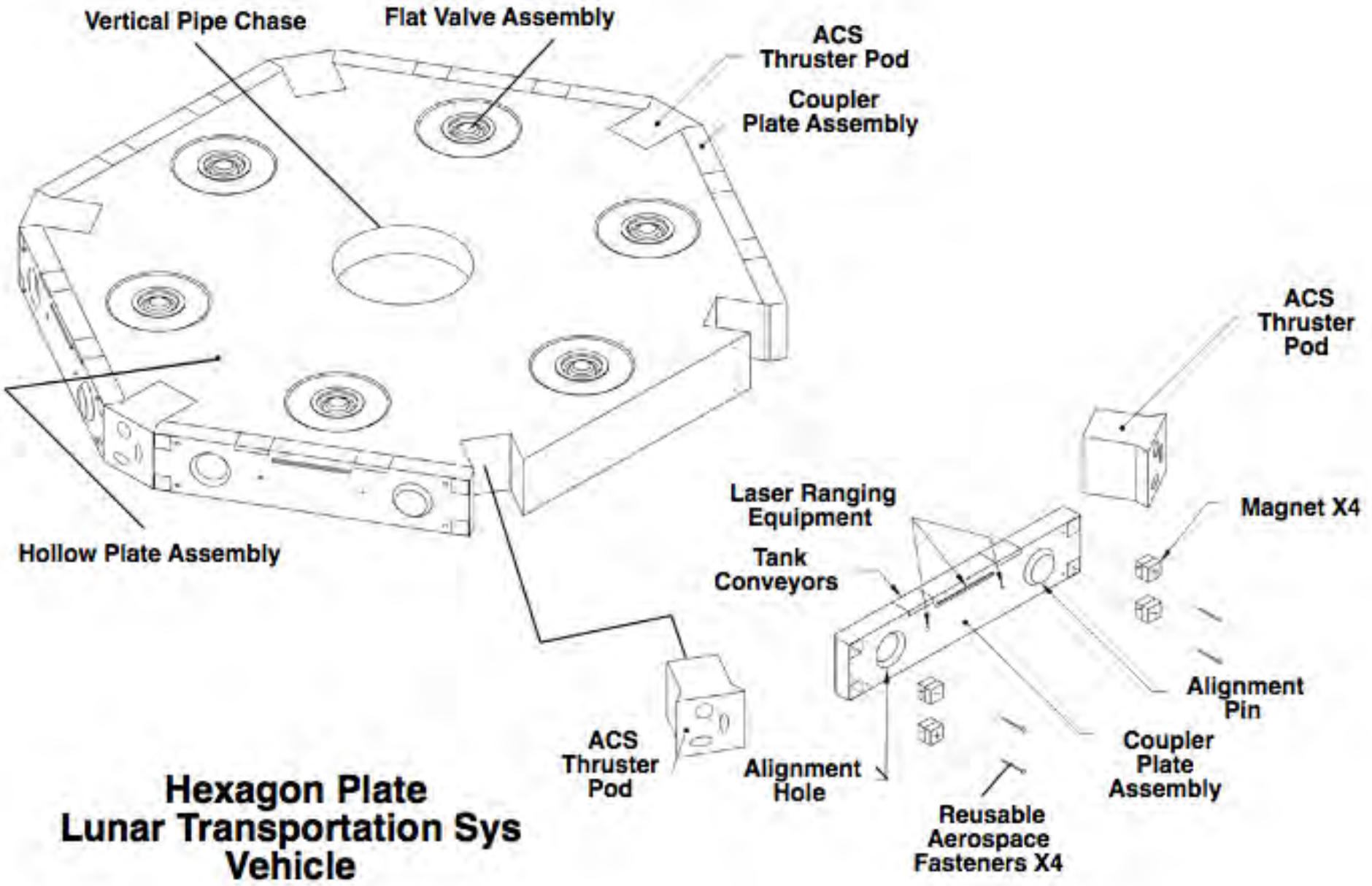
- Cargo uses EELV's
- 1st cycle is already **Commercial**
- LTS Units find each other with a laser ranging system & RCS at Left
- Logistics Service available & unmanned
- **99% of the cargo could go on a non-critical affordable workhorse vehicles**

Lunar Lander

Laser Range Finder

Payload BTF with Strut Reuse

LTS Hexagon Plate Components



Payload Transfer Anywhere

Transfer Payloads & Tanks Any Size in LEO & in Route

Reduce Commercial Transport $

- Separate Humans from Cargo Vehicles
- Use Multiple Trade Routes, AK had Four Trade Routes, Sometimes None Worked
- Move toward Reusable Hardware
- Learn from other industries-labor saving
- Foster Commercial Competitive Ideas
- Understand the Earth Orbit is like a Shoreline
- Be a Own Propellant Depot, if Others Slow

