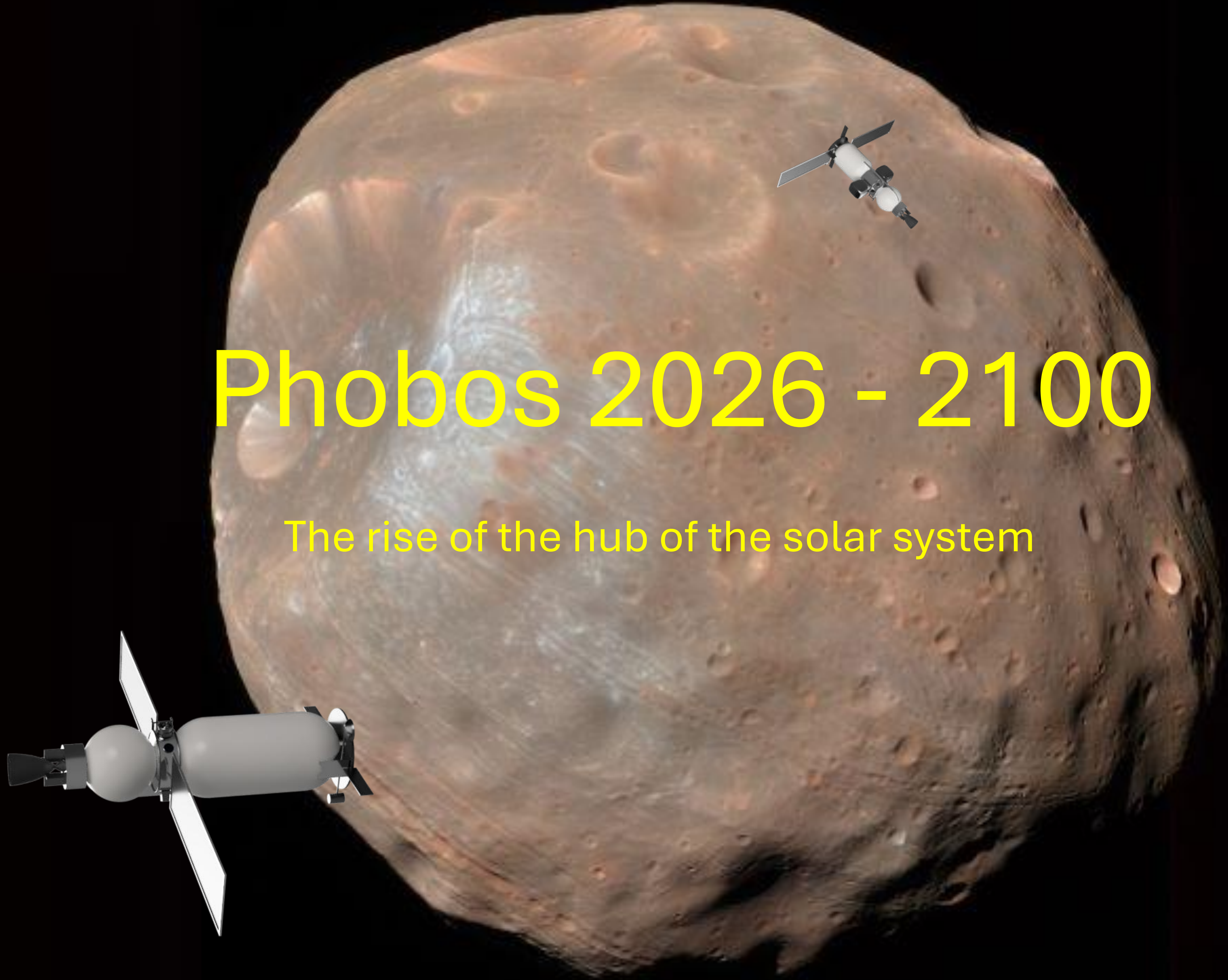
Phobos 2026 - 2100

The rise of the hub of the solar system

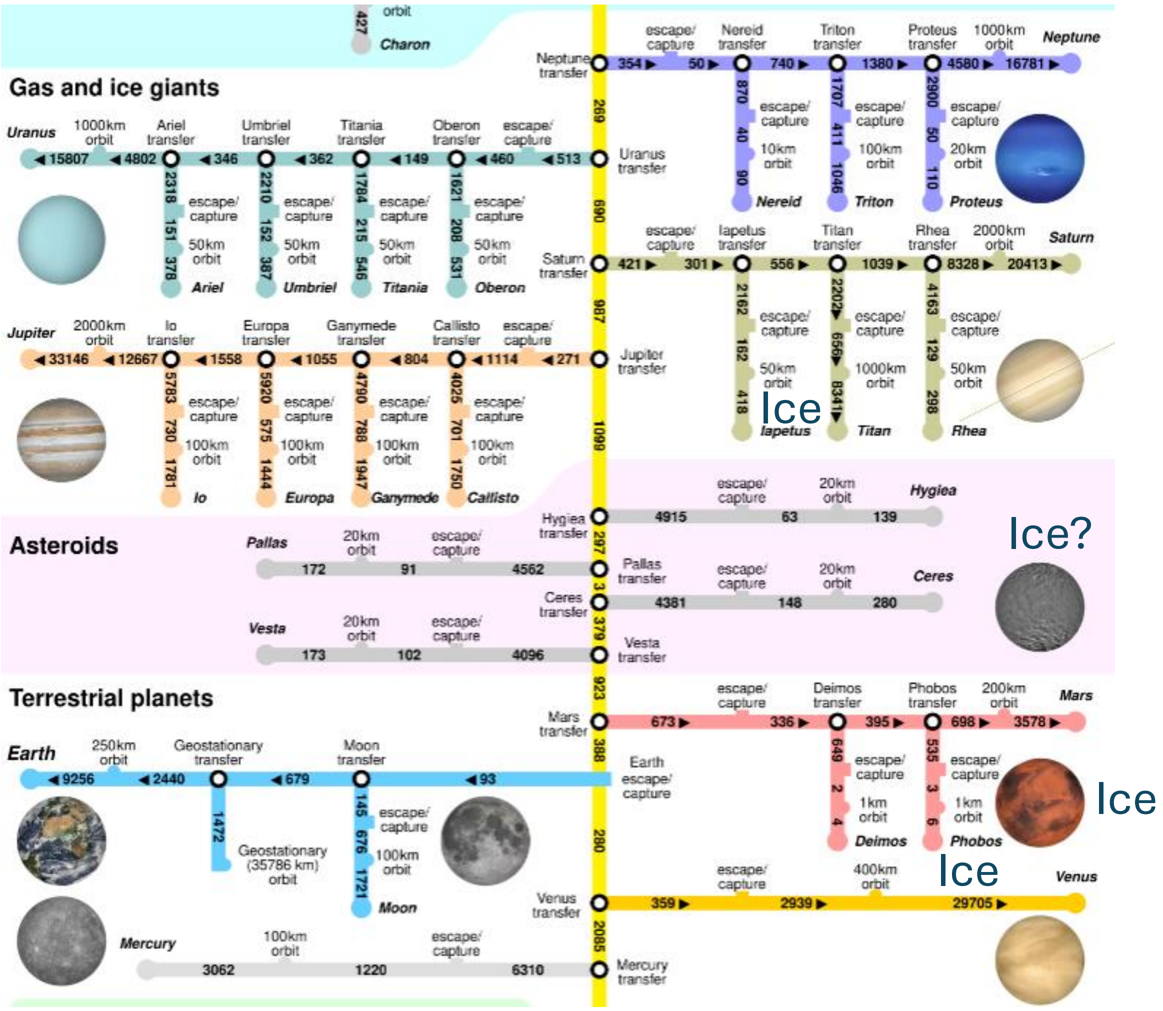


High potential earth events

- International treaties limit the crewed occupation on Mars to a small area with a limited number of people (essentially mirroring what has happened at the South Pole), but robotics on Mars is unlimited.
- Chinese success on the Moon (vs Artemis) rebuilds a western resolve to make a statement with a robust Mars program
- Launching of significant radioactive material though the Earth’s atmosphere is banned, creating a need to mine on the Moon and Mars and then transport it the Moon, Phobos and MEO (where NEP cores are attached to spacecraft).

