SpaceXchange

Space commodity trading on the Moon and with other Solar System locations

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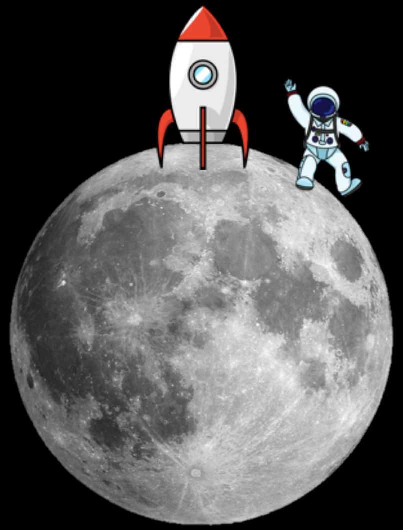
The basis of a self-sufficient space economy

- Maximum self-sufficiency enabled by *in situ* resource utilization
- Trade with Earth and other Solar System locations



Required basic commodities (produced locally or imported):

- Human life support (water, oxygen, food)
- Structural materials (metals, concrete, glass, plastic, plant fiber)
- Industrial chemicals (H_2SO_4, NaOH, etc.), fertilizer (N, K, P), organics
- Propellant (H_2/O_2, CH_4/O_2) for rockets and surface mobility
- Power (Si for solar photovoltaics)
- Small amounts of rare elements

Focus of this talk: the Moon

Abundant:

Metals (Ca, Al, Mg, Fe, Ti)

Silicon

Oxygen

Water (at poles)

Sunlight

Hard vacuum

Scarce:

Carbon

Nitrogen

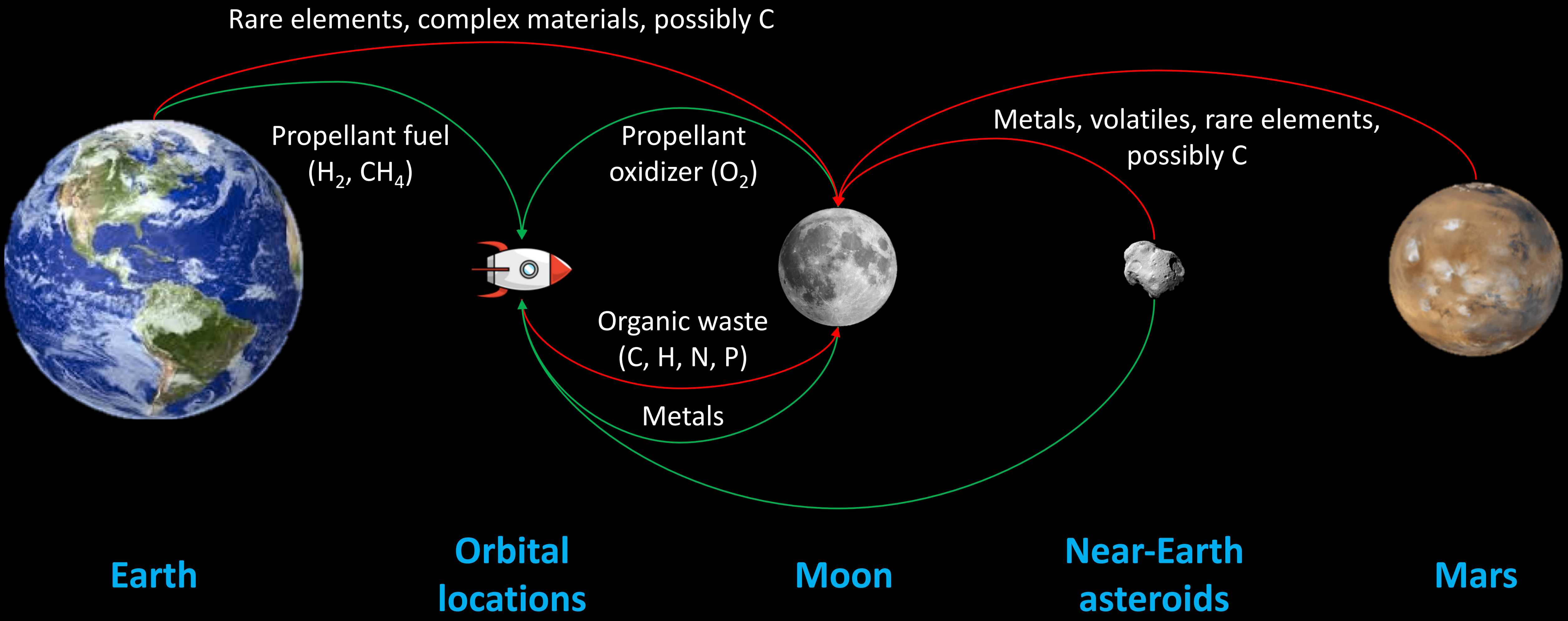
Phosphorus

Sodium/Potassium

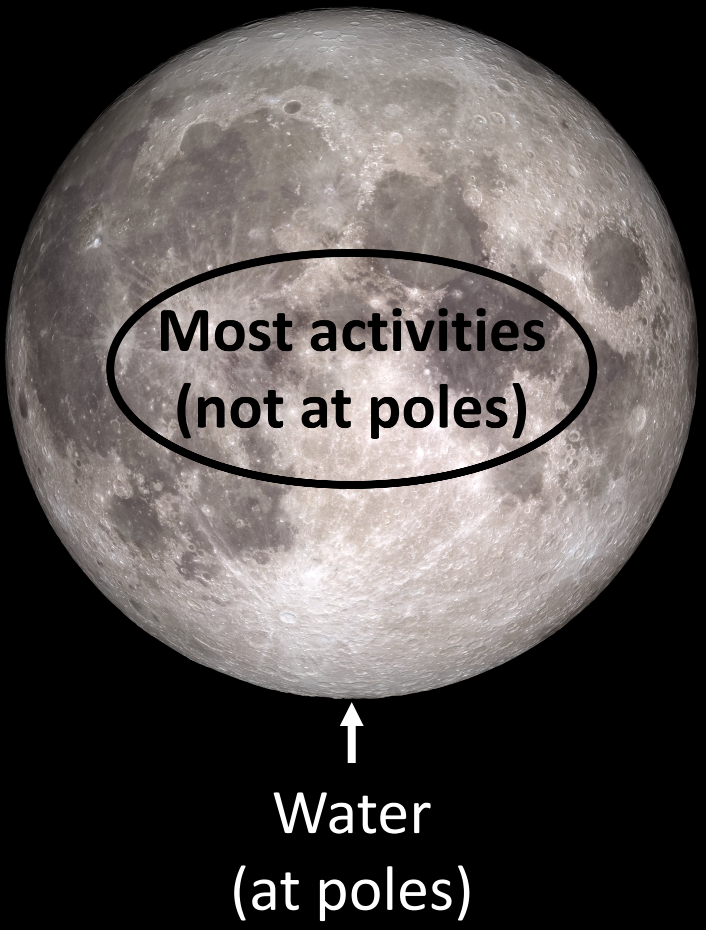
Halogens

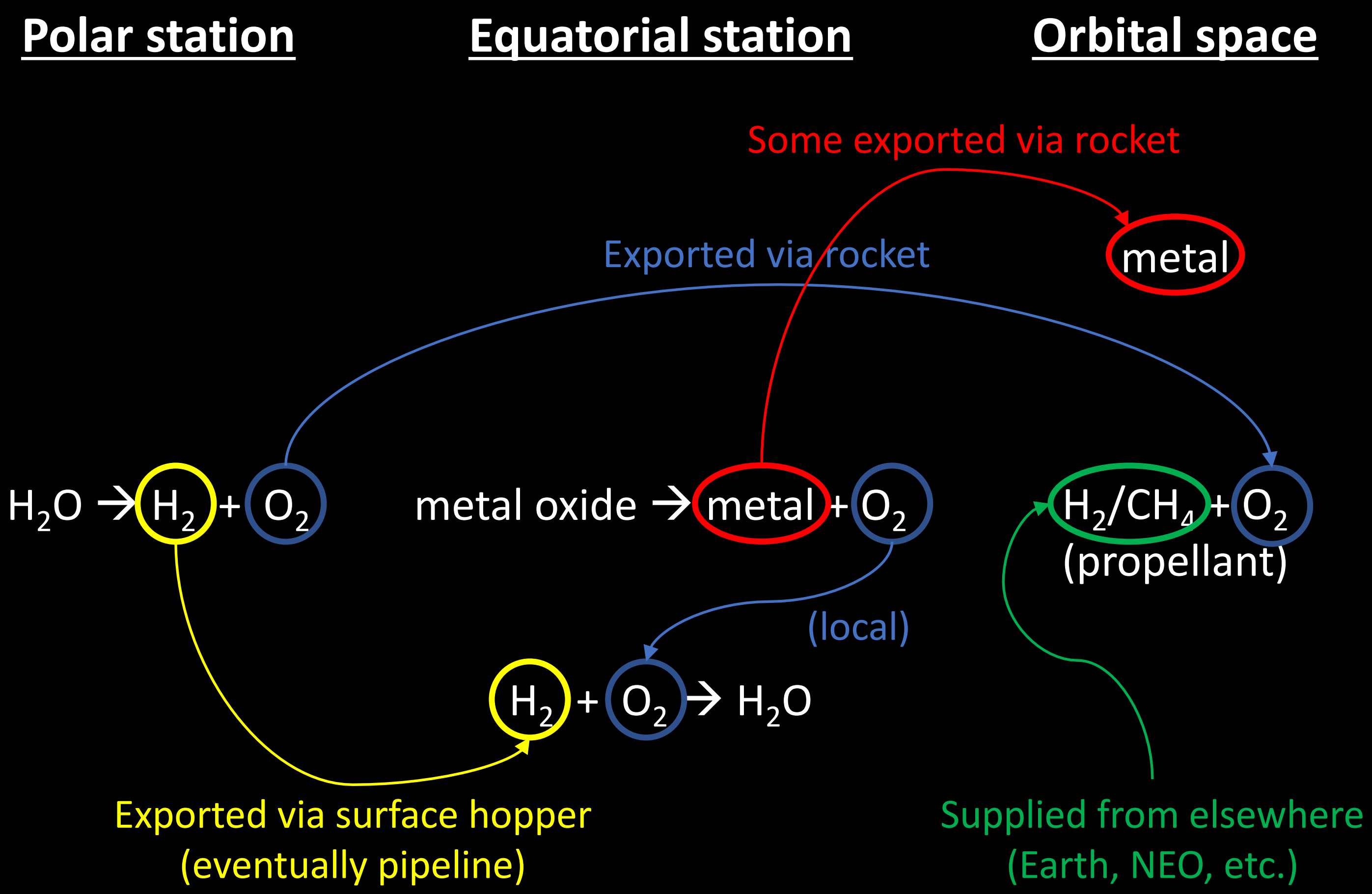
Most other elements

Need for interplanetary trading



Water is not where you necessarily need it; hydrogen is precious, oxygen is not





Some simple calculations

- Water (assume 99% recycling): 4,000 kg/person-yr. (includes growing food)
  - O_2: 3,500 kg/person-yr. (exported to space and replaced at equator)
  - H_2: 440 kg/person-yr. (exported from pole to equator)
- Breathing O_2 (assume 97% recycling): 11 kg/person-yr.
- Regolith processing of 9,700 kg/person-yr. to match O_2 need (90% recov.):
  - Assume 50% recovery of mixed metals (Al, Fe, Ca, Mg, Ti: 1,750 kg) + Si (1,000 kg)
- Carbon (90% recycling of CO_2, food & human waste): 11 kg/person-yr.
- A 50,000-person Lunar settlement* would:
  - Require 540 kt/yr. of water (including human, agriculture and propellant needs)
  - Move 24 kt/yr. of H_2 from pole to equator
  - Export 188 kt/yr. of O_2 into space
  - Produce 51 kt/yr. of Si, 87 kt/yr. of mixed metals (including 32 kt/yr. of aluminum)
  - Import 730 t/yr. of carbon

*See spaceeconomy.spacevault.world/moonvsmars

If the migration to Mars were underway…

- Elon Musk wants to move **1 million people to Mars.** Let's assume:
  - Migration occurs over 50 years, and each BFR moves 100 people (need 200 trips/yr.)
  - Ships can return in same synodic period and 10% are offline (fleet size = 470 ships)
  - Each ship lasts 20 yrs. and 75% of dry mass (64 t) is aluminum; need 1,500 t/yr.
  - Lunar aluminum production is 32,000 t/yr., only 5% needed to replace ships
- **Carbon waste** from 20,000 person/yr. 4-mo. migration to Mars: 730 t/yr.
  - Carbon imports could supply just enough to replenish lunar population needs
- **CH_4/O_2 propellant** refueling need of 1 BFR (6.25 km/s Δv, 150 t payload):
  - O_2: 860 t (lunar exports could support entire annual demand)
  - CH_4: 240 t (exported from Earth using ~1.3 BFR tankers instead of ~6)

Open questions

- **What is the best way to produce metals, and which ones?**
  - Steel: requires C (could use H as reducing agent?)
  - Aluminum: complex smelting process, requires C anodes, F-based solvents
  - Titanium: how best to purify?
  - Magnesium: easy win?
- **Can we make pure Si on the Moon** and enable lunar semiconductor manufacturing for solar PV + electronics self-sufficiency and export?
- **How much can we recycle volatiles** from waste water, organic waste, air, refining processes, etc. to minimize extraction and imports?
- **What is truly valuable** to export from the Moon?

Thank you!

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