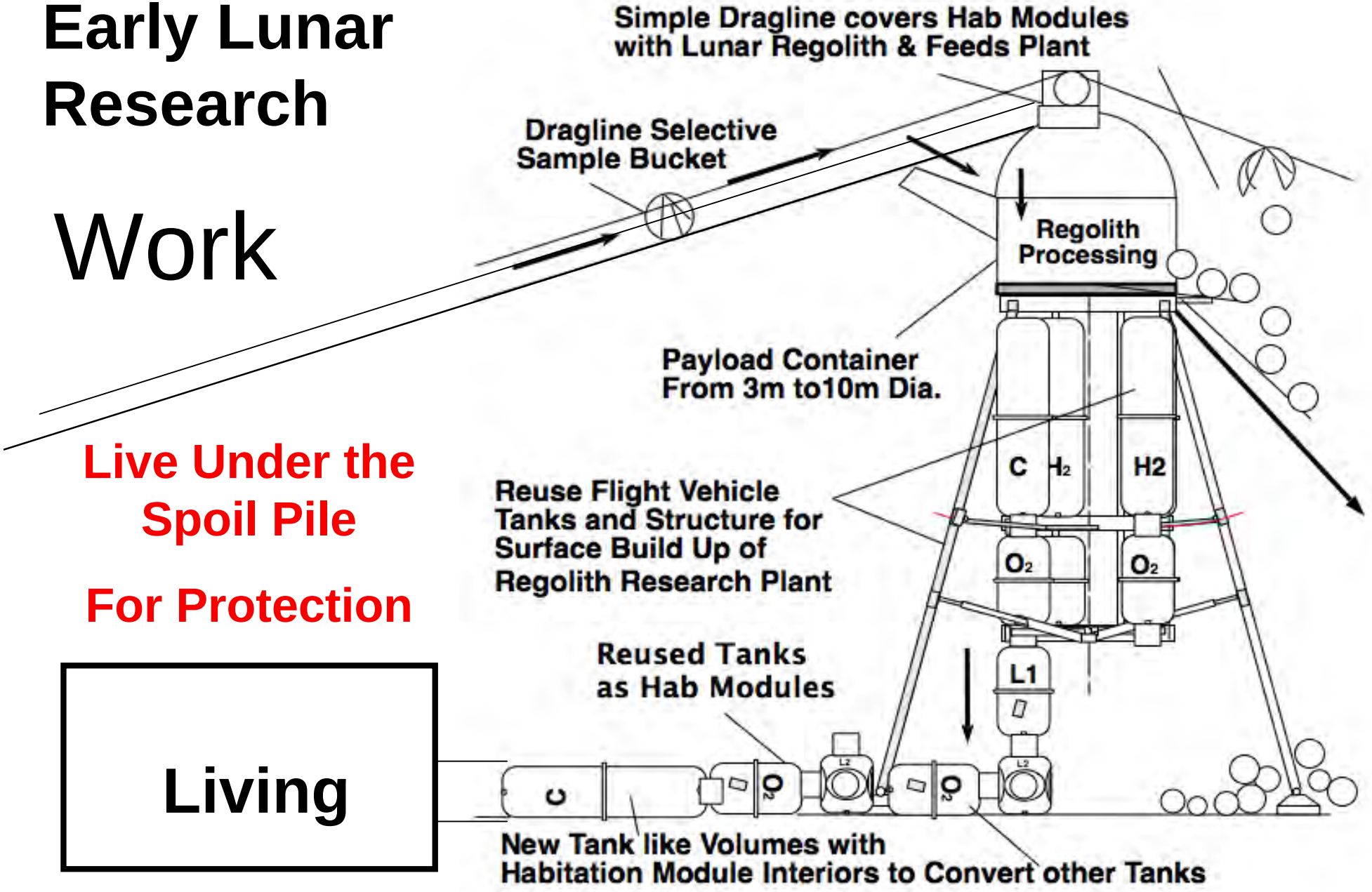
Early Lunar Research

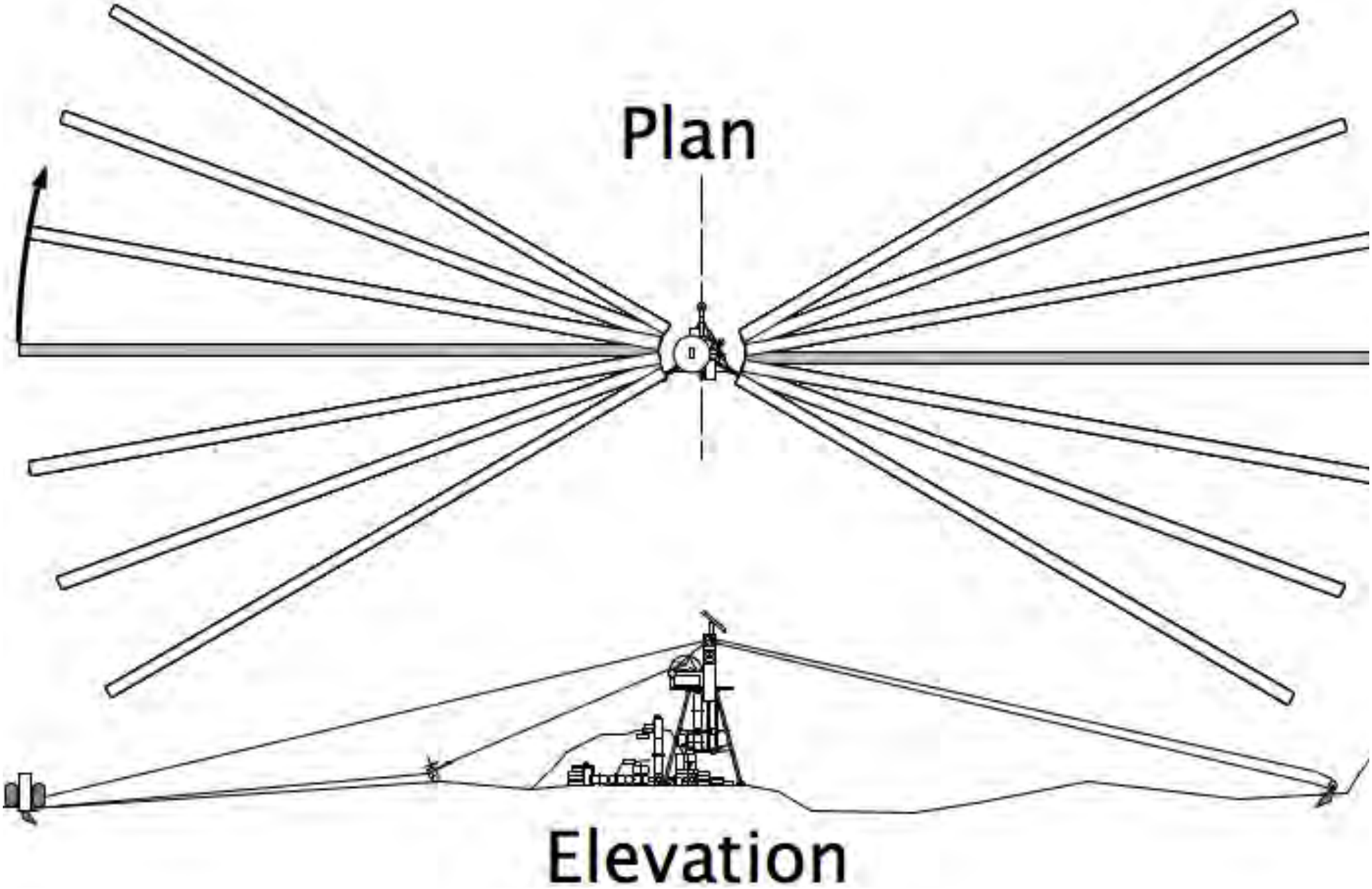
Work

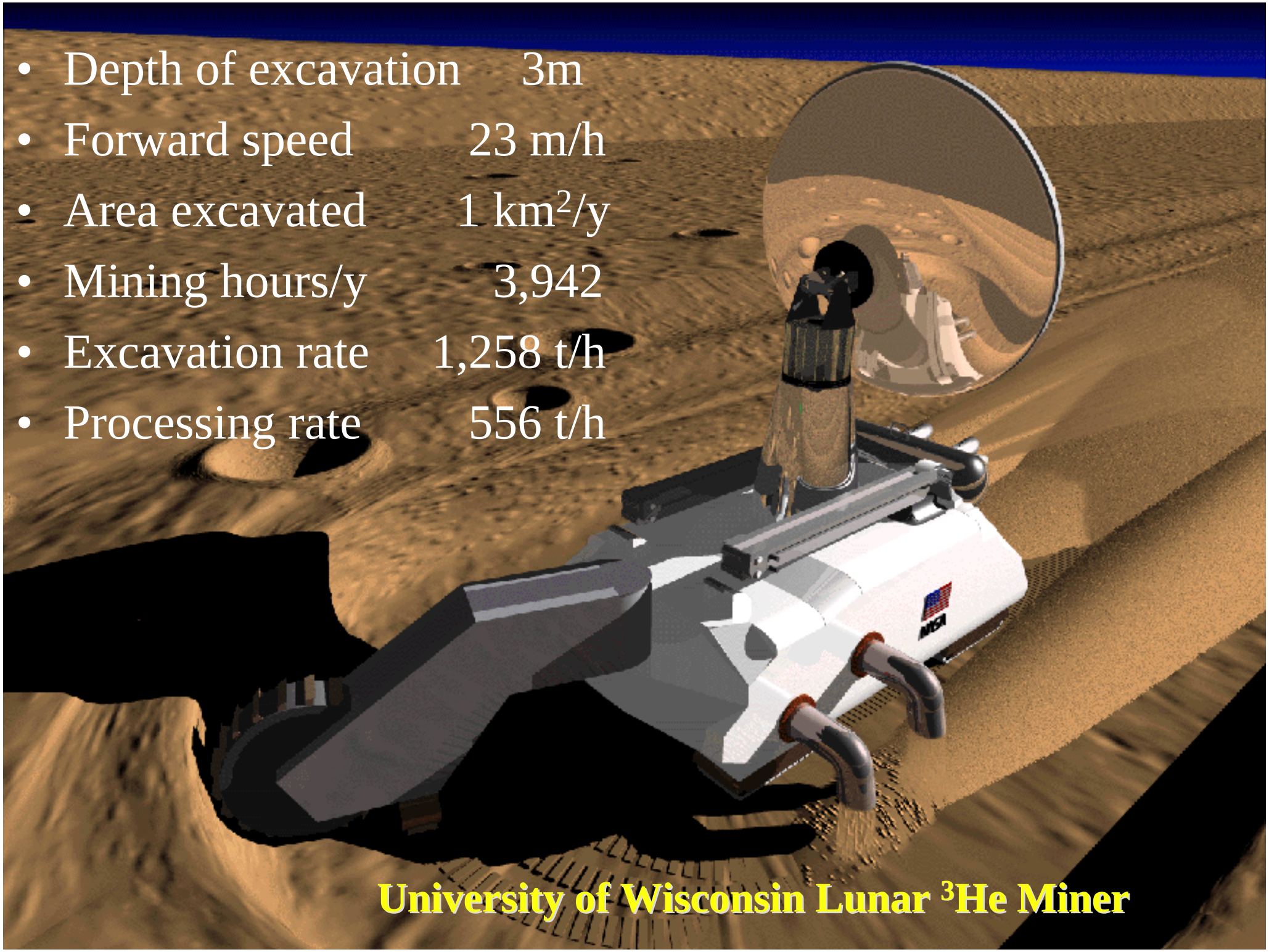
Live Under the Spoil Pile

For Protection

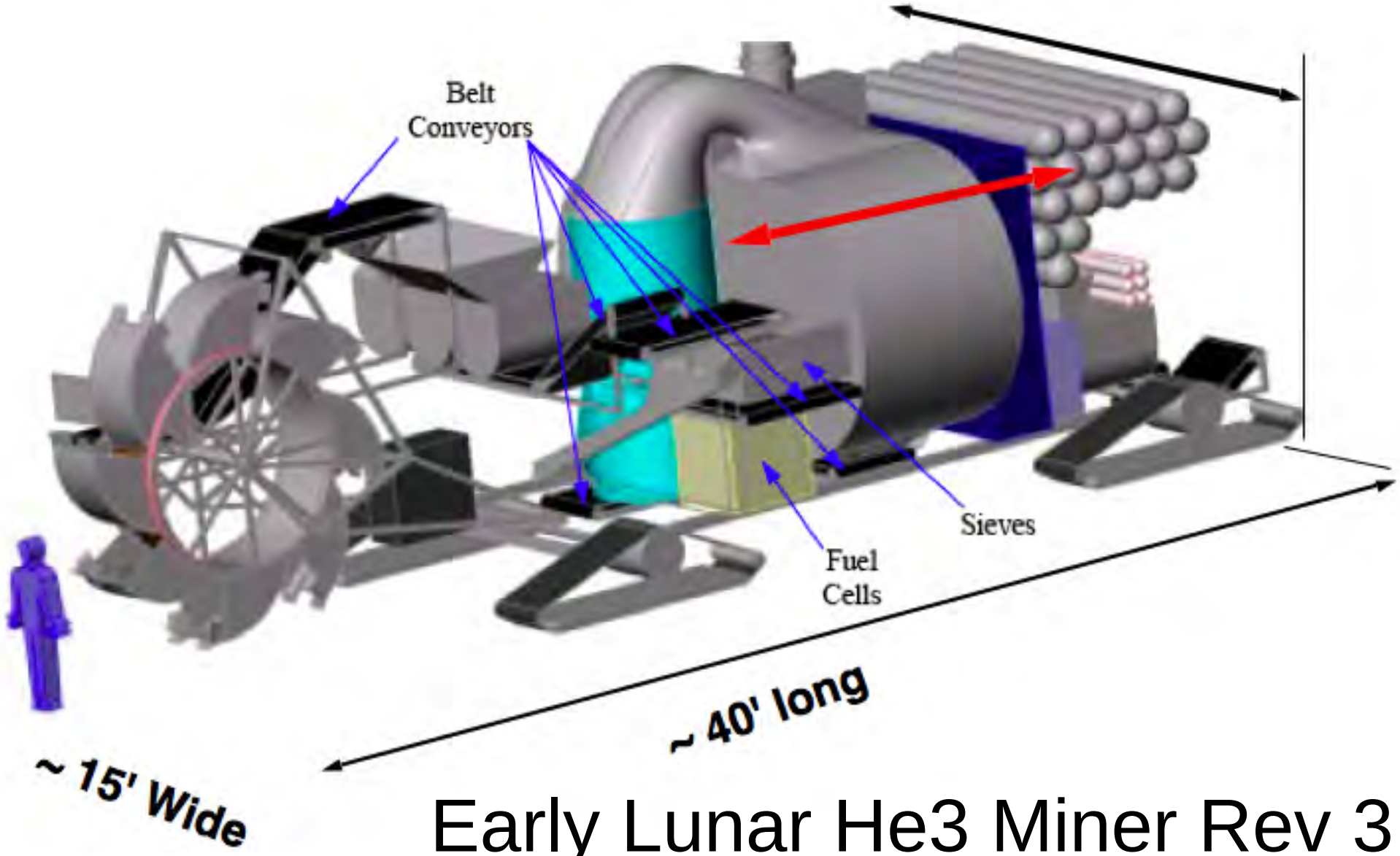
Living




Plan
Elevation

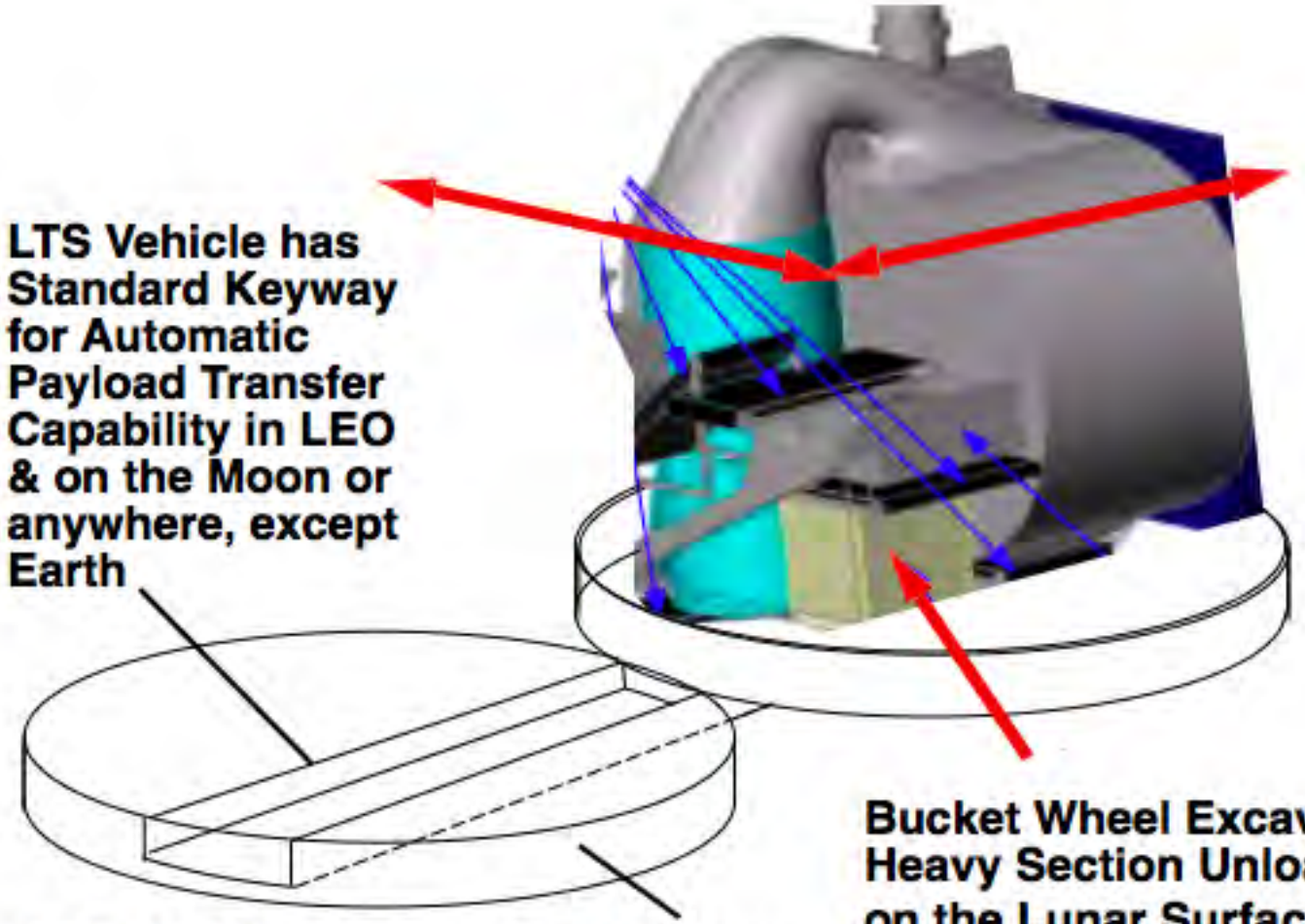

• Depth of excavation 3m
• Forward speed 23 m/h
• Area excavated 1 km²/y
• Mining hours/y 3,942
• Excavation rate 1,258 t/h
• Processing rate 556 t/h
University of Wisconsin Lunar ³He Miner