What makes Phobos unique

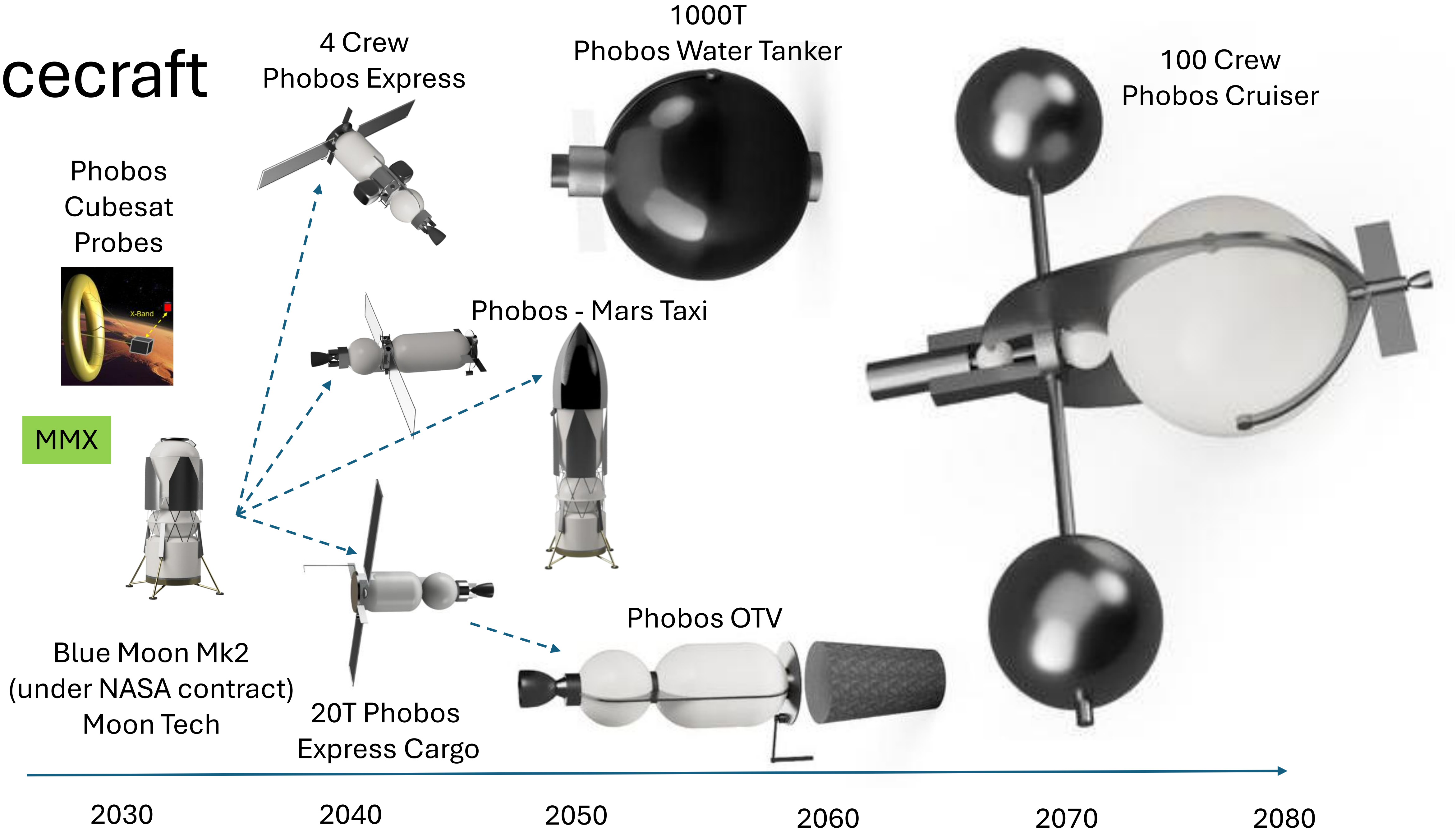
- As there is no atmosphere and tiny gravity (but enough to separate fluids), it is more like a gigantic space station
- Close orbit to Mars, tidally locked
  - Facing side is warmer, has less CGR
- It may be a binary comet = more ice content (20%-80%)
- The DV needed to transit Phobos to LLO is less that LEO to LLO
- Can enable purely propulsive landings and returns on Mars surface, eliminating the need for risky aerobraking and landing ops.



Best case Phobos Eras

- 2030s: Era of unmanned exploration, mapping, testing machinery
- 2040s: Era of the first base, support for Mars teleops, robotics landings
- 2050s: Era of spin gravity, water exporting, MW space nukes, small Mars Crew base (if allowed)
- 2060s: Era of base expansion to 1,000+ people, tourism option testing, 100 person Mars base
- 2070s: Era of 1,000 people per synod commercial crew hosting / tourism
- 2080s: Era of initial Phobos ice caverns and colonization for 10,000+ people, 10,000 visitors per year ($3M 2-year adventures)
- 2090s: Era of ice cavern towns connected by tunnels

Spacecraft


4 Crew
Phobos Express
1000T
Phobos Water Tanker
100 Crew
Phobos Cruiser
Phobos
Cubesat
Probes
X-Band
Phobos - Mars Taxi
MMX
Blue Moon Mk2
(under NASA contract)
Moon Tech
20T Phobos
Express Cargo
Phobos OTV
2030
2040
2050
2060
2070
2080

Red Moon LEO <-> Phobos/MLO/LLO Reusable Spacecraft

Fits within an expendable Starship fairing
(Only 1 launch needed + 1 Crew Dragon run)

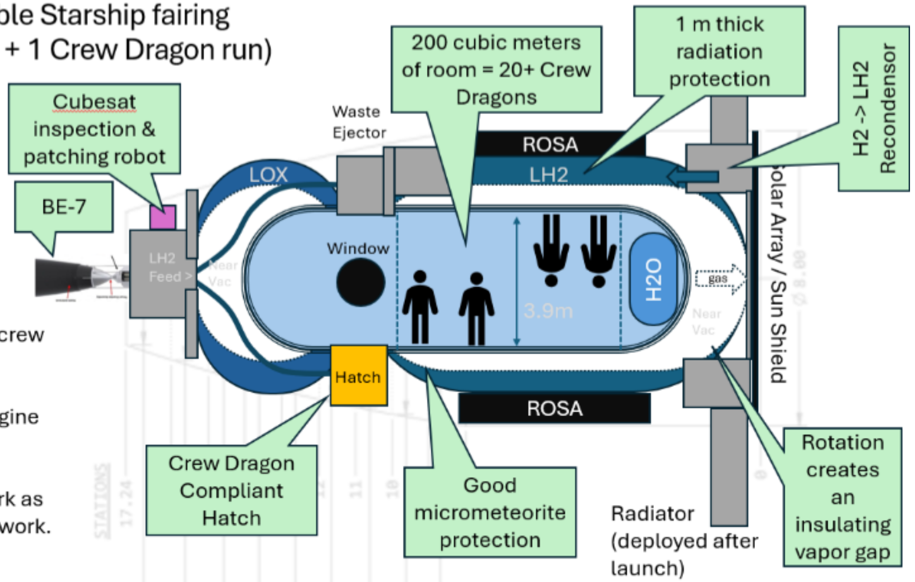
DV = 5.7 km/s
ISP = 450s
~ 200 day journey
No aero-breaking needed

Mass fueled = 150 T
Mass fuel = 109 T
Mass dry = 41 T:

10% of mass is allocated to crew and supplies = 4.1T

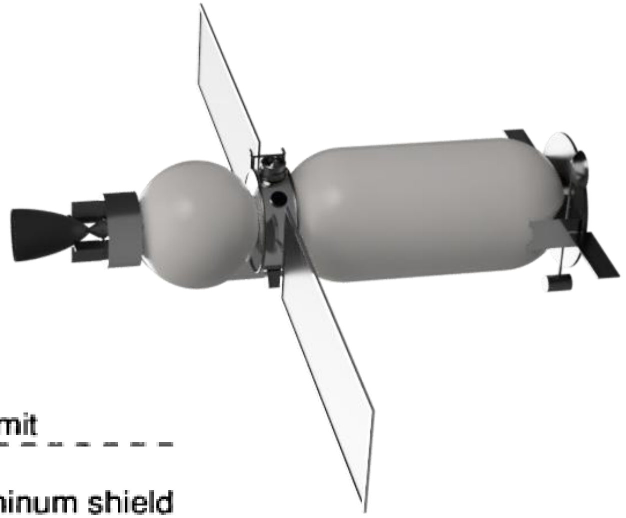
Rescue possible if fuel or engine fails during transit.

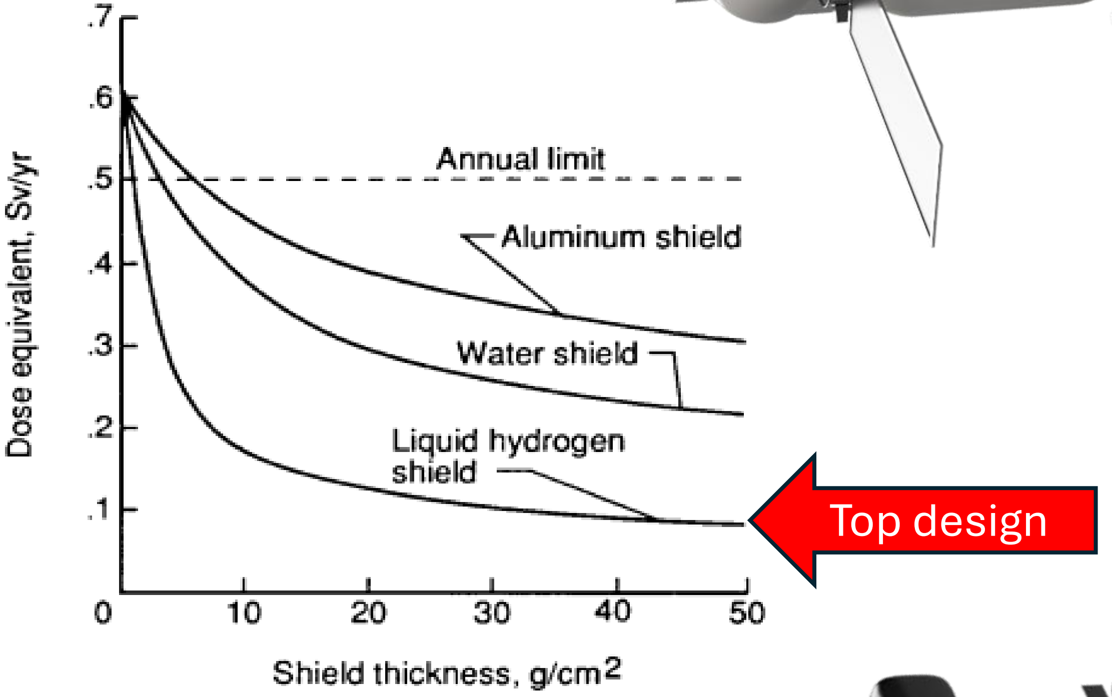
Blue Moon Mk2 needs to work as hoped to for this concept to work.