University of Wisconsin - Madison



Early Lunar He3 Miner Rev 3

He3 Excavator Unload



Process for Extracting Helium-3 from Lunar Regolith

80 deg F

- 370 deg F

- 456.97deg F

300 °K

Radiator/ Condenser

50 °K

Isotopic Separation

1.5 °K

1 tonne Helium-3

- 223 deg C

6100 tonnes

3300

500

1700

1600

1900

3100

H_2 Fuel

H_2O N_2 CO_2 CH_4 CO Life Support

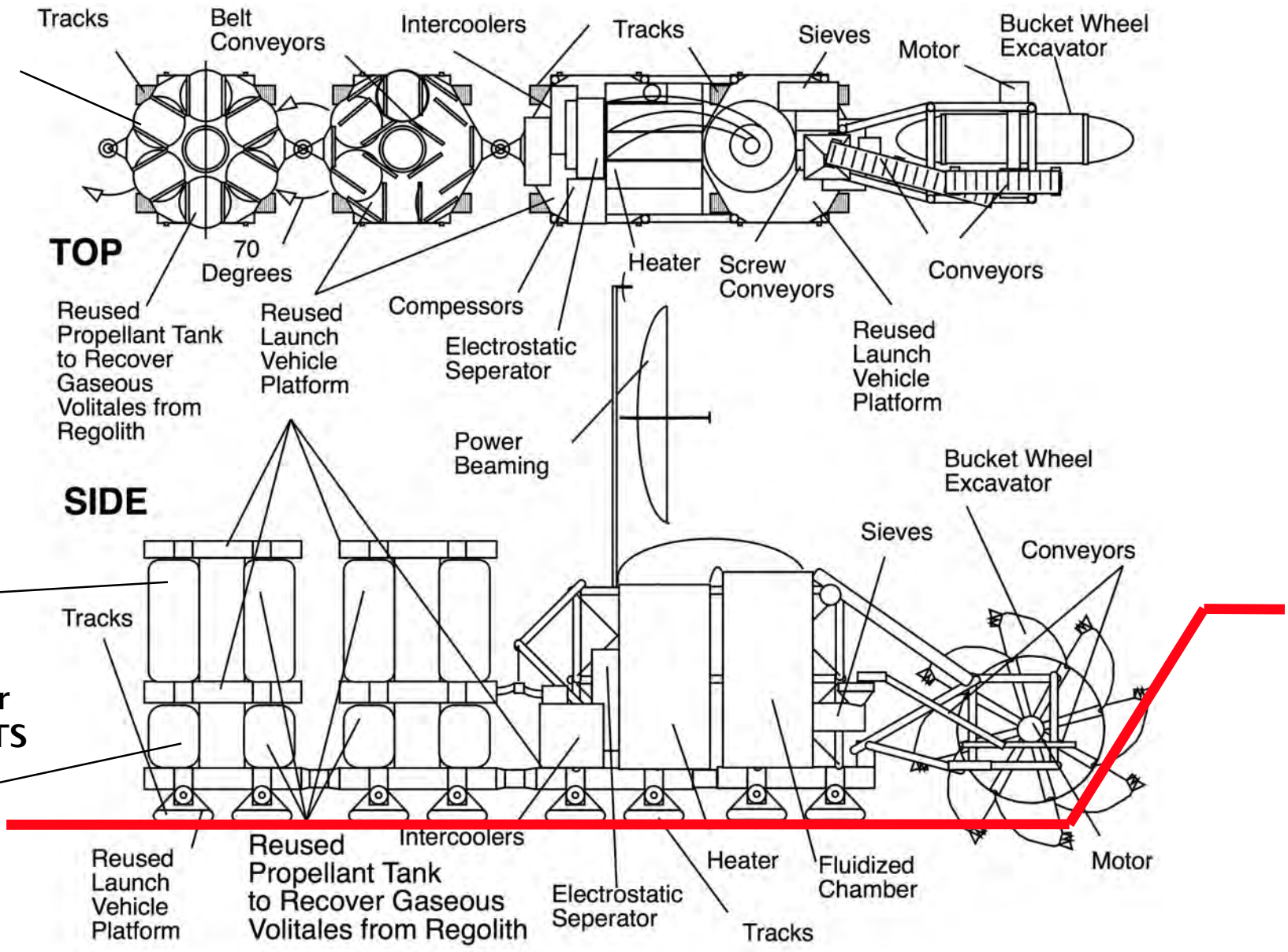
Helium-4 Cryogenics

Clean Fusion Energy on Earth

From Univ of Wisc-Madison

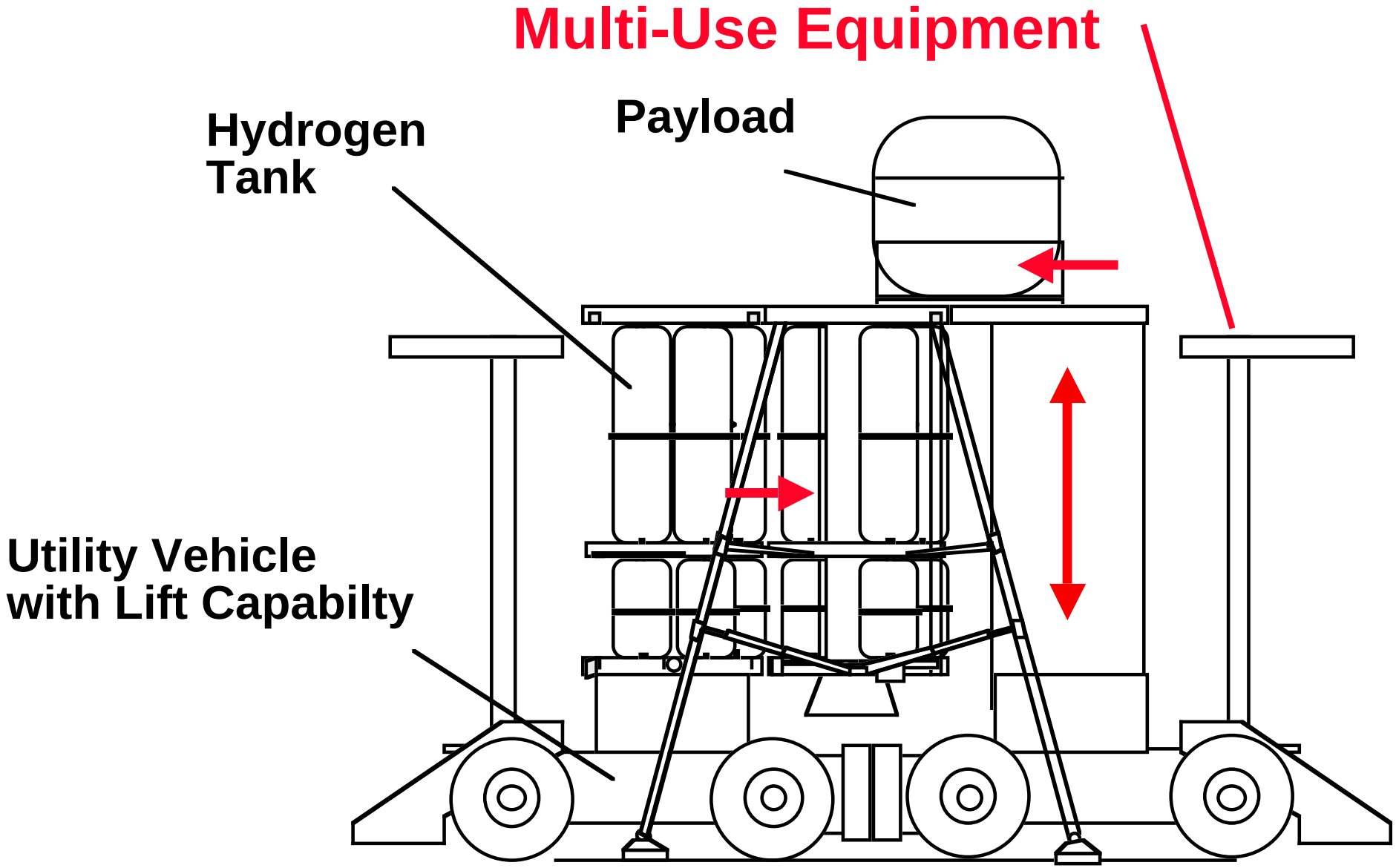
Process Regolith in Place with Reused Equipment

Std. LTS Frame becomes 12 Pack Frame



Std. LTS Tanks Transport Gases. Cryo, Water And Use LTS Robotics To change tanks

Reloading LTS Vehicles



8. Use “Living off the Land” Save $

- Est. 90% of mass used in AK was there
- Water, Power, O2 needed early & often
- Explore methods w/ less Cost & Transport
- Involve Space Resource Recovery, Tourists
- Evolve Lunar Economies into product types
- Involve other Nations & Commercial Partners
- Learn to Reuse Hardware

Trade Routes Used to Develop Prudhoe Bay Energy Gaps in the Past

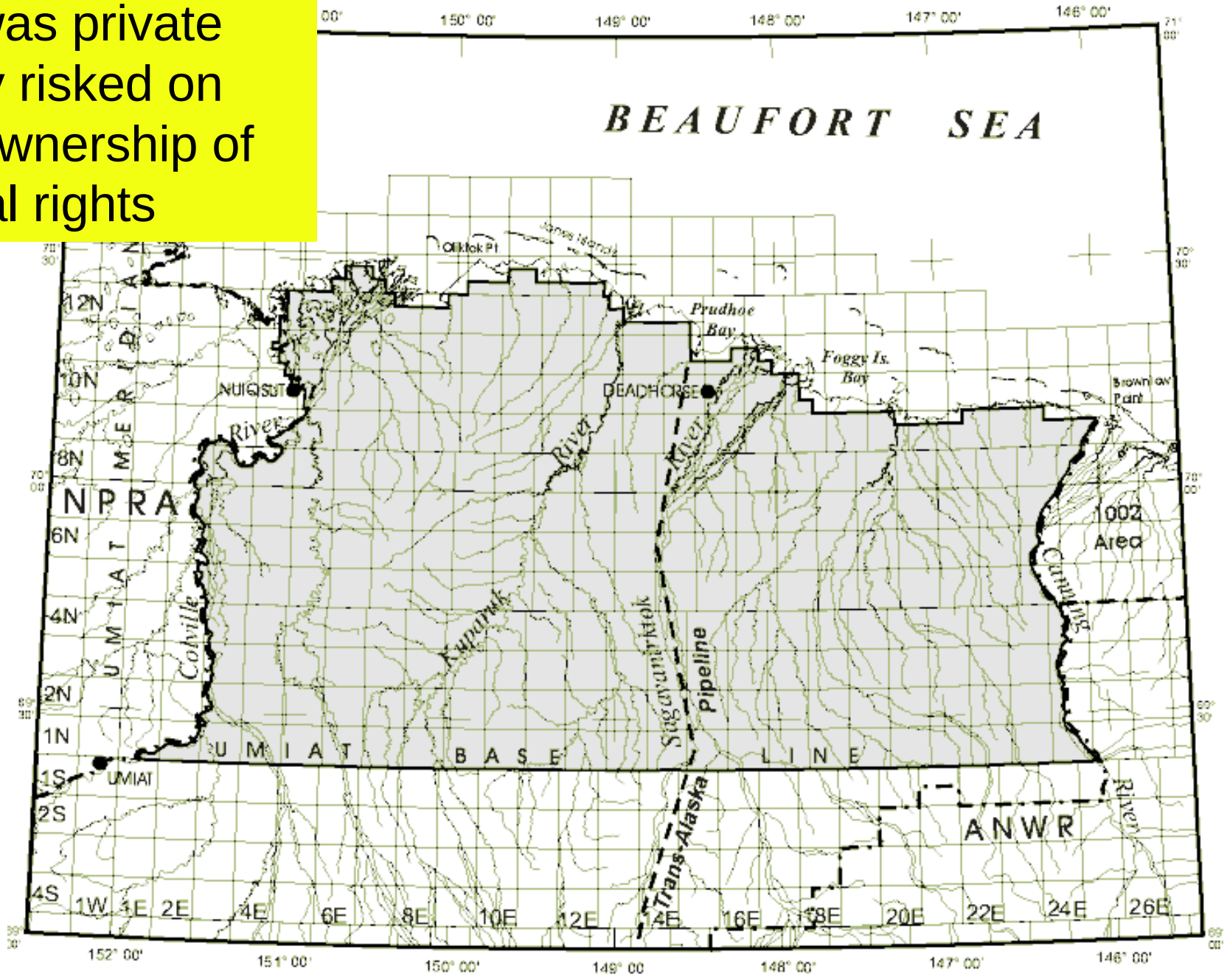
The Senate Energy Committee is considering the largest construction project in the history of mankind. **Natural Gas Pipeline is #5 Trade Route.**

1. Barges
2. Air
3. Trucks
4. Pipeline

4. Pooling Risk Money

- Companies varied in size, their skills in oil field development & Money to put in
- With so many leases available, small guys could buy in and they all used the facilities w/o duplication of facilities
- This means all pooled their money and reduced the risk to individual companies
- The risks varied greatly at each level

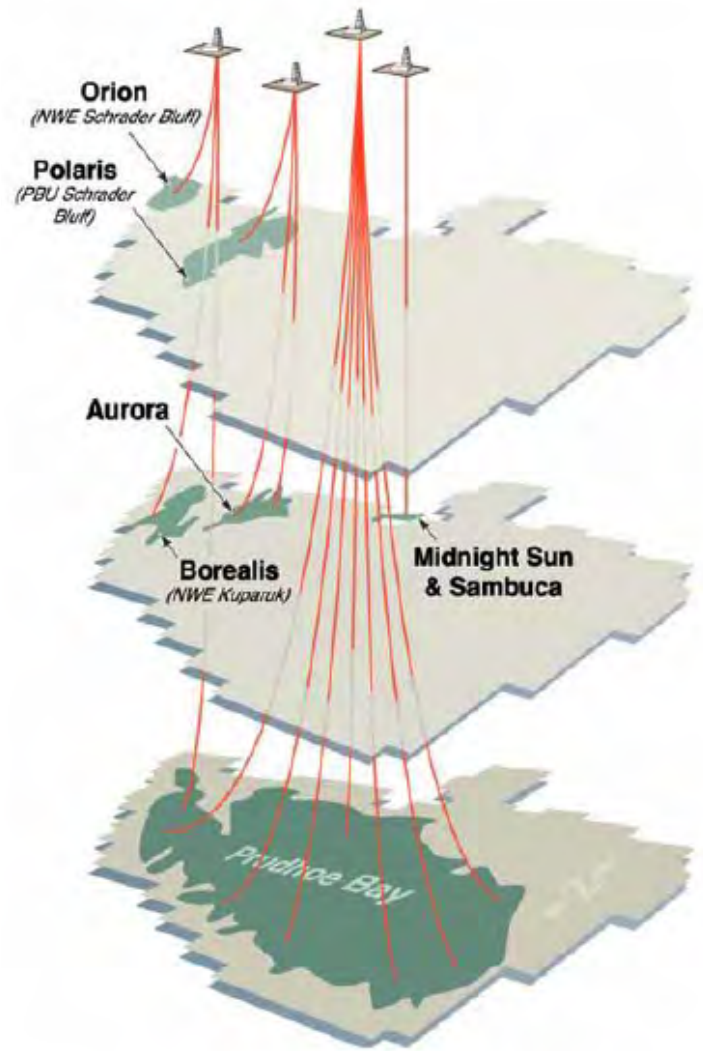
Why was private Money risked on Oil? Ownership of mineral rights



6. Pooling Changes the Risks, Recovery & Develop Phases

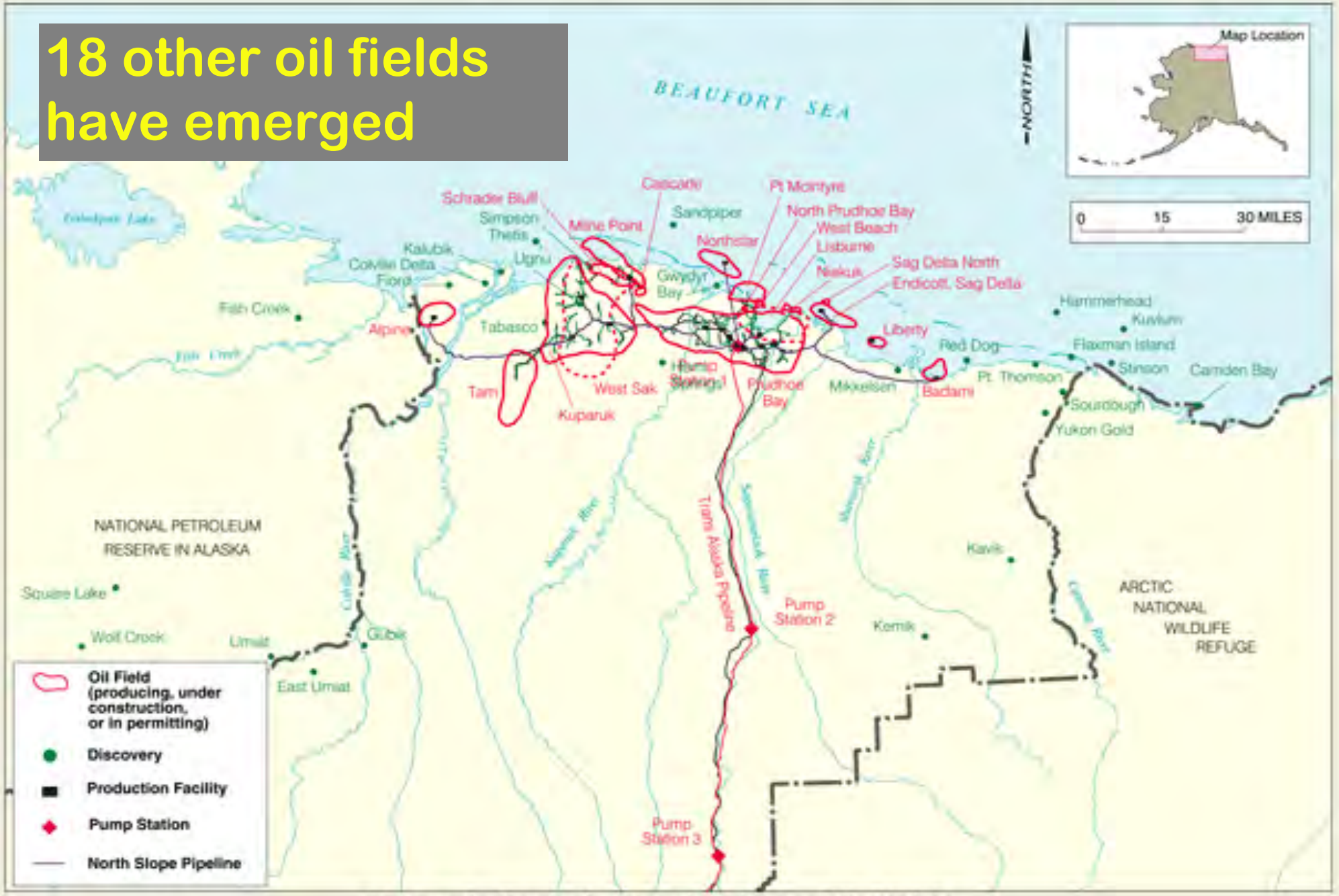
- Prudhoe Bay taught me a lot, but I wasn't there learn their techniques, I worked long hours, etc. & respect the cold conditions
- The Moon is 3 times colder, bigger money
- He3 is $6 to 15B/ton based on the Oil price to generation of Electricity
- Lunar Pooling can work. If the market forces can be stimulated

Private Financing $20B (1975)



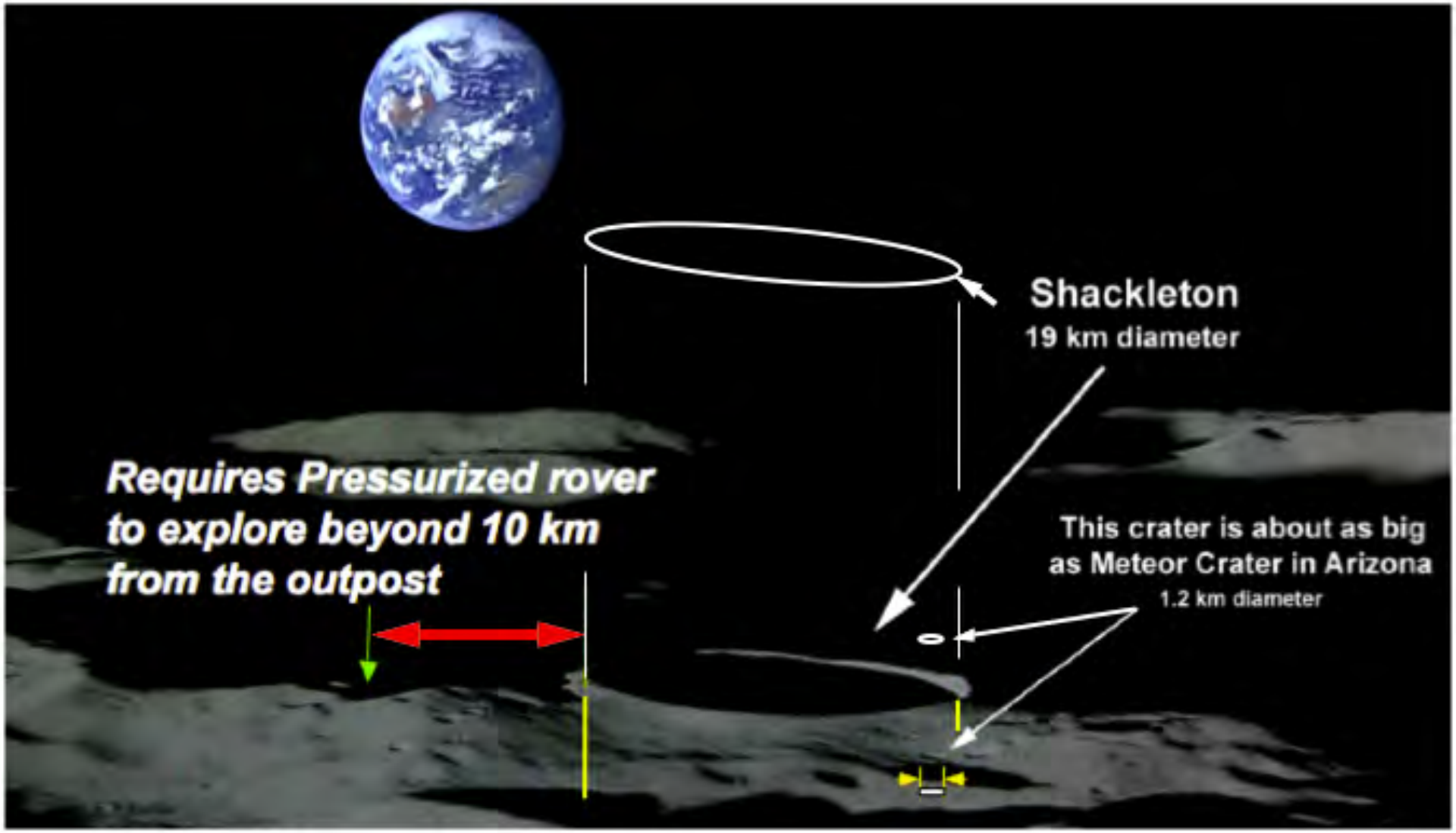
- BigOil invested private **$20B** to make trillions on recovered Oil
- Remote Base had 4 Logistics routes, sometimes none worked for short periods in winter
- ~90% of mass used on the slope was already there, so “Living off the Land” was a cost reduction factor
- Private $ spent on future Resource Recovery ~ **$200B + $200B on 18 Fields, so far at Prudhoe Bay**
- **He3 is bigger economically**

North Slope Oil Fields



Map of Alaska's North Slope Oil Fields.

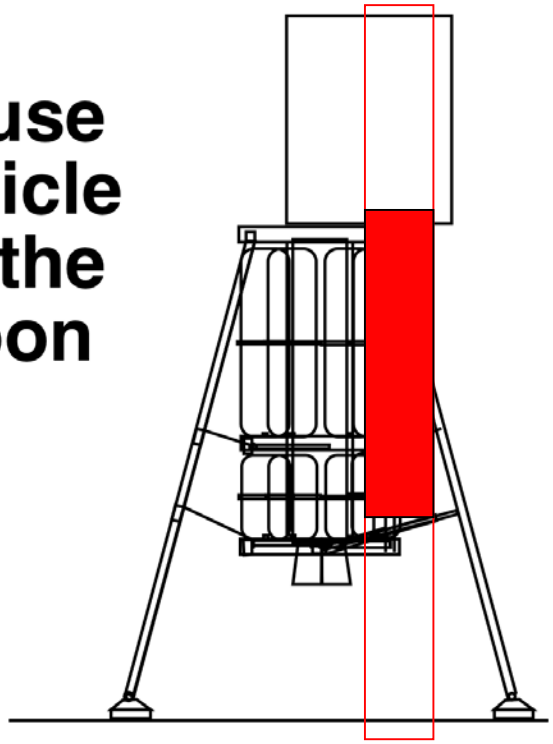
The Moon is Vast



Vertical Shaft Recovery

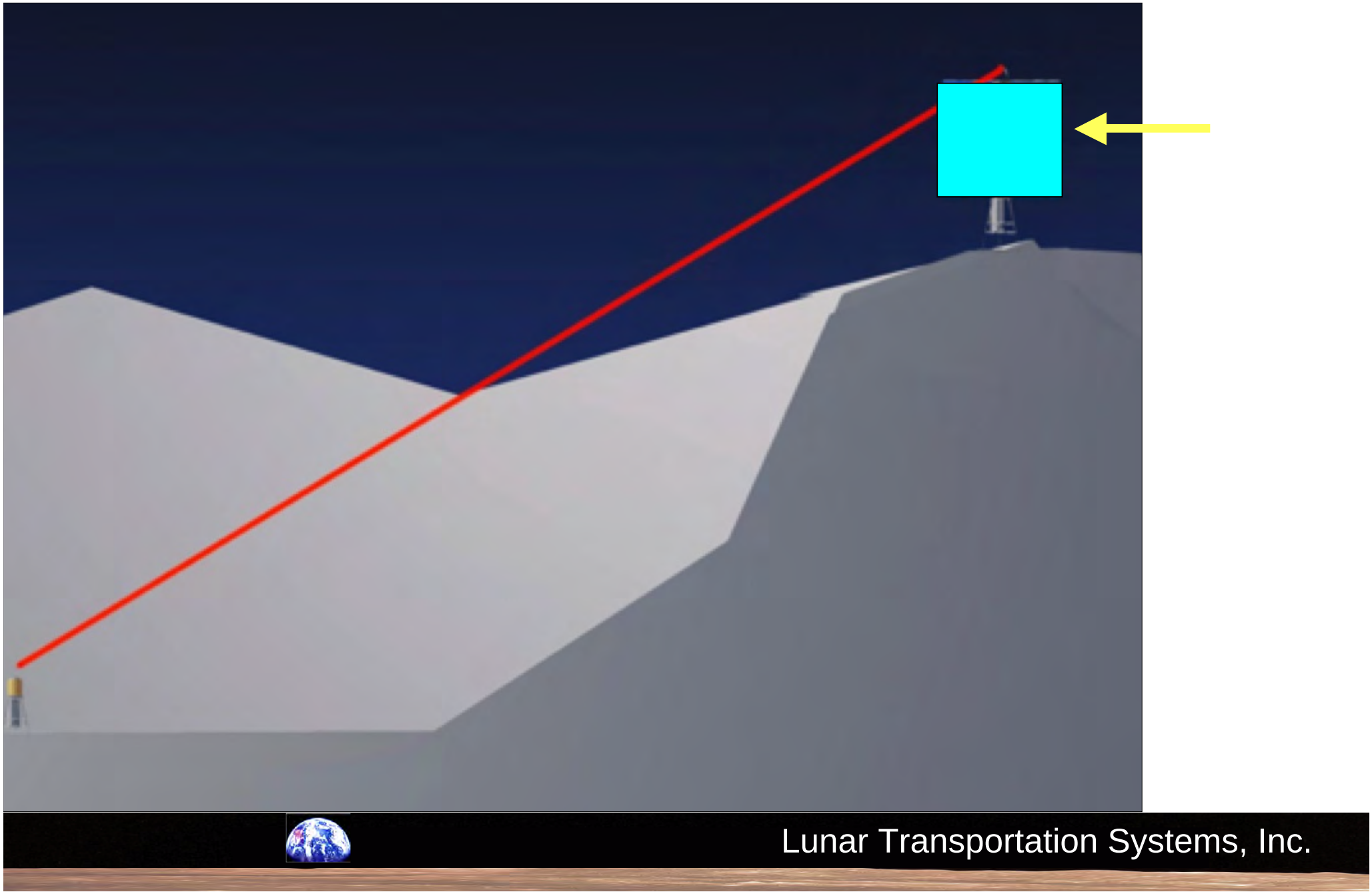
LTS, Inc.

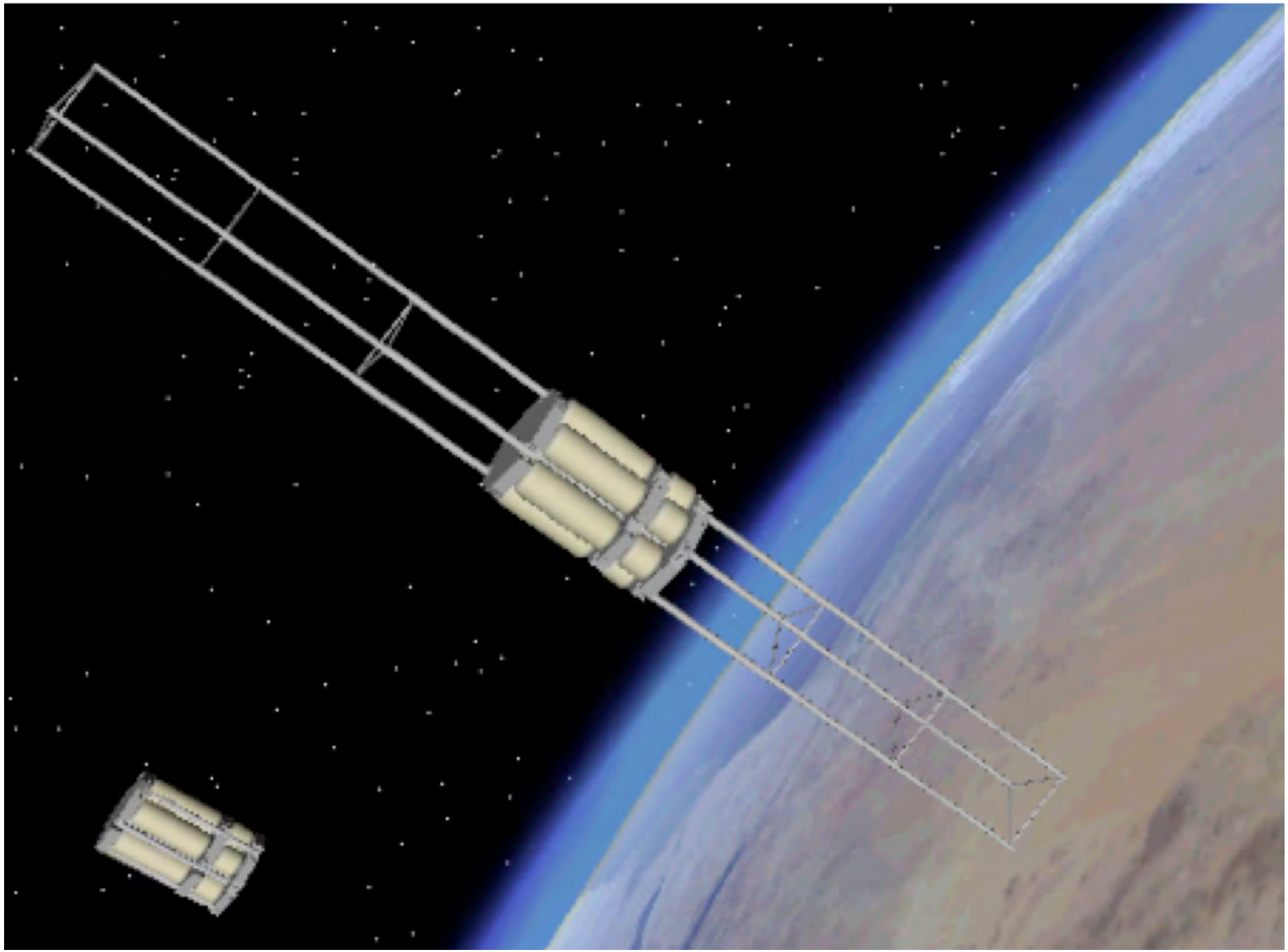
Reuse Vehicle on the Moon



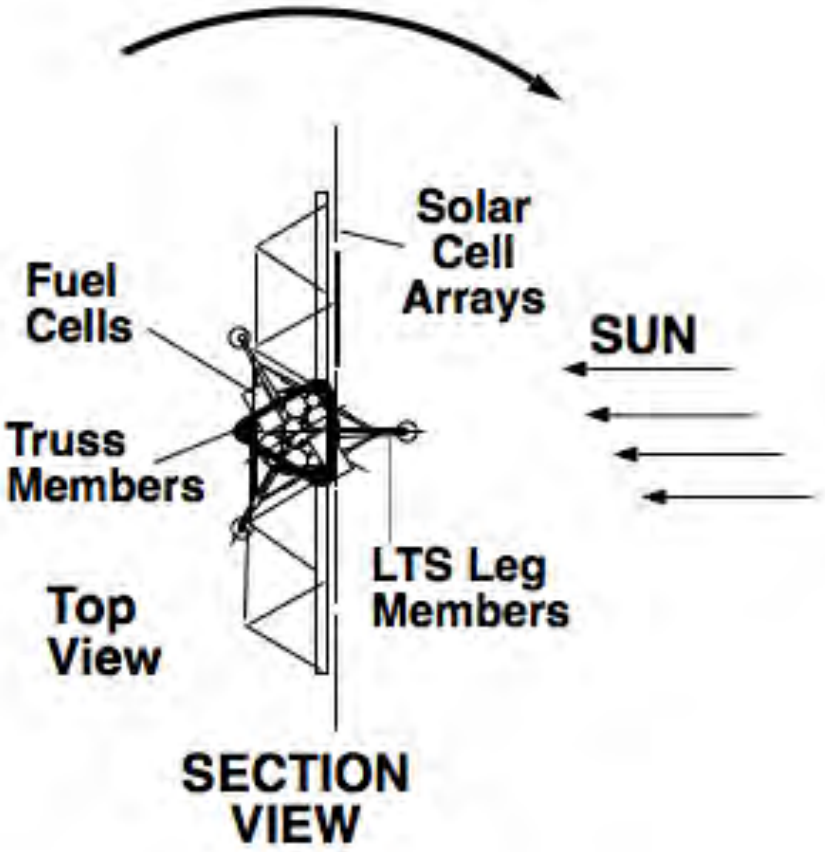
- Reuse LTS Stack
- Encourage innovation
- Design to Drill
- Telescope to cut the cost
- Hardware depends on the recovered resource recovery and value