70% Based on Blue Moon Mk2 tech: BE-7, Carbon Composite Tanks, Recondensors

Radiation Minimizing





Red Moon LEO <-> Phobos/MLO/LLO Reusable Spacecraft

Mid-cabin design

Fits within an expendable Starship fairing
(Only 1 Starship launch needed + 1 Crew Dragon

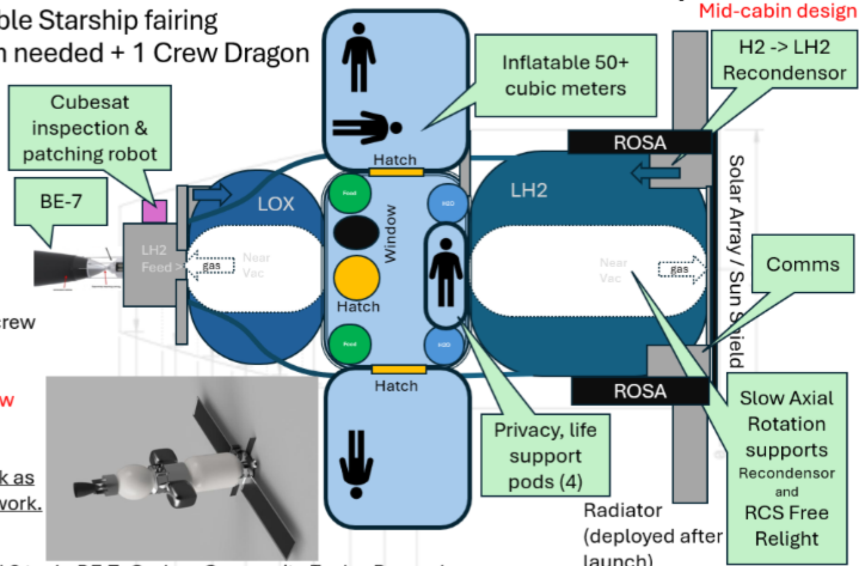
DV = 5.7 km/s
ISP = 450s
~ 200-day journey
No aero-breaking needed

Mass fueled = 150 T
Mass fuel = 109 T
Mass dry = 41 T:

10% of mass is allocated to crew and supplies = 4.1T

50% less radiation than a crew cabin at the end type design

Blue Moon Mk2 needs to work as hoped to for this concept to work.



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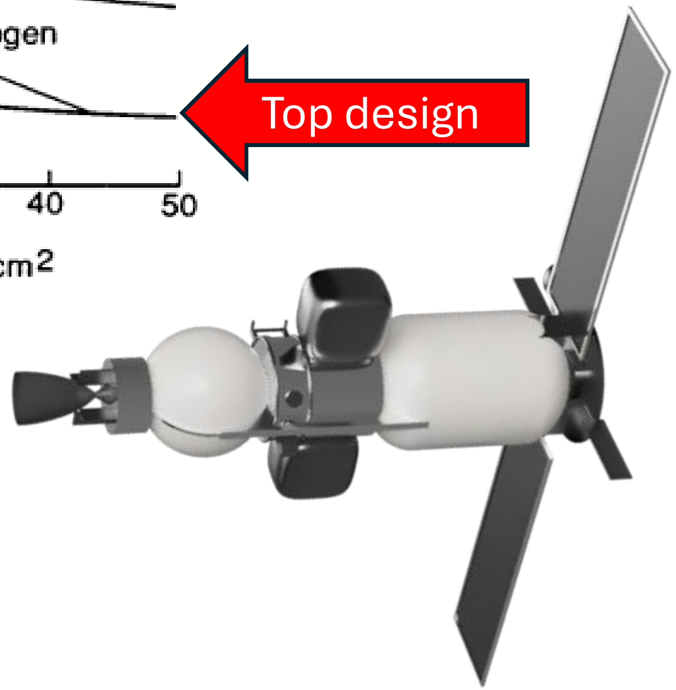
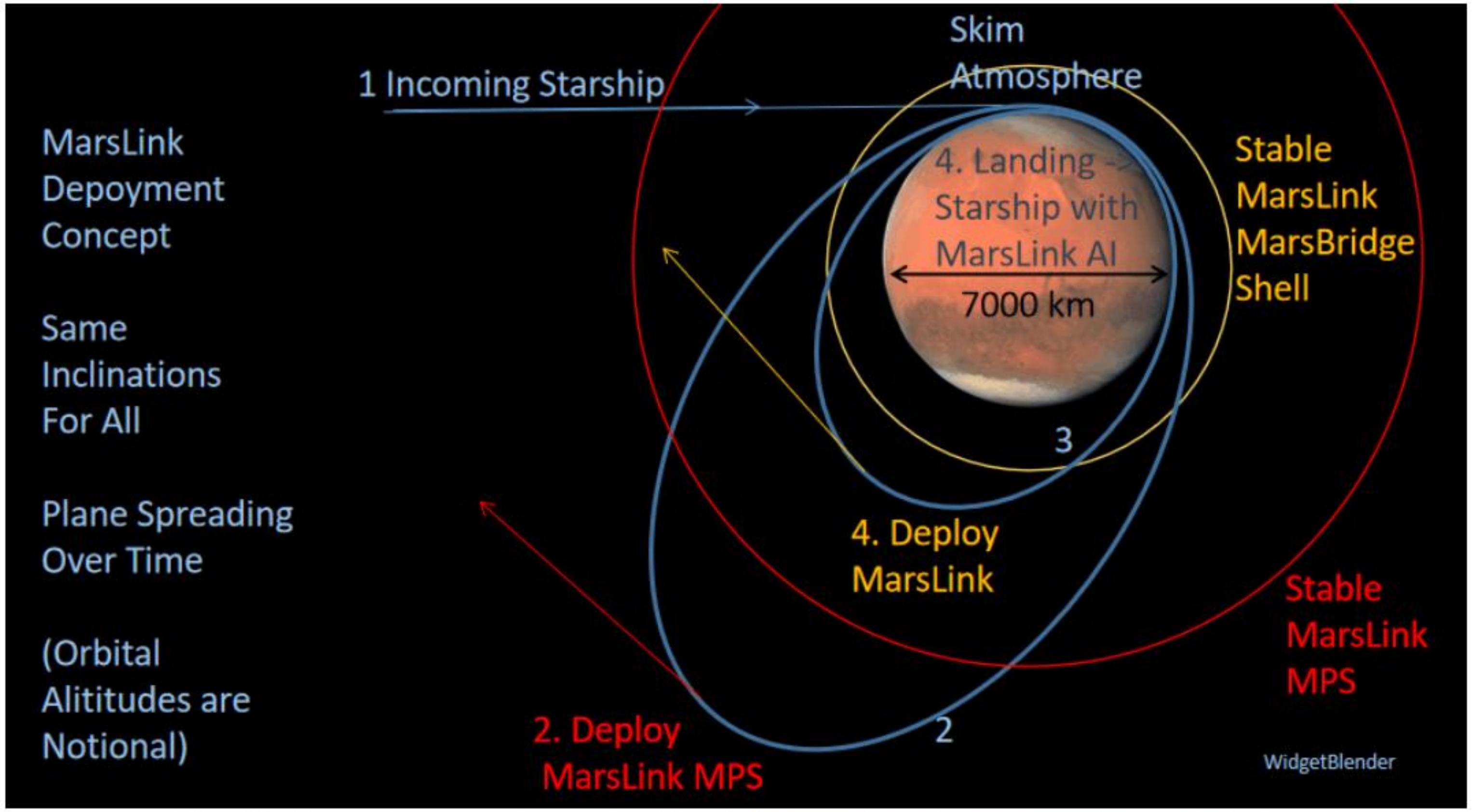
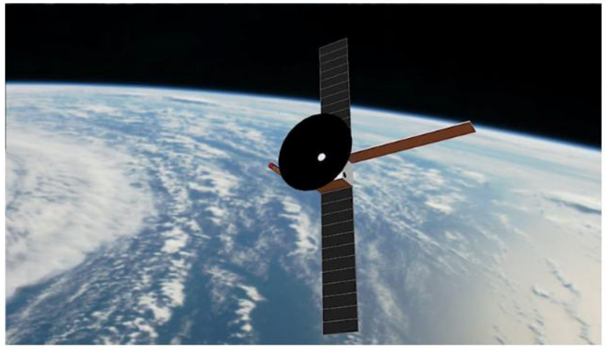


Steps #0 (2026 – 2036)

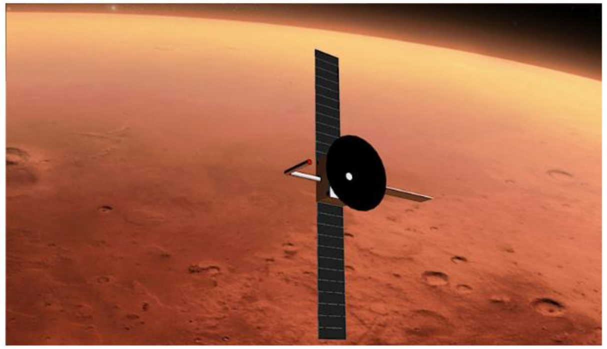
- Detailed recon of Phobos
- Phobos lander and surface characterizer
  - Japan's MMX will launch in 2026
    - As MMX descends to Phobos for landing, it will deploy a small German and French-built rover based on the MASCOT, which Hayabusa2 dropped to tumble around asteroid Ryugu. The rover will travel around Phobos for at least 100 days analyzing the surface.
- Marslink (2028) – SX has announced a 2026 mission to Mars
  - Better Mars to Mars and Mars to Orbit comms
  - Better Phobos to Earth (laser) comms