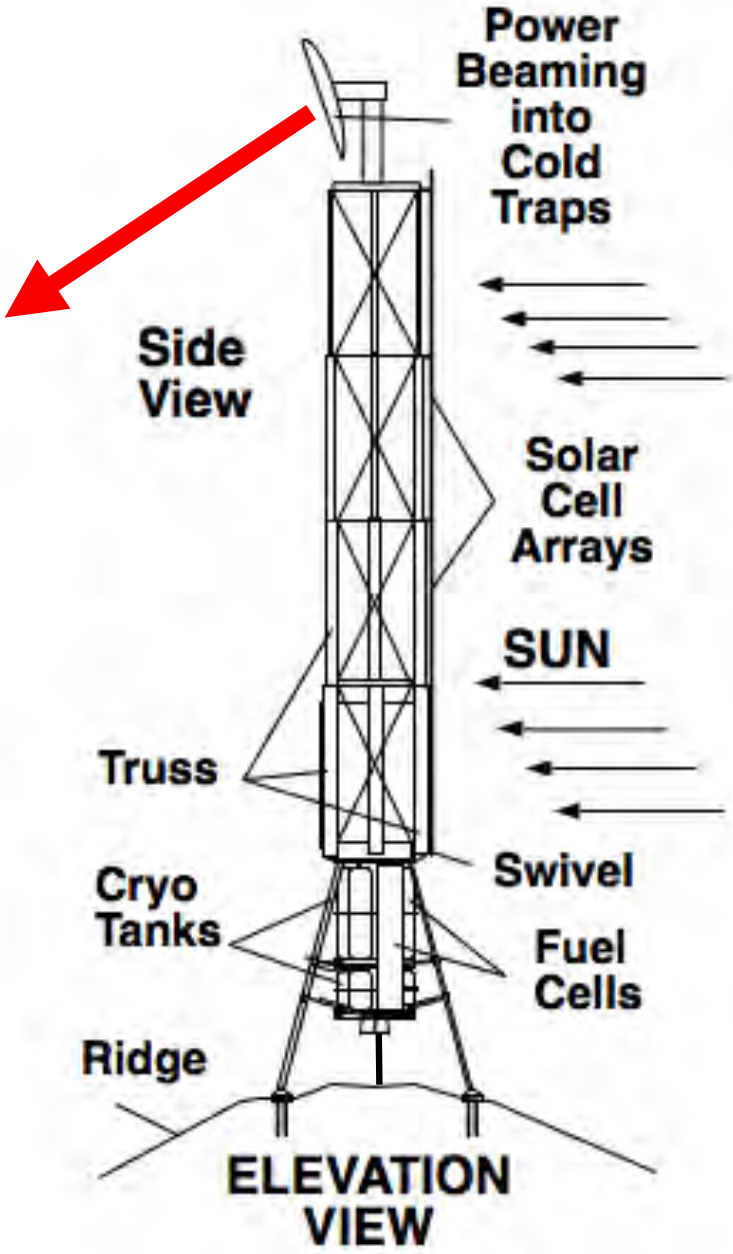
Mining & Living Underground



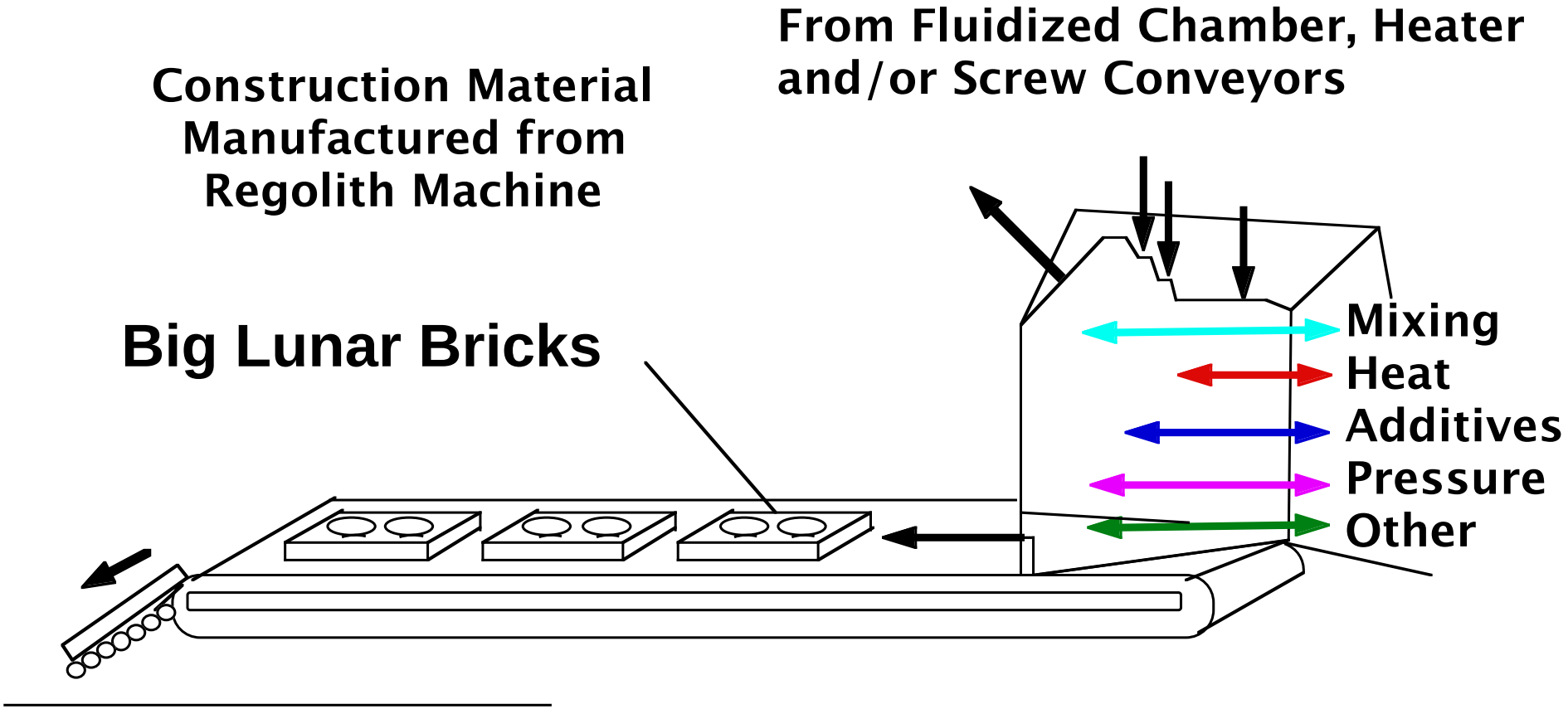


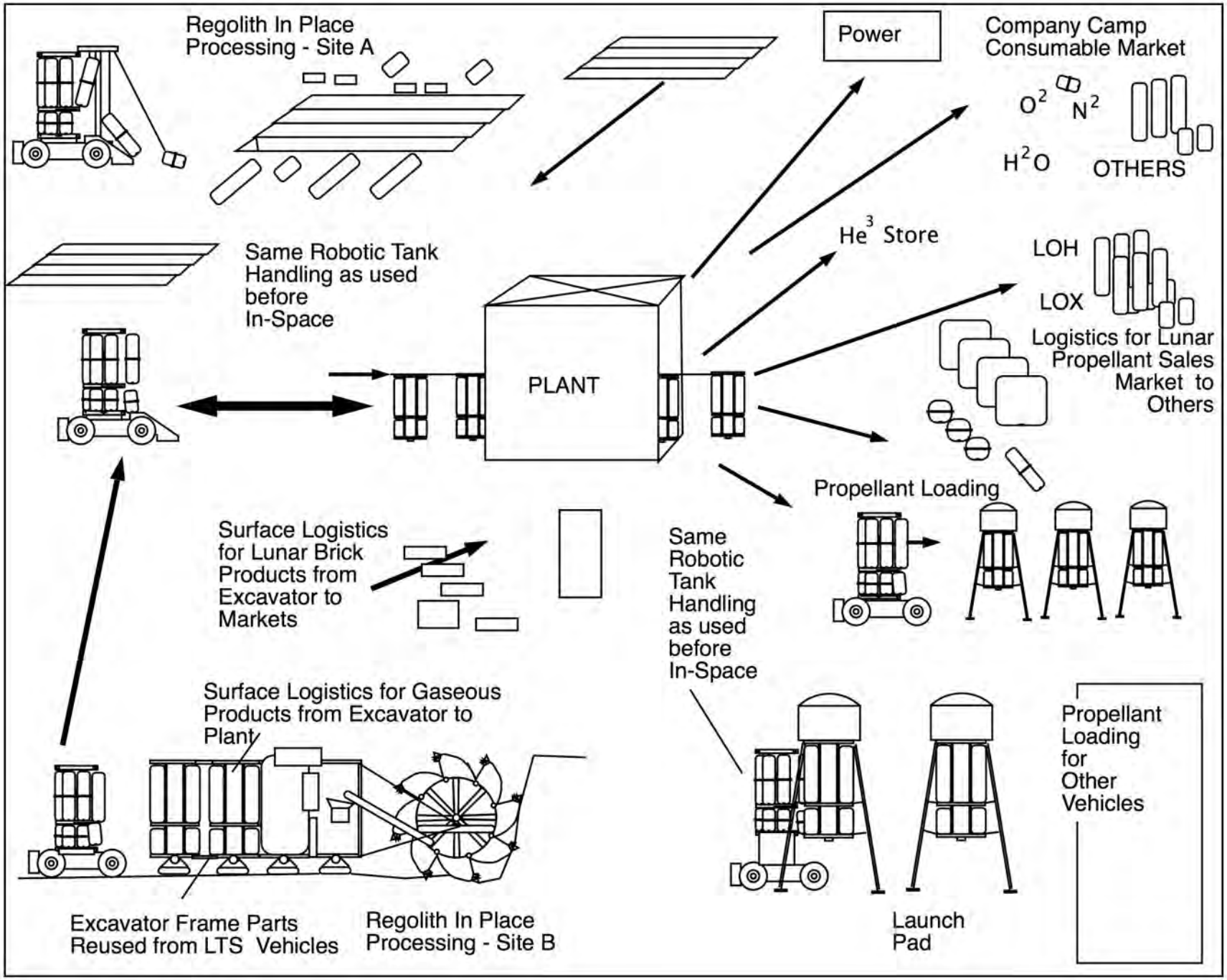
Energy Tower Utility





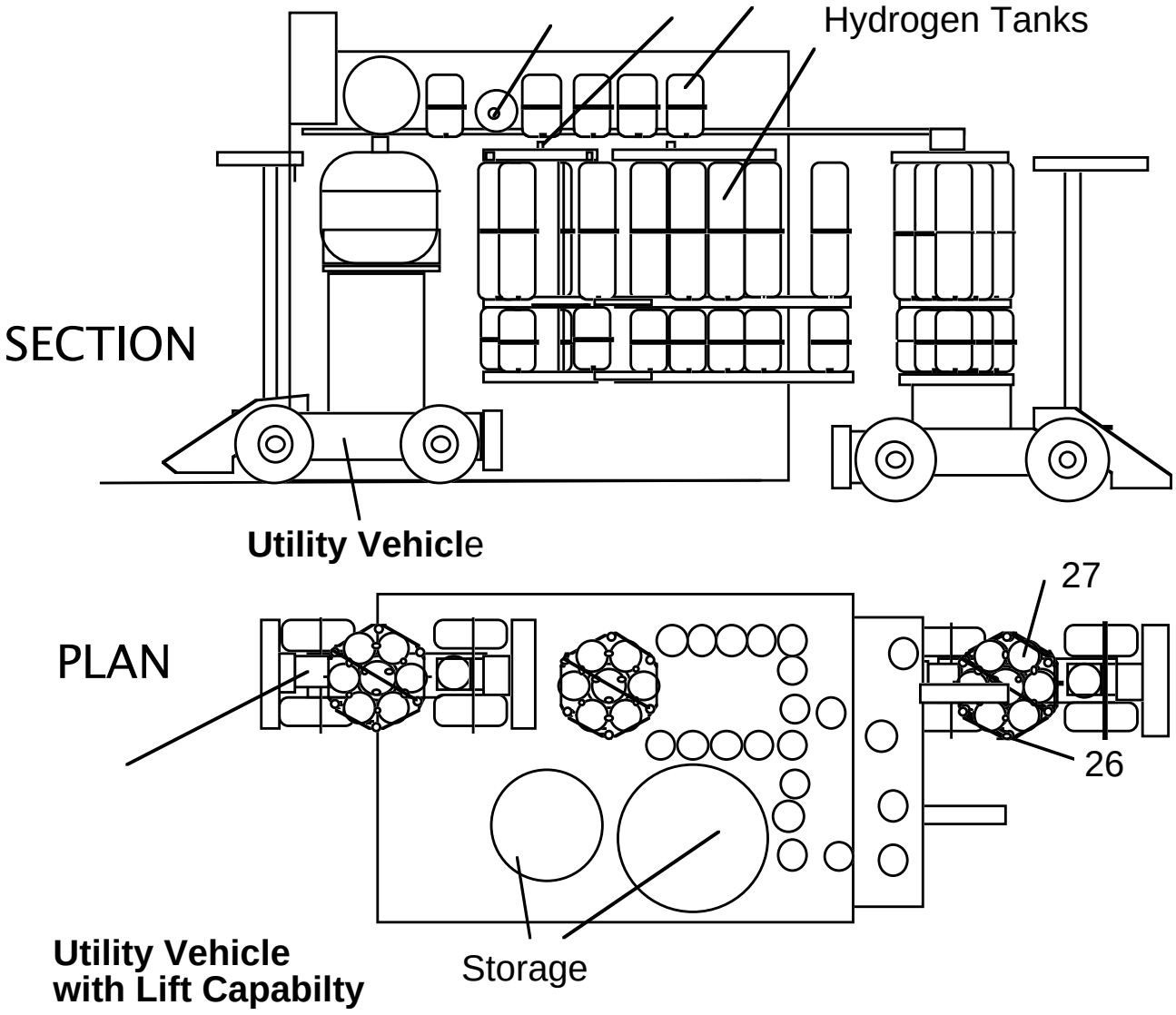
Products from Regolith




Regolith In Place
Processing - Site A
Power
Company Camp
Consumable Market
O^2
N^2
H^2O
OTHERS
He^3 Store
Same Robotic Tank
Handling as used
before
In-Space
LOH
LOX
Logistics for Lunar
Propellant Sales
Market to
Others
PLANT
Propellant Loading
Surface Logistics
for Lunar Brick
Products from
Excavator to
Markets
Same
Robotic
Tank
Handling
as used
before
In-Space
Surface Logistics for Gaseous
Products from Excavator to
Plant
Propellant
Loading
for
Other
Vehicles
Excavator Frame Parts
Reused from LTS Vehicles
Regolith In Place
Processing - Site B
Launch
Pad

Propellant Depot Processing

Converts H2 and O2 Gas to Crygenic Propellant

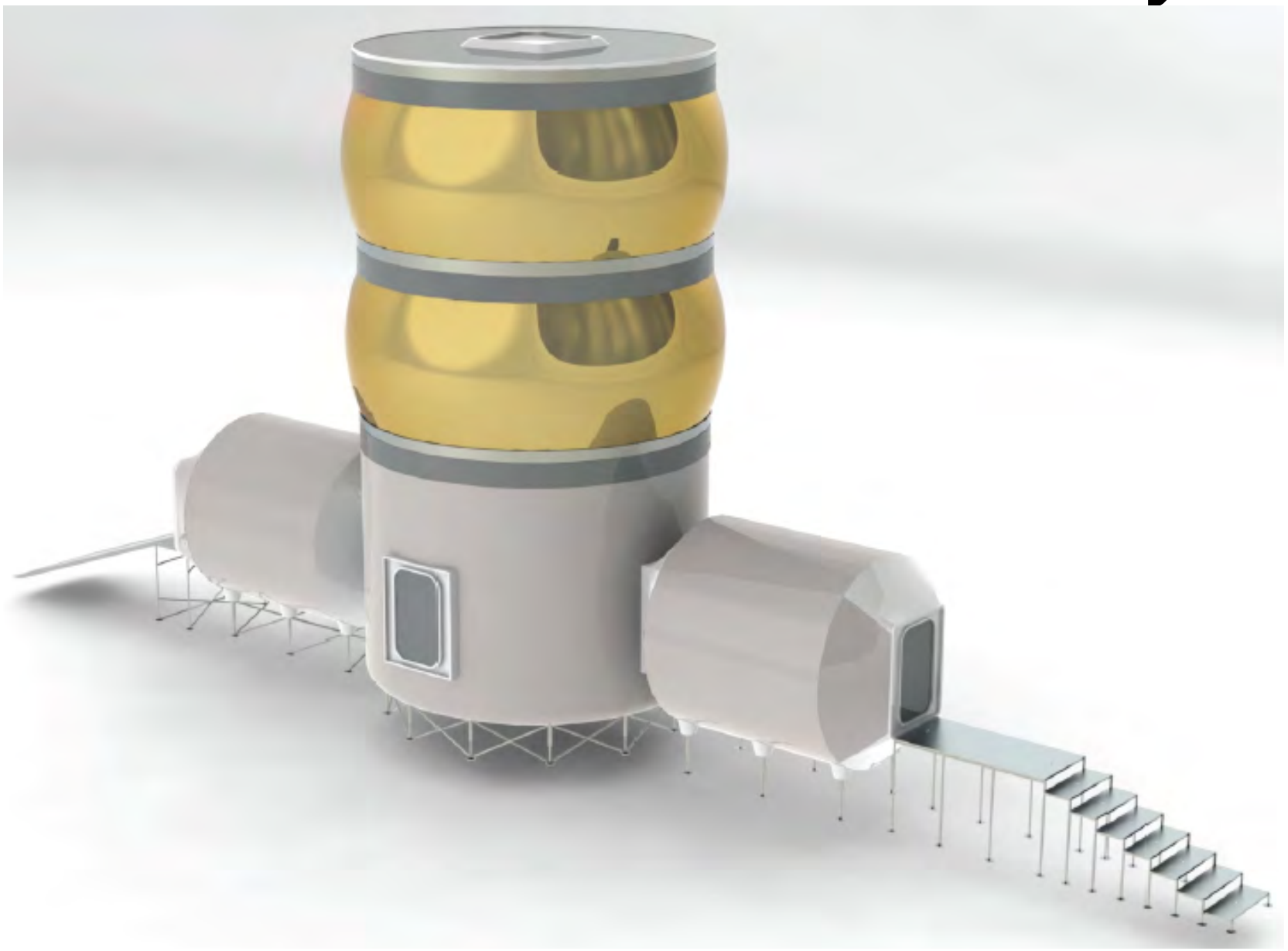


Utility Vehicle with Lift Capabilty

Helium3 as a Revenue Cargo

- He_3 Available on the moon & expensive on earth,
- Worth $6-15B per ton on earth (**$8.7B ~$60/bbl oil)**
- Easier to burn magnetic containment fusion power
- May be closer to practical use than other solutions or alternatives
- Responds well to large prize stimulation
- Non radioactive solution & results in lower cost grid power generation plants inside cities & maybe vehicles
- Could solve oil dependence & move our nation into the technical age

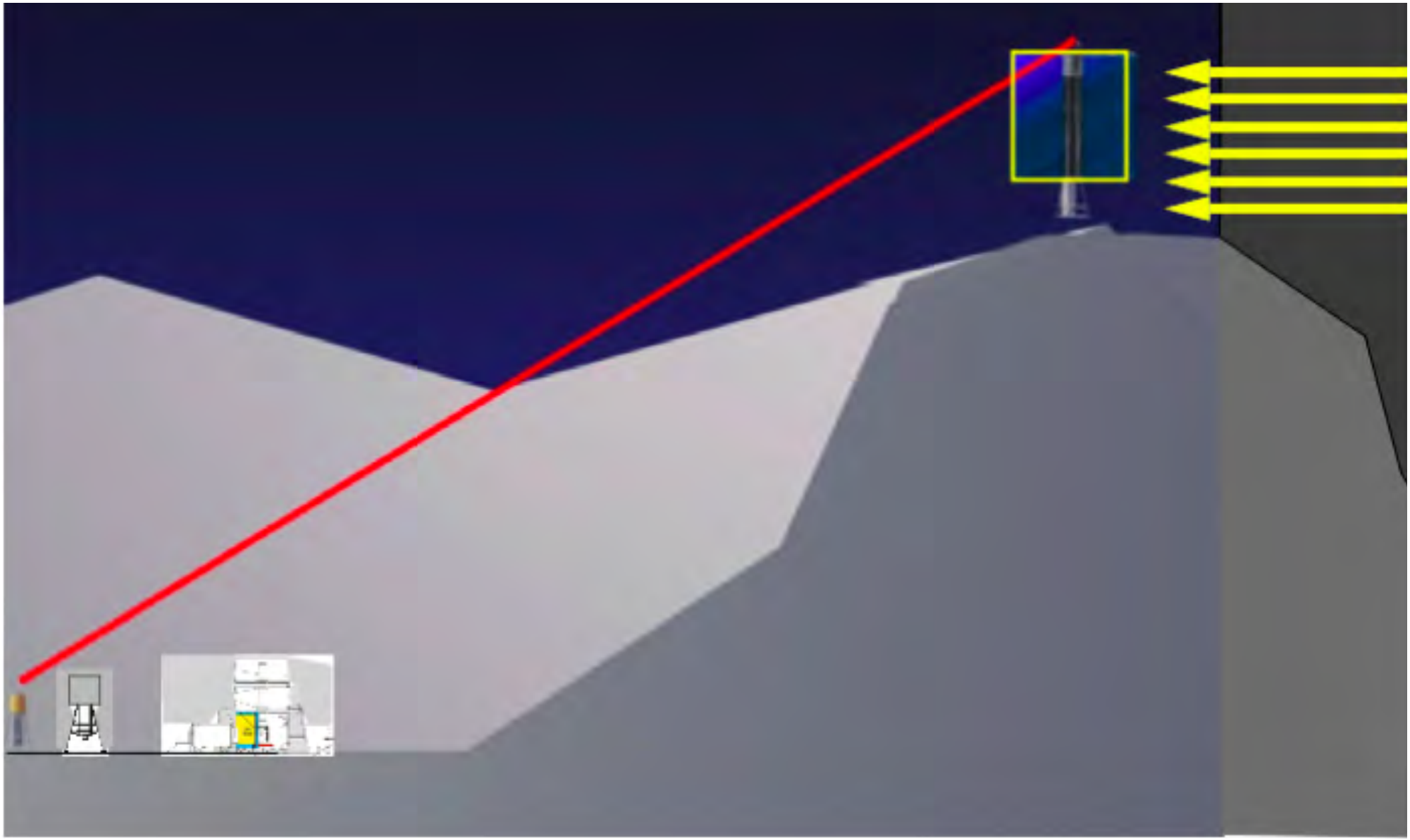
MFHE Lunar Hab - Early



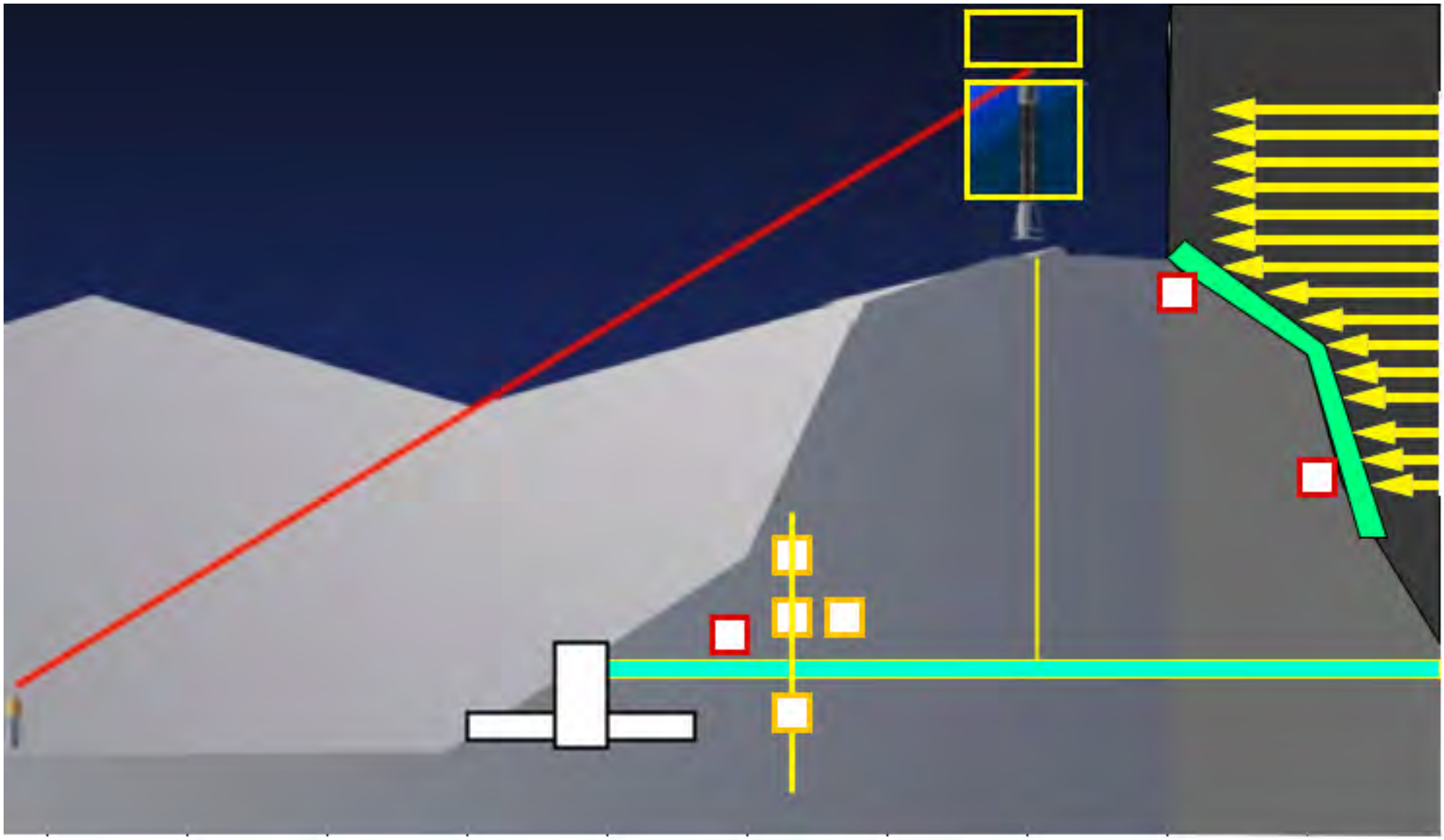
Alaska Living off the Land (LOTL)

- 90% of the Mass used in Prudhoe Bay was already there before man
- AK 2nd Use of Hardware
- Commonality of Equipment Components
- Multiple User Equipment Shared
- Commercial Pooling of Risk Money
- Lunar Use of Resources Recovered
- Water, Fuel from Oil, Gravel, Air, Sunlight
- Stimulate Markets by Purchasing Services