Marslink: Complete Comms

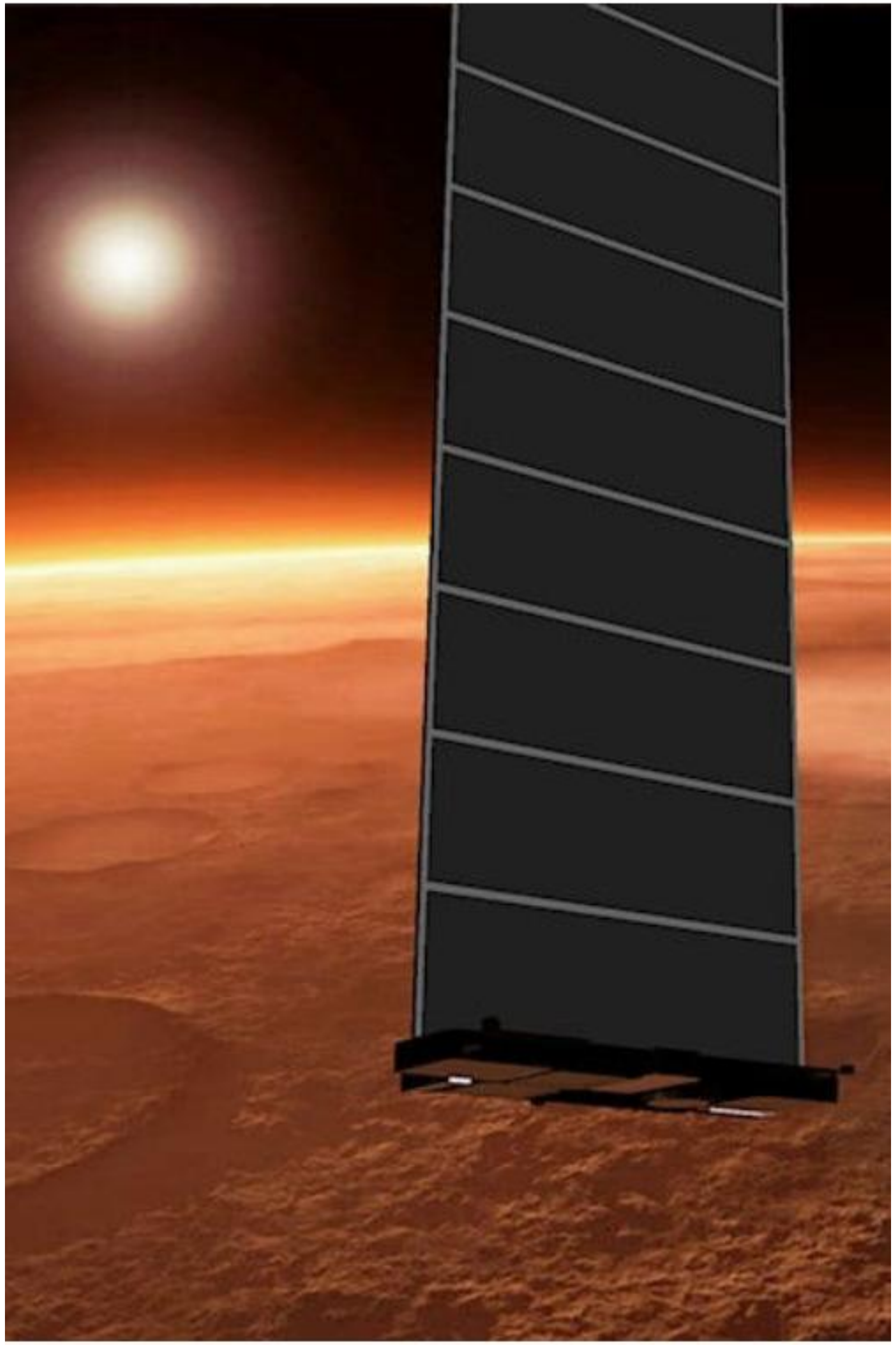




MarsBridge Laser Comms in LEO (3 sats - StarLink integrated)



MarsBridge Laser Comms in LMO (3 sats - MarsLink Comms integrated)



MarsLink based on Starlink

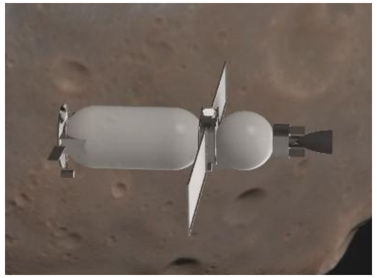
#2. Power & HydroLOX production (2038)

- 3 Phobos Express Cargo (PEC) each with a 20T package
- 20T Water production (1 Phobos Express Cargo)
  - 5T Ice Anchors
  - 5T Ice Melter
- 20T Solar power plant (1 Phobos Express Cargo)
  - 10 T Solar array film -> 2,000 sq meters -> **118 kW peak**
- 20T HyrdroLOX production (1 Phobos Express Cargo)
- PEC can return to Earth for reuse

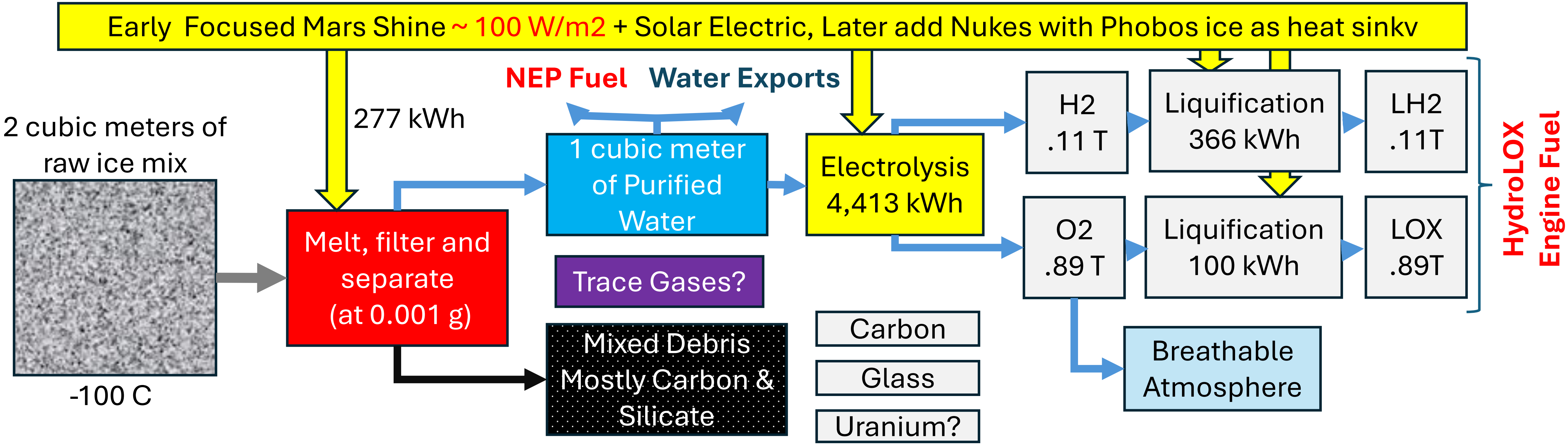
Water is key, more key than Methane

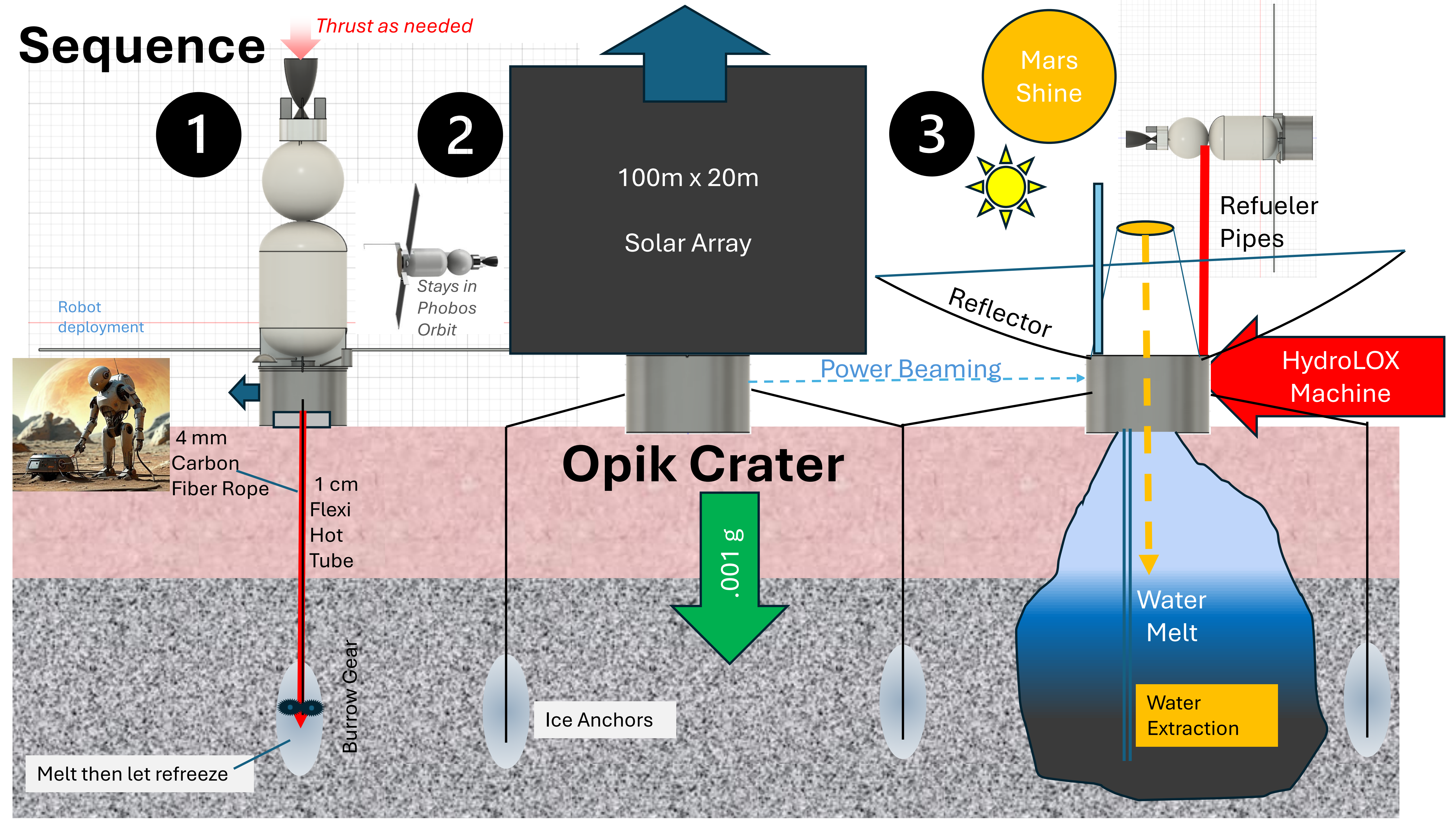
- Water -> breathing, drinking, HydroLOX high ISP engine fuel
- Water (as a liquid) can be moved around the solar system without the boil off losses you get with HydroLOX or MethLOX. It can be converted to HydroLOX when and where it is needed.
- Every hour 1T of HydroLOX is created using 5200 kWh of power, which would require about 1 football field sized thin film (30%) solar array