Mining the Moon 1/7

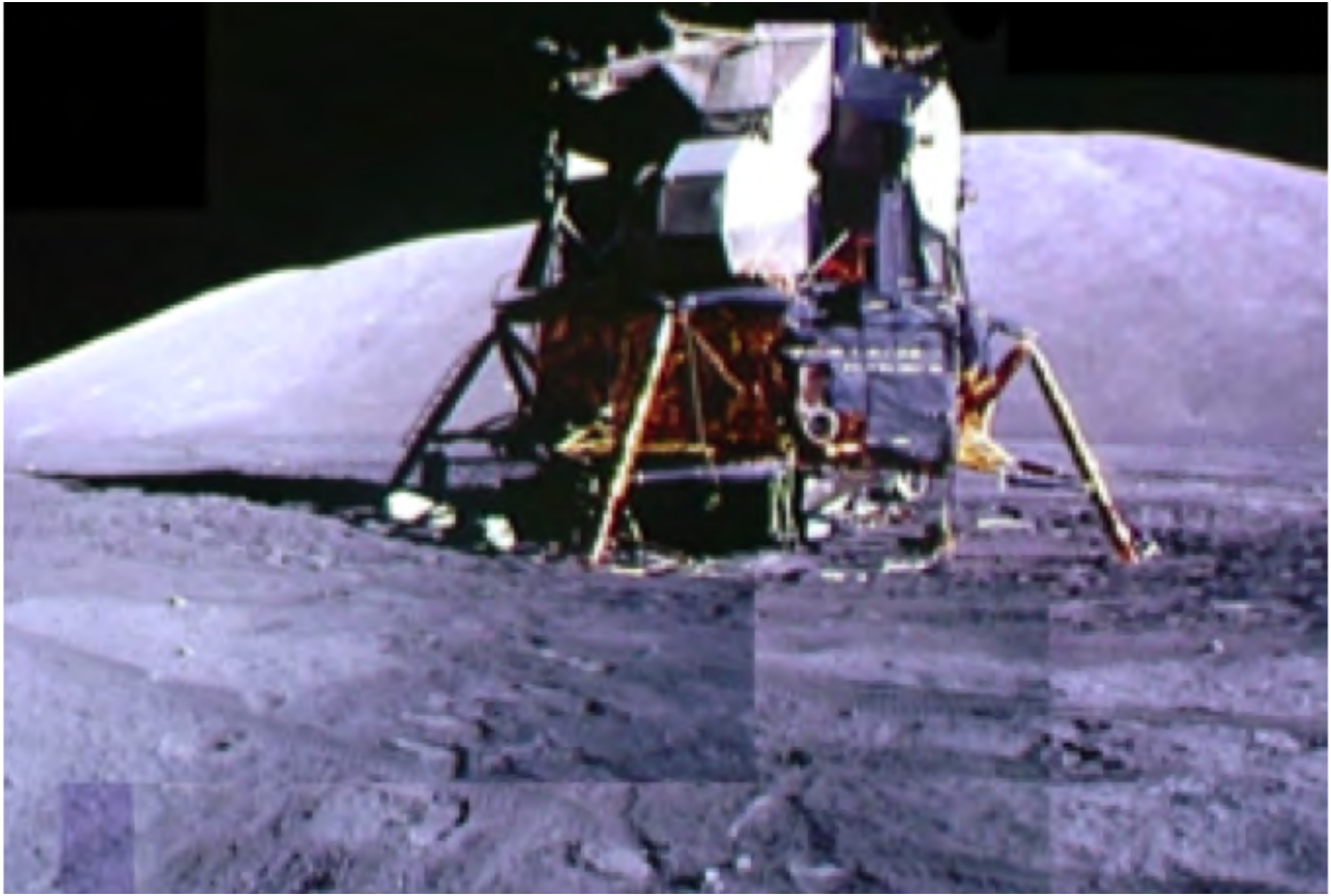


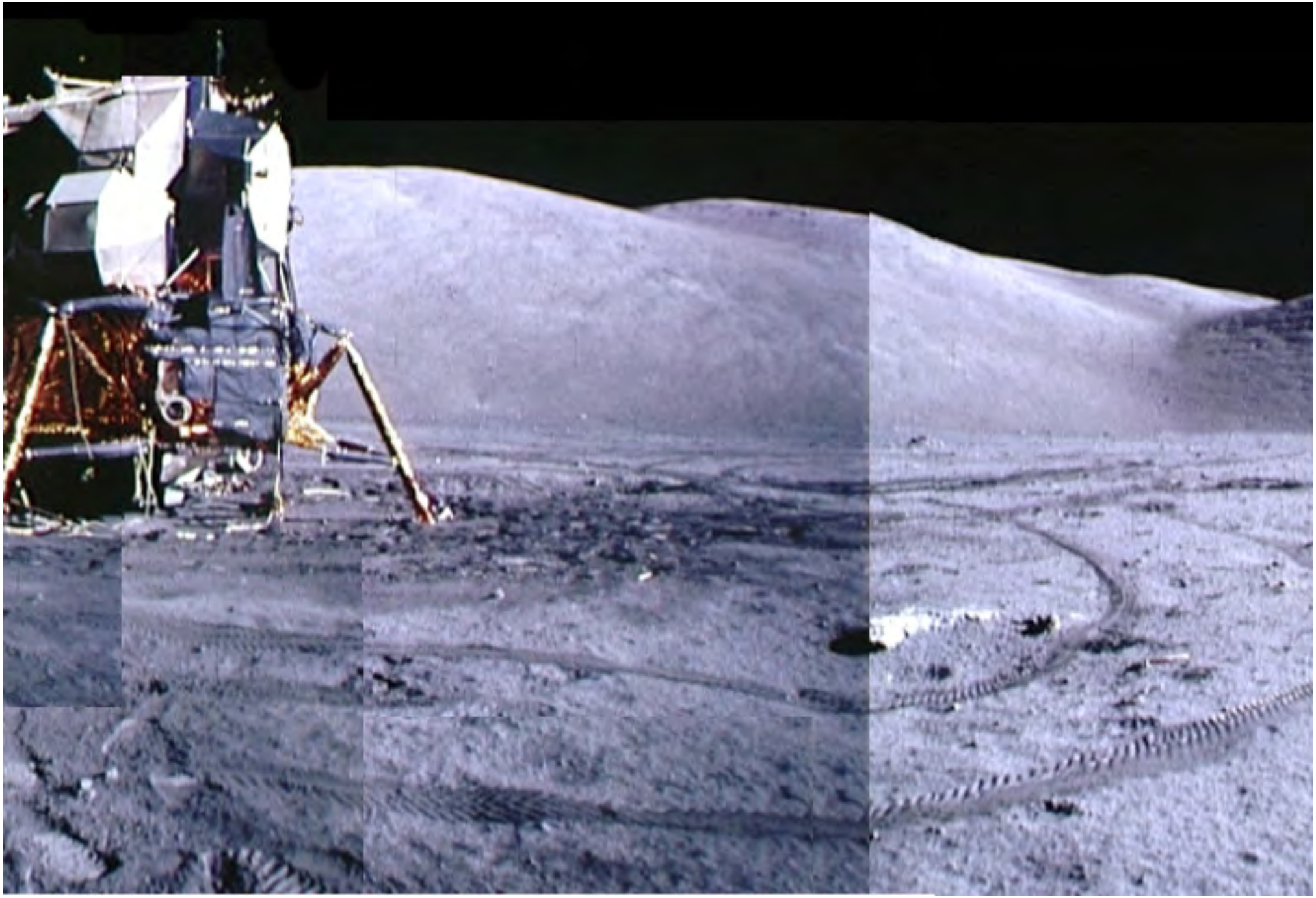
Mining the Moon 7/7



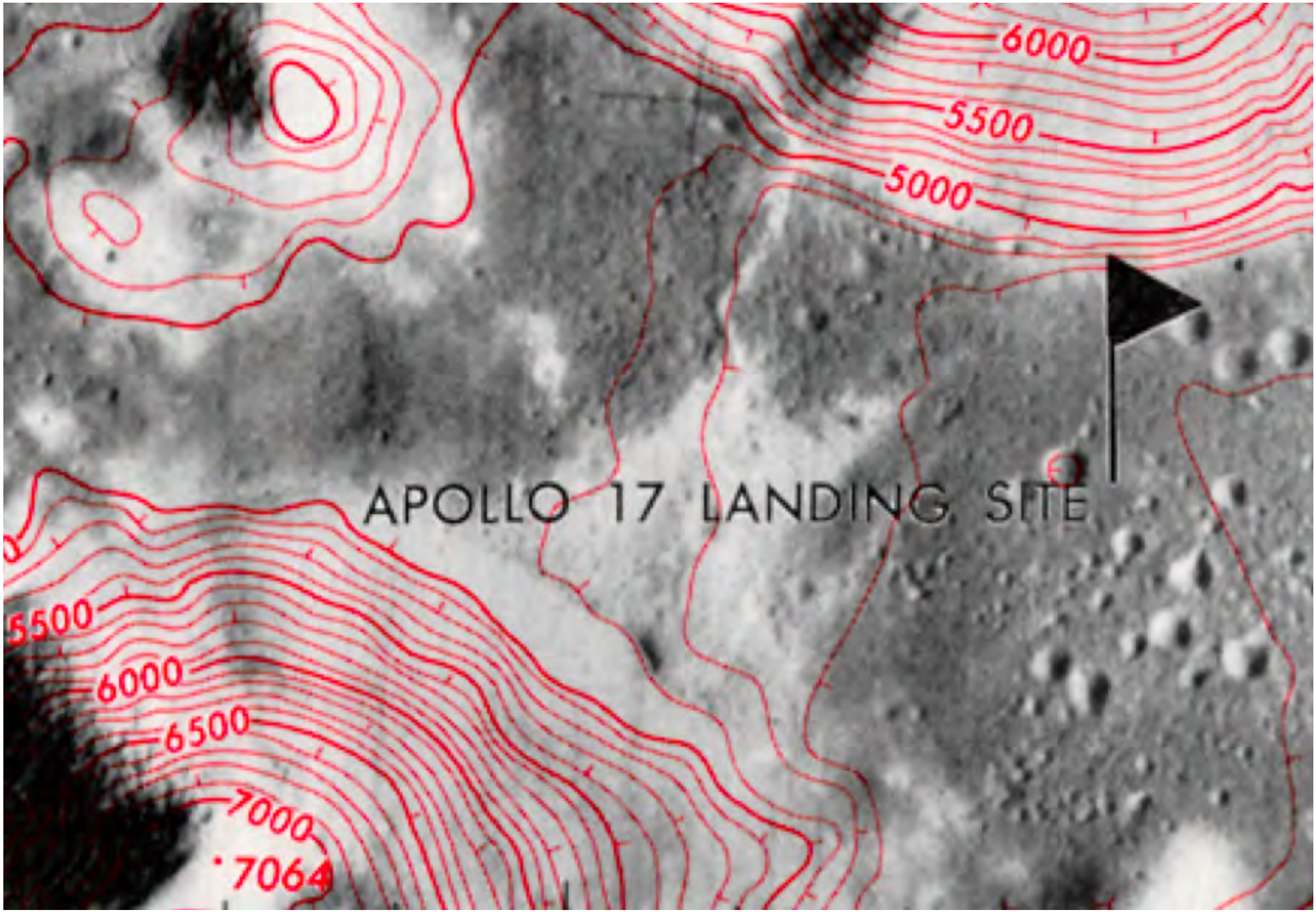
Conclusions - Market Stimulation

- Market Types - Pick 3 $ Levels of Lunar Resources Price Based on Expense to Produce each Group
  - Used on Moon Surface, Water, Oxygen.etc **<$ from Earth**
  - Used in Space like Cryogenic Propellants < same
  - Valuable enough to bring to Earth like He3 $6-15B/ton
- Accelerate Commercial Financing & Space Resource Development by Stimulating Markets
- Use He3 to Generate Innovation on Earth
- It is Time to Move into the “Near Earth Universe” commercially & Build an Economy on the Moon
- Governments can Stimulate Movement OFF-Planet by Setting a Price for He3 Delivered to Earth





Lunar Transportation Systems, Inc.


6000
5500
5000
APOLLO 17 LANDING SITE
5500
6000
6500
7000
7064

Questions

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7 minute video LTS animation on UTUBE by Bob Citron

http://www.youtube.com/watch?v=26Y5w0vqtIU

Paper 7899 - PT/MSS Toronto, Canada 7May2013

Backup Slides

Backup Slides

Tom Taylor

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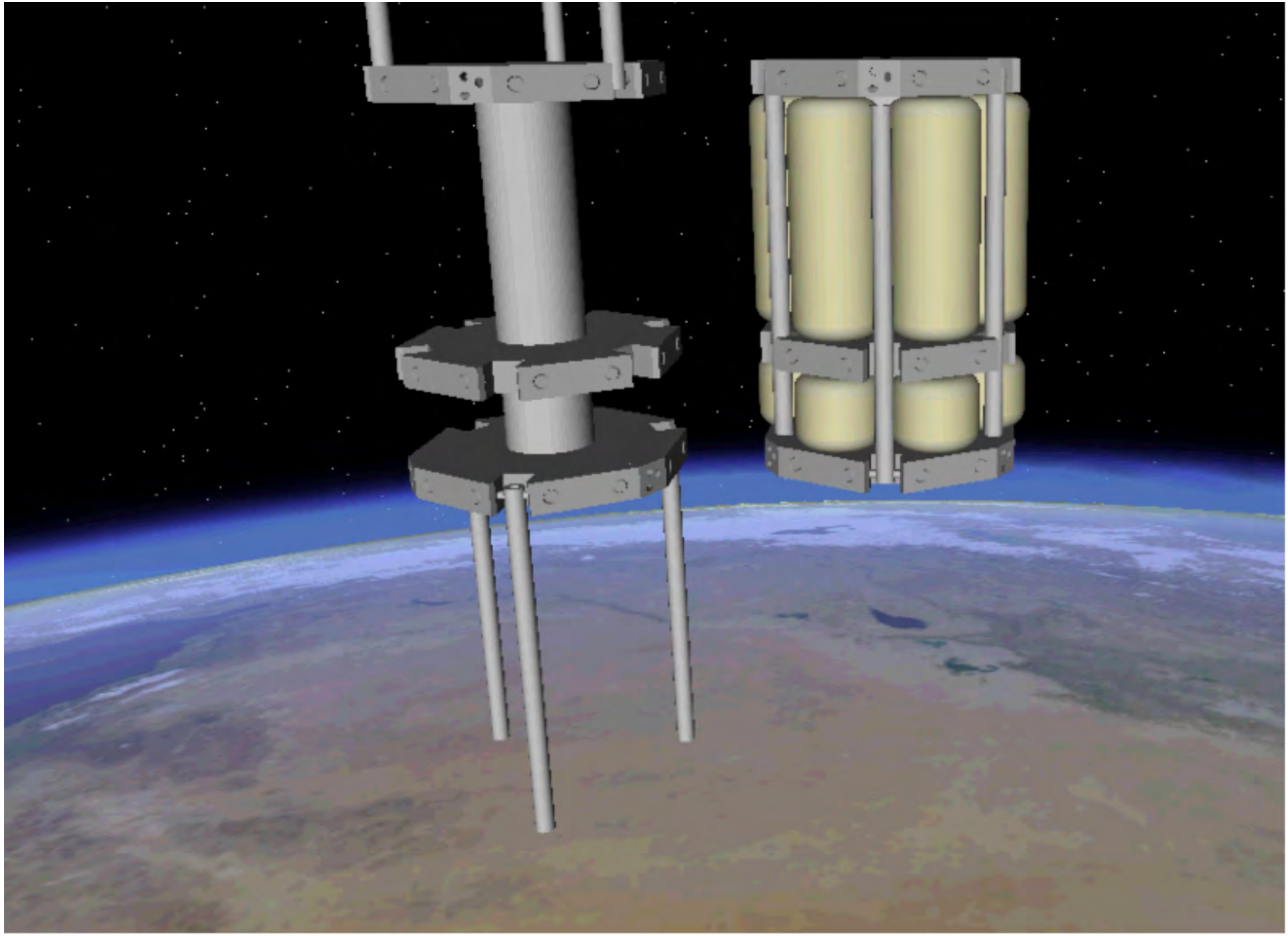
LEO is like a Shoreline

Gravity Well

- Atmosphere
- TPS required
- Pushes up thru gravity well
- Cargo transfer from a different vehicle
- Commercial cycle
- Like land to water
- Needs harbor

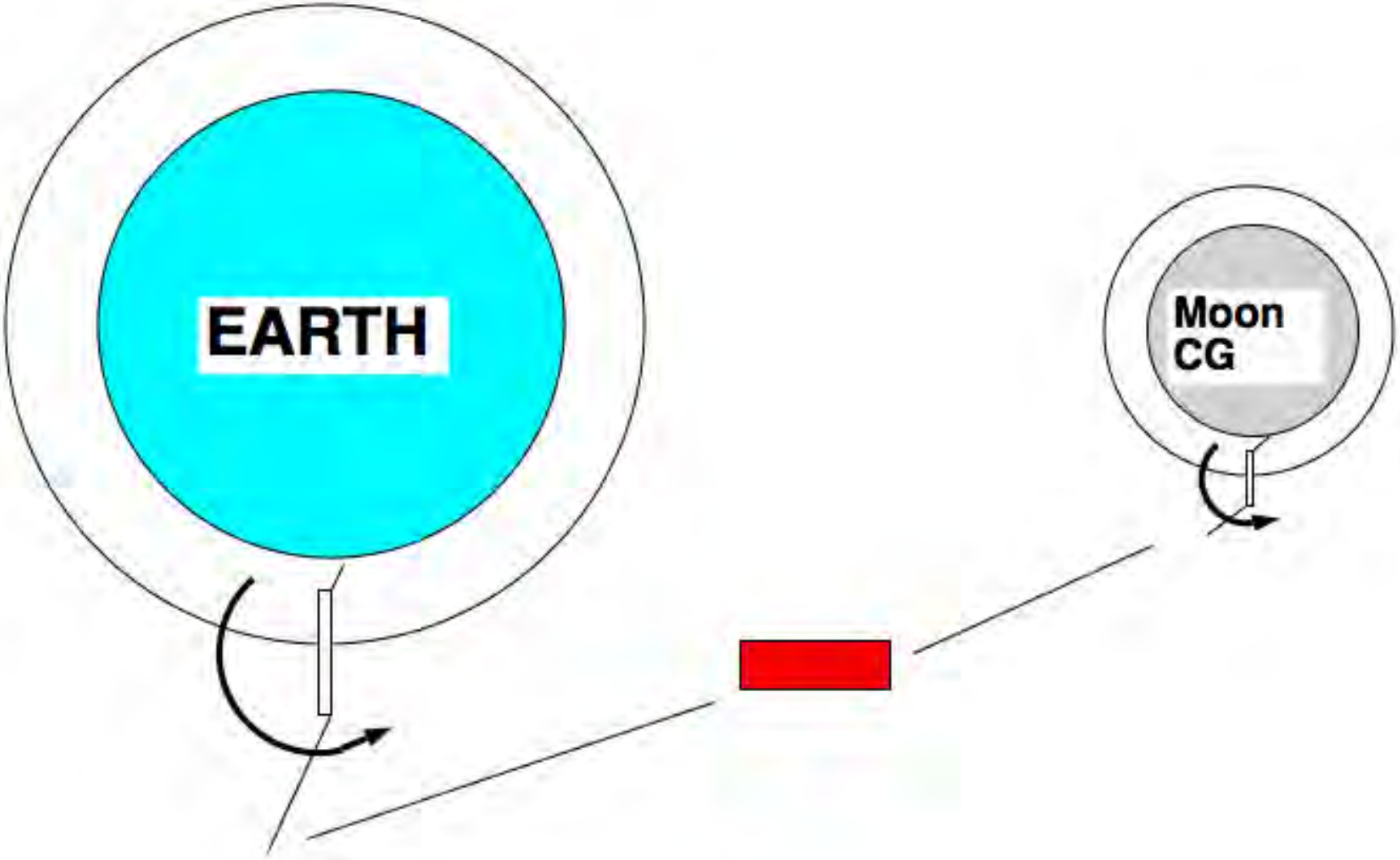
Space beyond Earth

- No atmosphere
- Little TPS required
- No gravity well
- Cargo transfer to a different vehicle
- Not yet commercial
- Logistics Node -real estate emerges
- Commerce emerges

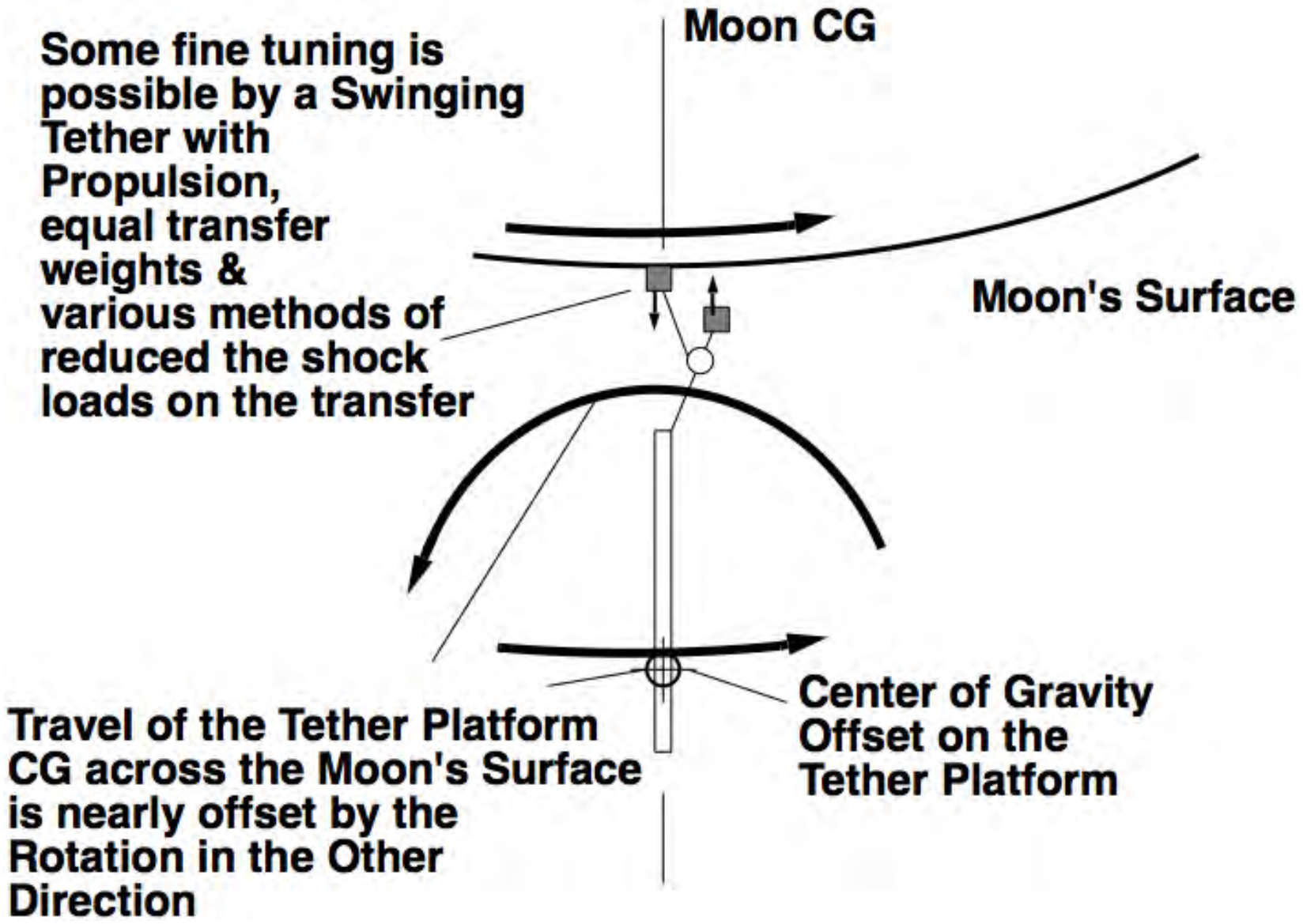


LEO is Like a Shoreline

Future Evolution Tethers 1/2



Future Evolution - Tethers 2/2



Reduce Upload Shock on Tether

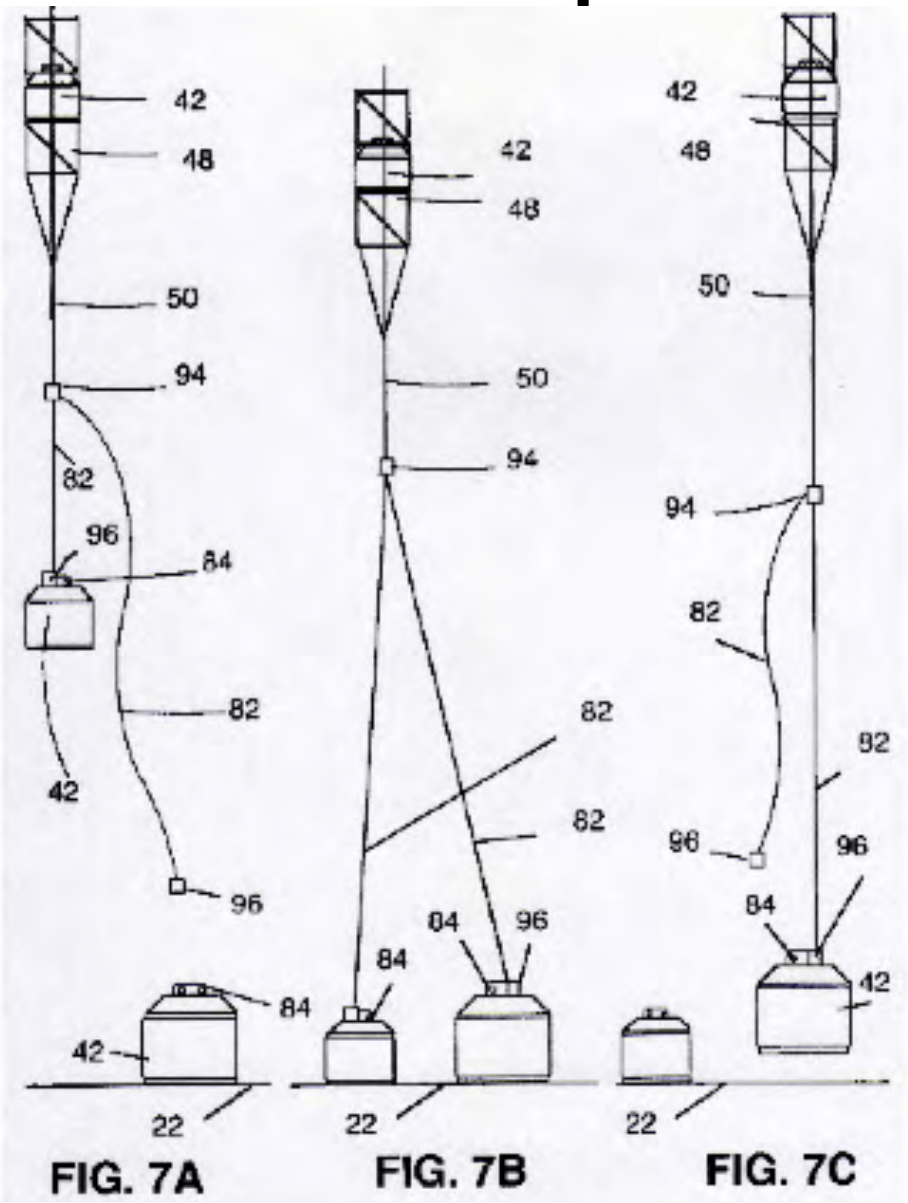


FIG. 7A FIG. 7B FIG. 7C

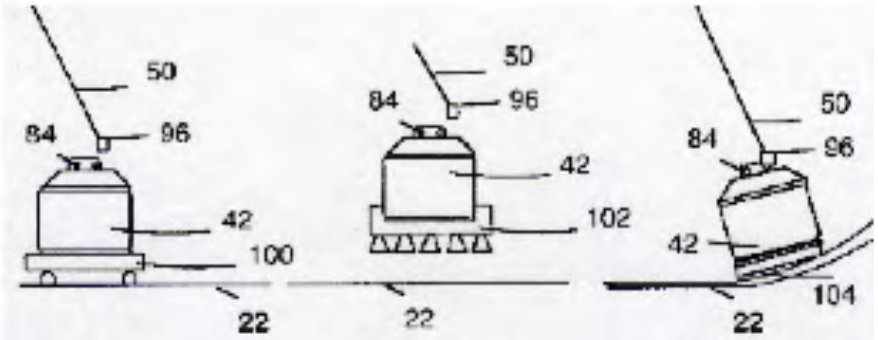


FIG. 8A FIG. 8B FIG. 8C

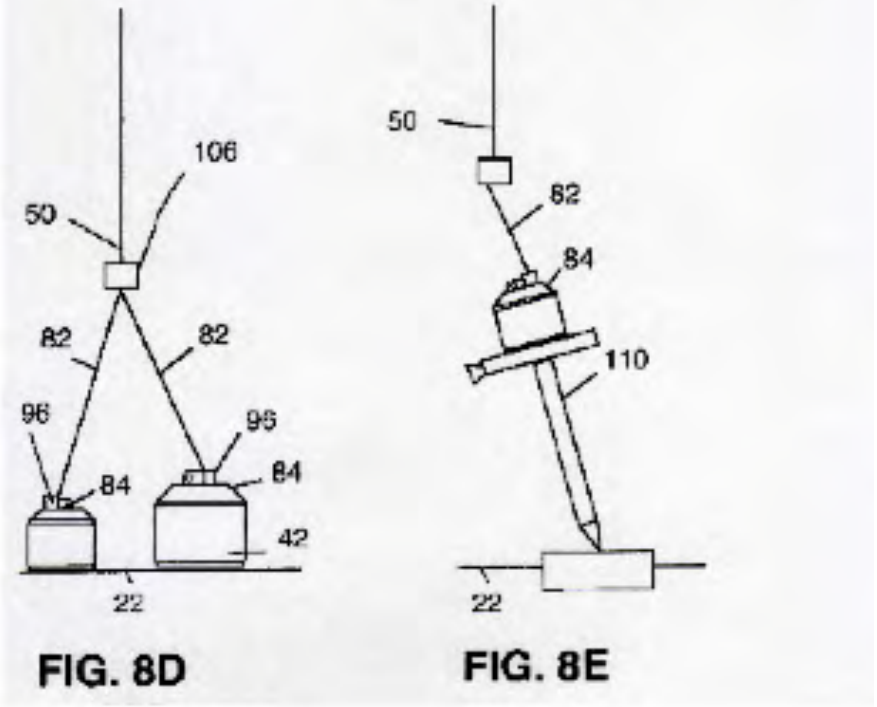


FIG. 8D FIG. 8E