Phobos to Earth = 109 T HydroLOX < 5 Days of Production



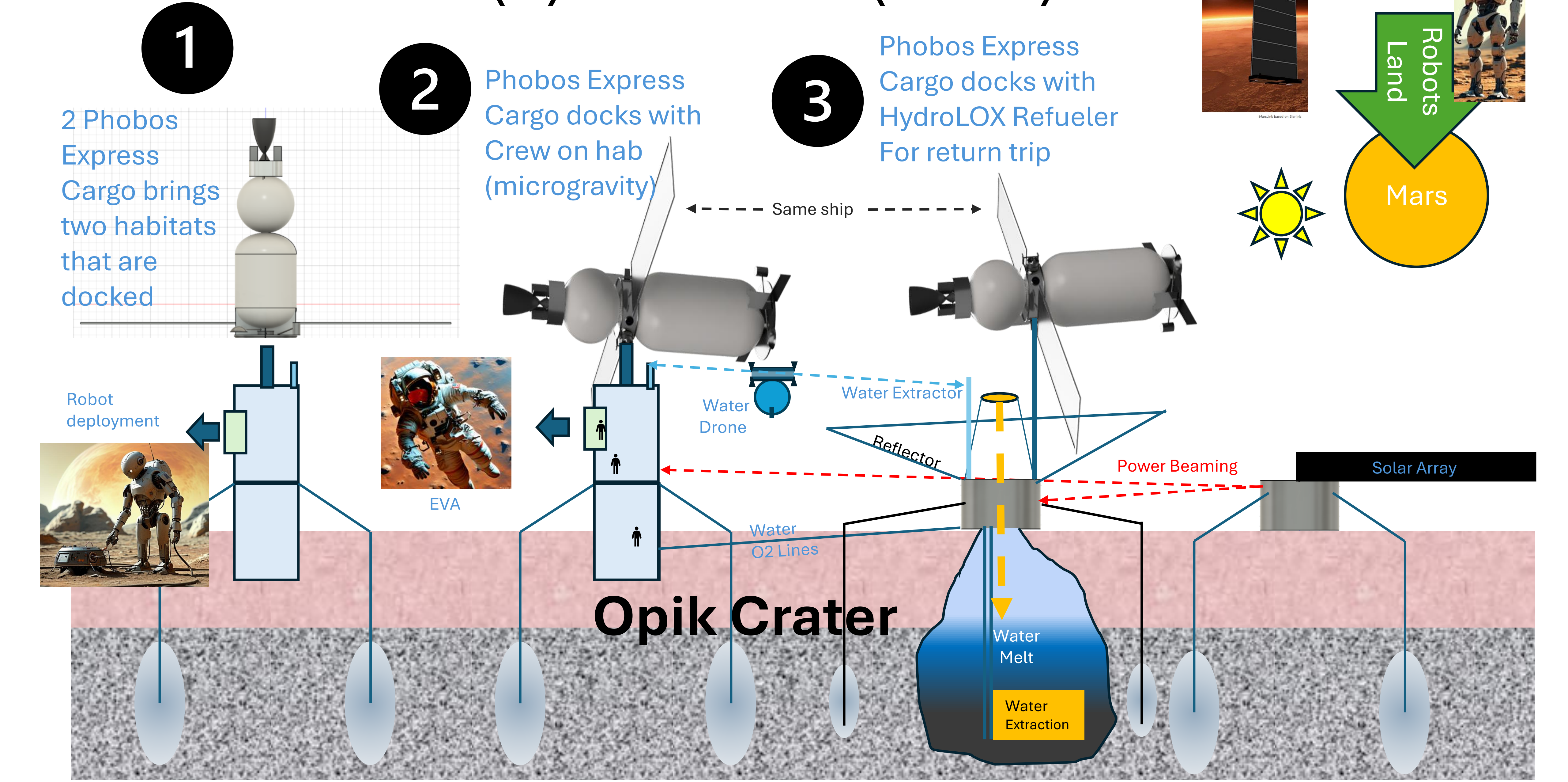
Phobos to Mars = 50T HydroLOX (refuel on Mars)



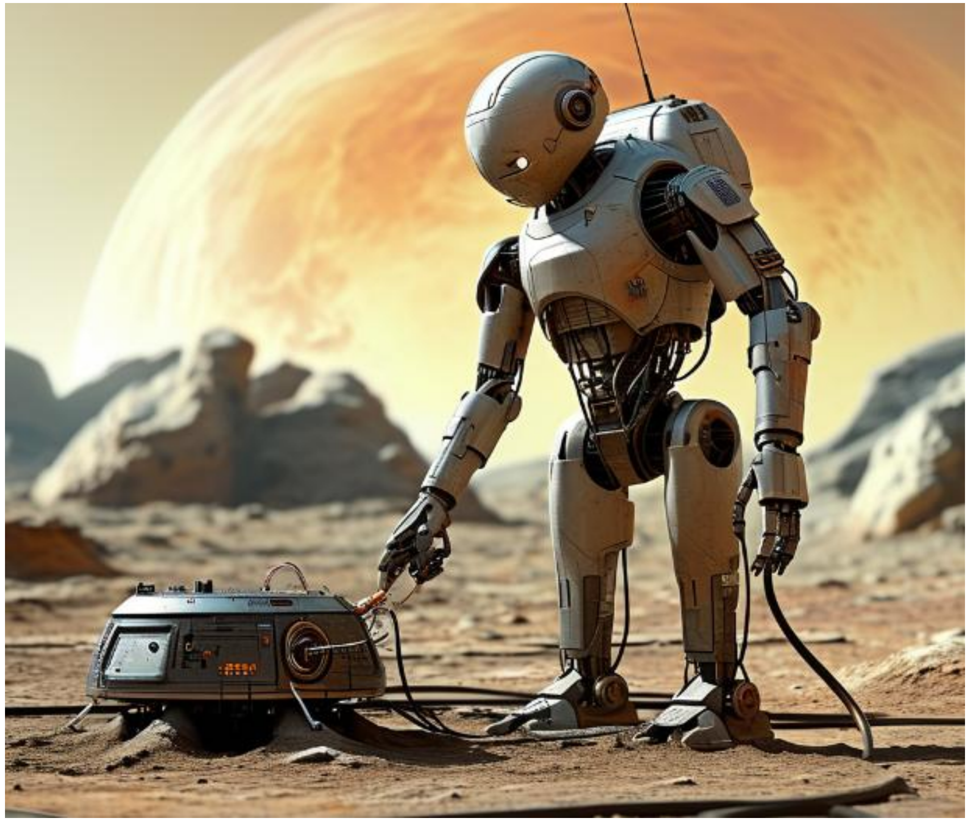


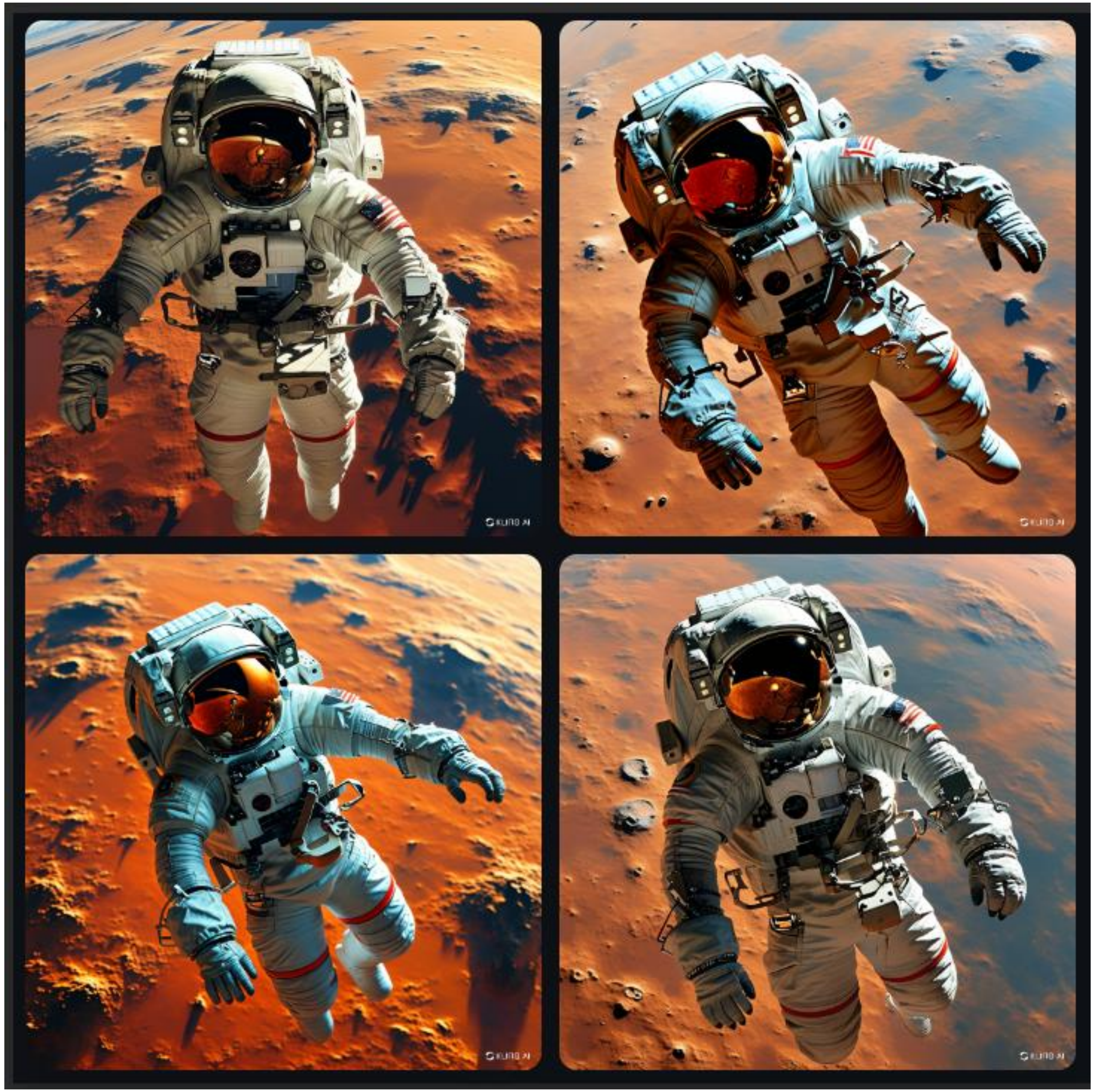
Sequence
Thrust as needed
1
2
3
Robot deployment
Stays in Phobos Orbit
100m x 20m
Solar Array
Mars Shine
Refueler Pipes
Reflector
HydroLOX Machine
Power Beaming
4 mm Carbon Fiber Rope
1 cm Flexi Hot Tube
Opik Crater
.001 g
Burrow Gear
Ice Anchors
Water Melt
Water Extraction
Melt then let refreeze

#3: First Human (4) Presence (2040)



Robotics and EVAs plug parts together
On Phobos

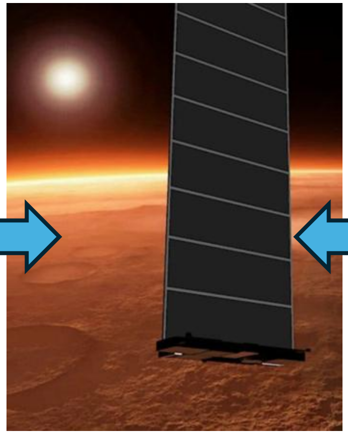




Broadband Marslink enables real time, high definition telerobotics on Mars (and Phobos) from Phobos (2040?)

Humanoid robot anywhere on Mars

100s of Marslink Satellites



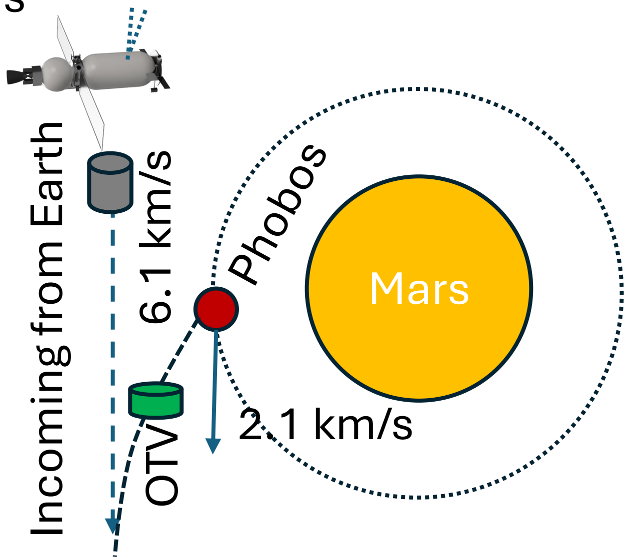
Round trip latency of 30 ms to 50 ms

Crew member operating a humanoid robot from Phobos

Phobos OTV (2042 to Mars)

- 10T Dry Mass HydroLOX Spacecraft refueling and operating out of at Phobos.
- A Starship OTV can send 45T to MTO and then return to Starship for reuse (~$20M/mission).
- Phobos OTV can “catch” 45T passing near, so just fuel costs to send these packages.
- Can also rescue incoming spacecraft if they can’t thrust to Phobos.

Loss of thrusters
or fuel leak
45T dry mass
Crew ship
Or
Capture ready
45T Payload

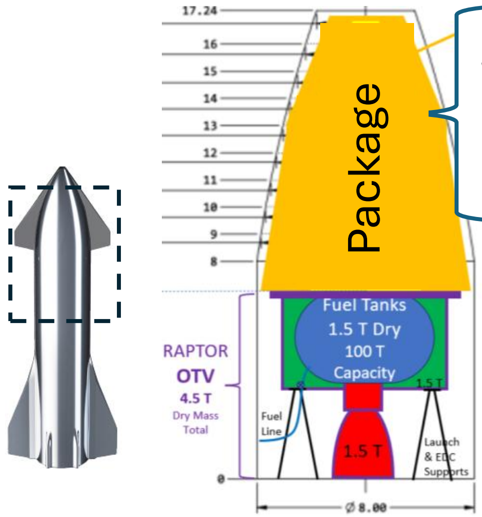


OTV

10T OTV + 250T fuel (~ 10 days of production)
+ 4 km/s To Rendezvous
-> 10T OTV + 105T fuel

OTV + Payload

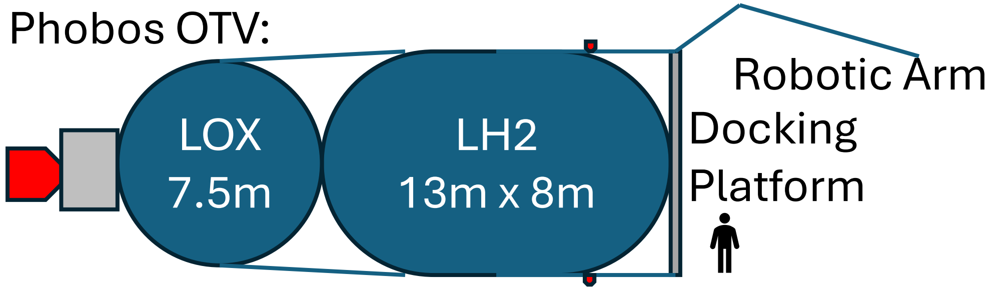
10T OTV + 45T Payload + 105T fuel
4 km/s To Enter Phobos Orbit
->10T OTV + 45 T Payload



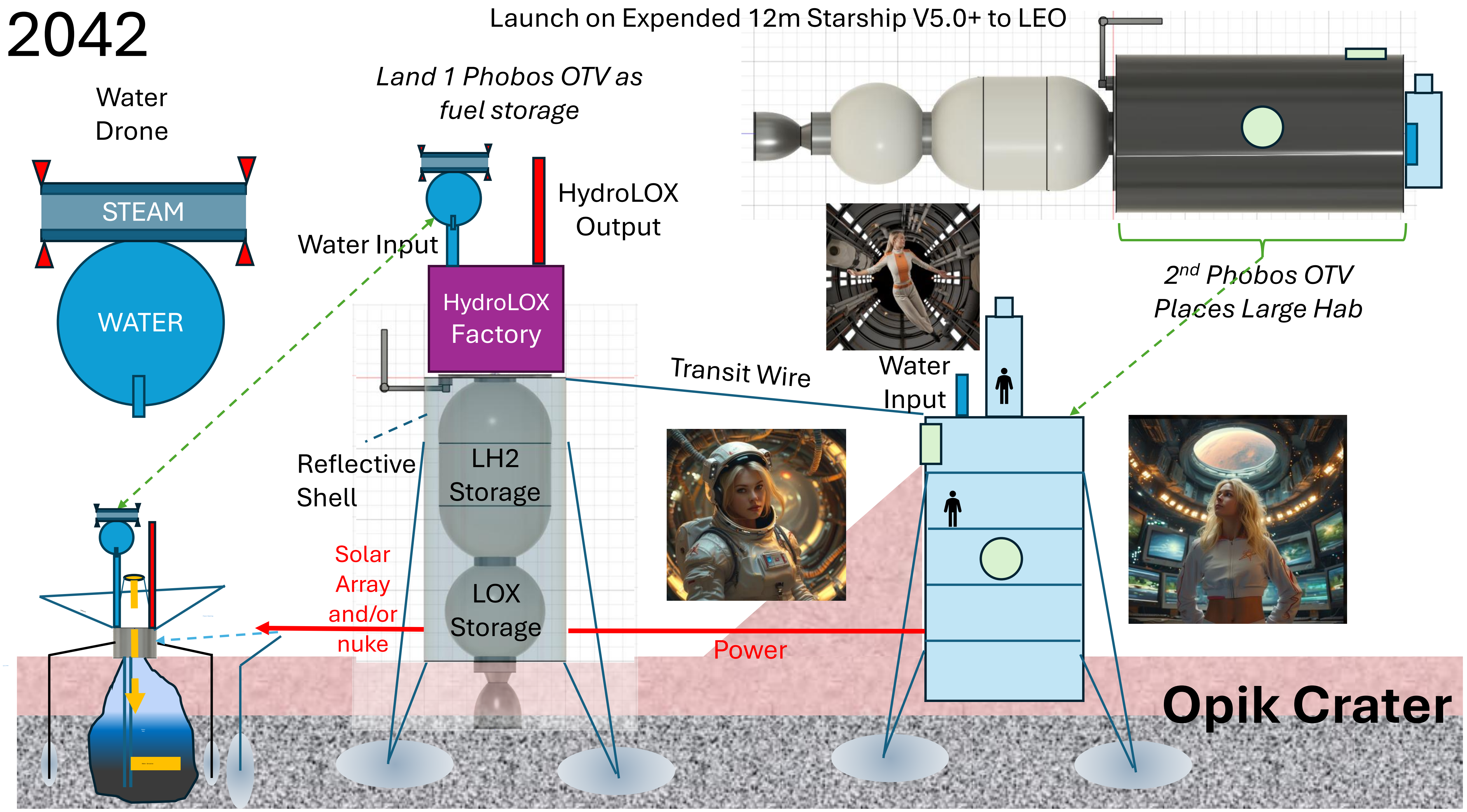
Starship Payload Bay

Supplies, N2, Food, Spare Parts …
Hab modules, solar arrays, machinery …
Construction components, wire, trusses …

Phobos OTV:



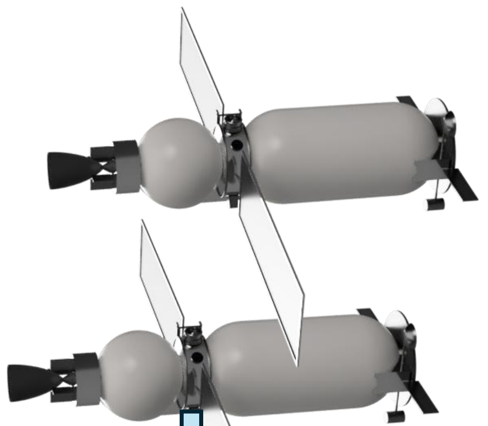
~ 8 mm thick carbon composite tanks

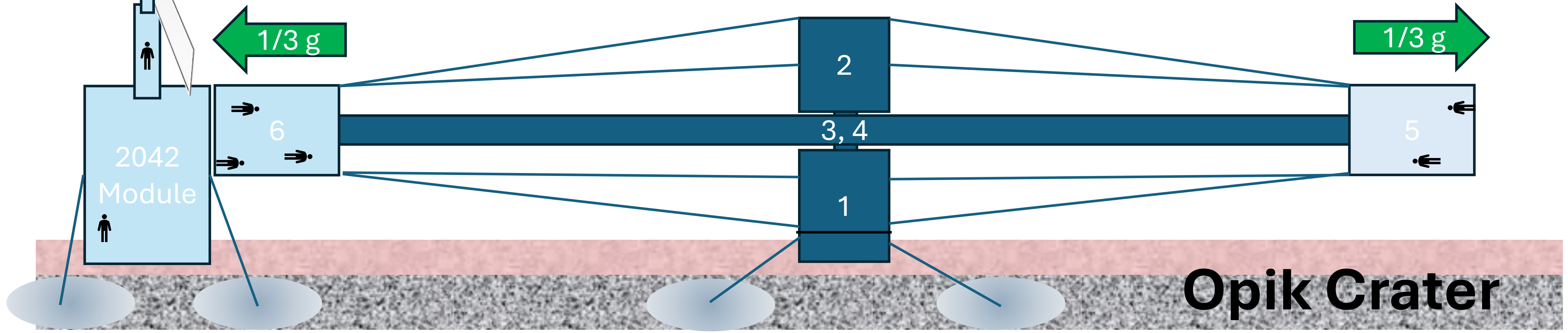

2042
Launch on Expended 12m Starship V5.0+ to LEO
Water Drone
STEAM
WATER
Land 1 Phobos OTV as fuel storage
HydroLOX Output
Water Input
HydroLOX Factory
LH2 Storage
LOX Storage
Reflective Shell
Solar Array and/or nuke
Transit Wire
Water Input
Power
2nd Phobos OTV Places Large Hab
Opik Crater

#4 Building up Phobos Base (2044)
Add 1/3 g spin gravity centrifuge with 2 habs
(6 40T packages)

Phobos OTV catching 40 T packages

2 Phobos Express (8 new Crew)

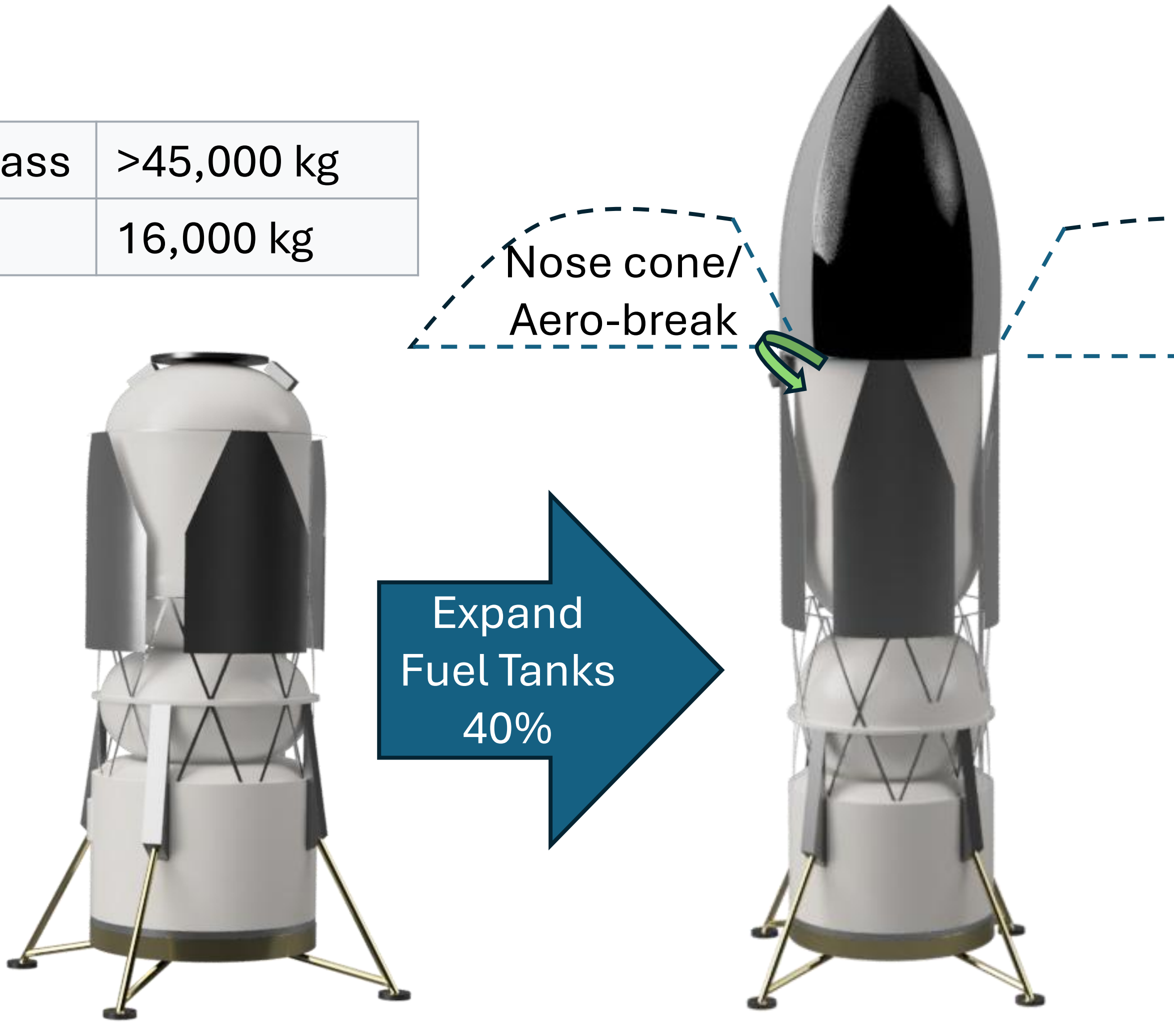




Mars Taxi (2048)

- Mostly propulsive
- Optimized for a crew of up to 10 + 5 tons of total payload
- Designed to land at a Mars base
- Mars water to HydroLOX refuels ship
- Reworks Blue Moon Mk 2 tech

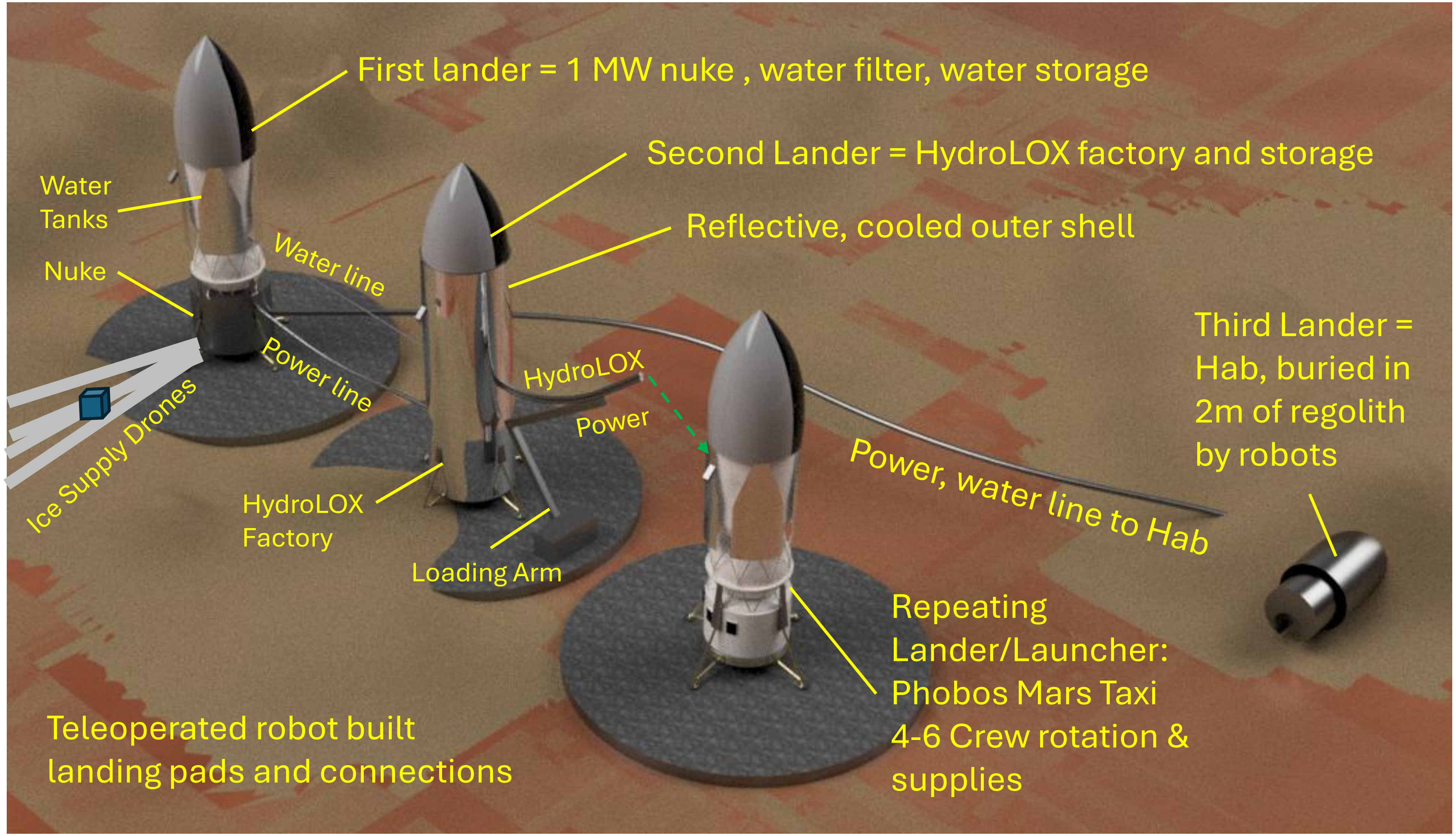
Launch mass	>45,000 kg
Dry mass	16,000 kg



Blue Moon Mk2
(under NASA contract)

Phobos-Mars Taxi

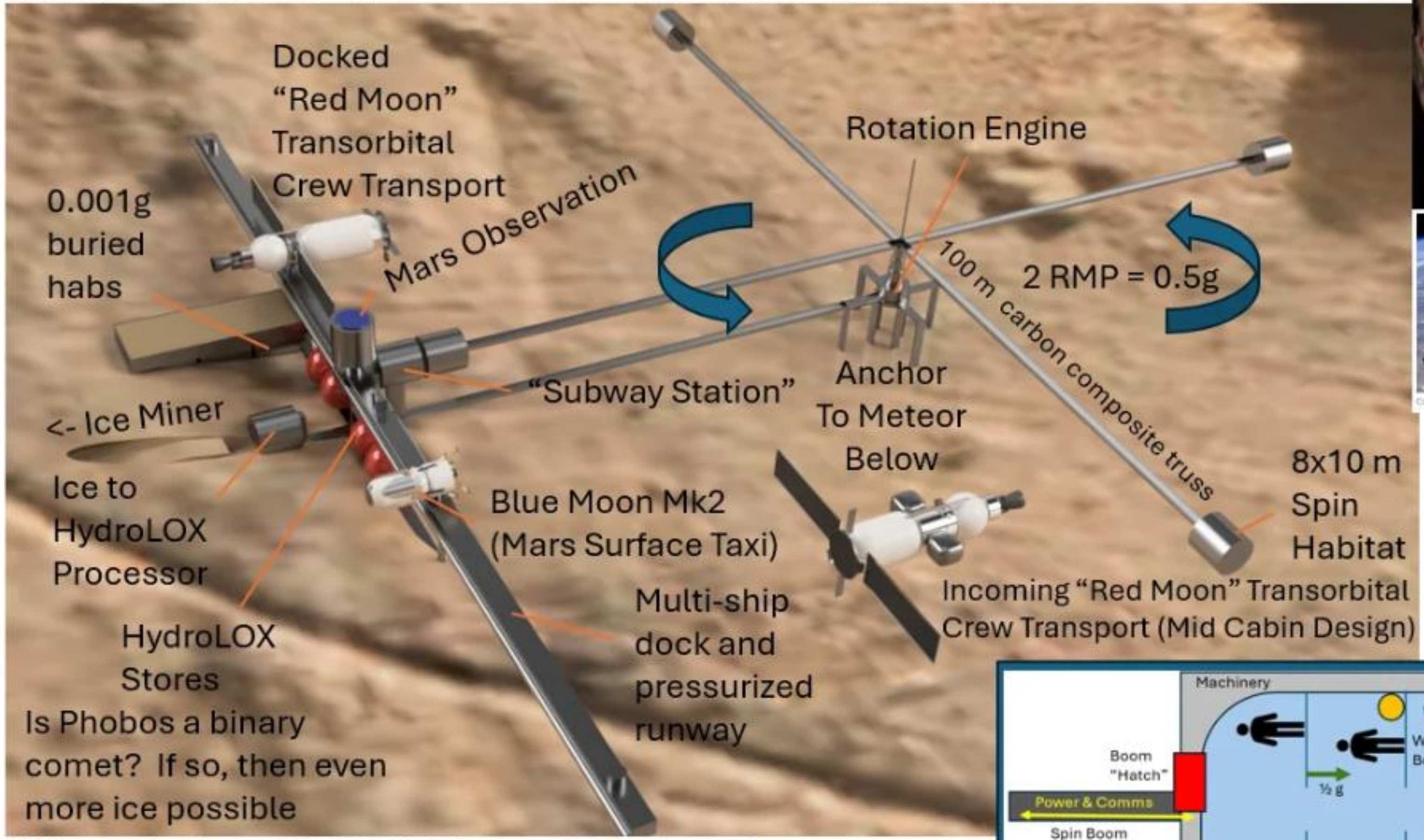
First Crewed Mars Base 2050 (4-6 crew)

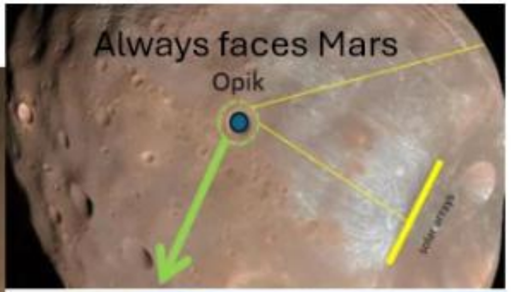


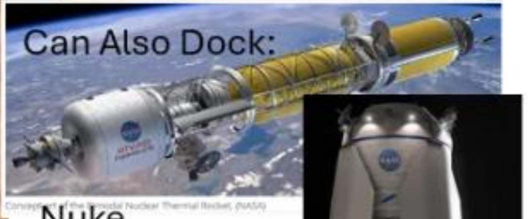
2050s

1 Phobos OTV catching 6 40 T packages every Synod

Phobos station





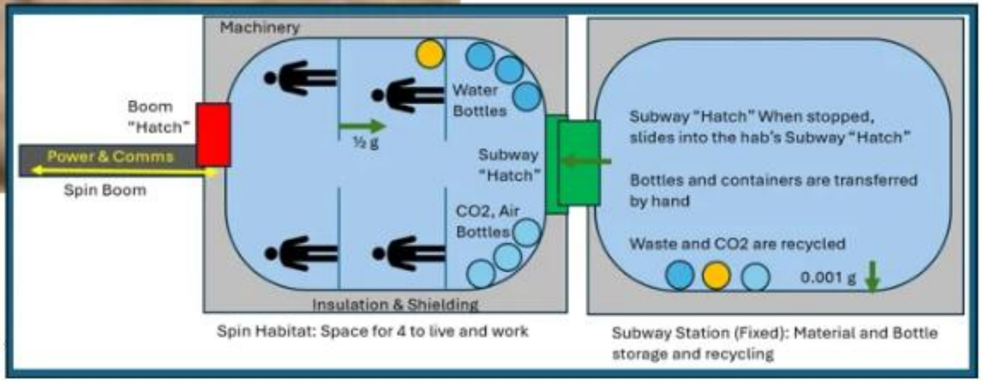


Nuke
Spacecraft

Blue
Moon
Mk2

Why at the bottom of Opik? Better GCR protection
Good shade for HydroLOX tanks. Great view of Mars.
Anchor to meteor that created the crater

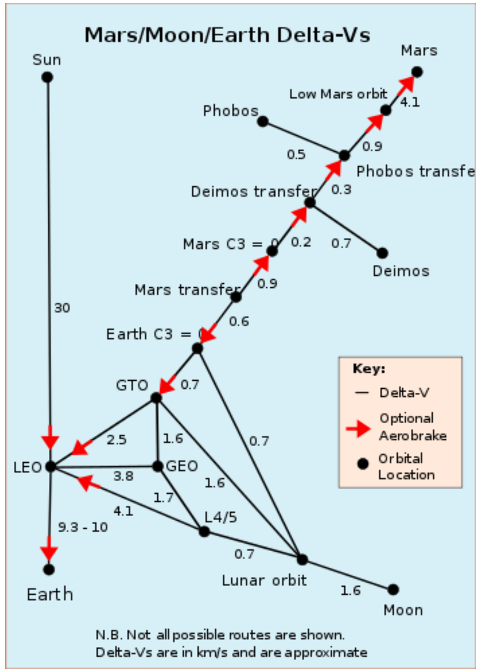
Phobos orbits so close to Mars that it receives significant heating via light reflected from that planet: the Mars-facing hemisphere is several tens of kelvins warmer than the center of its anti-Mars hemisphere.



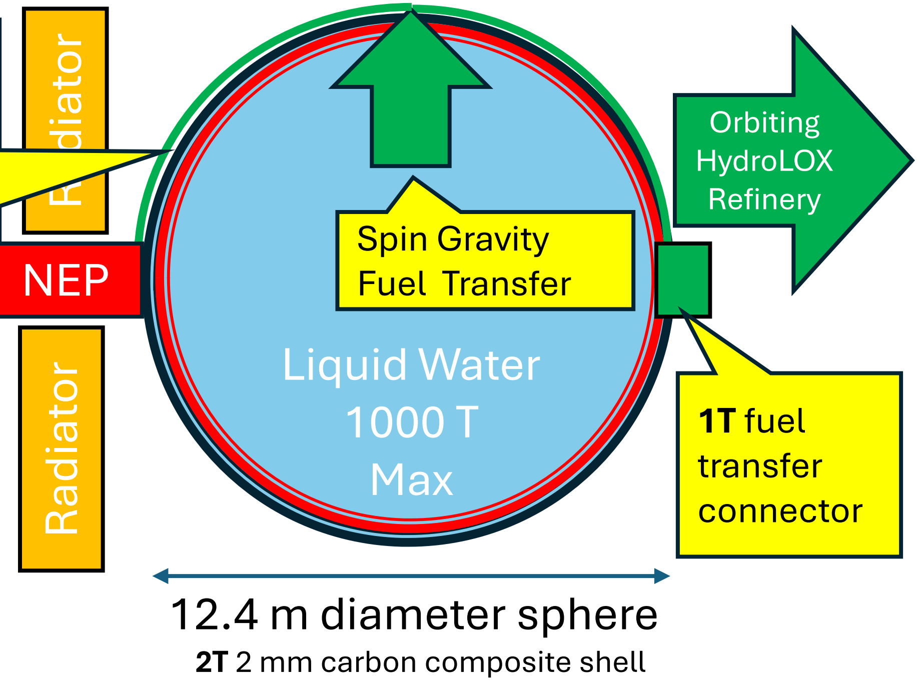
Phobos Water for NRHO (2050s) ...

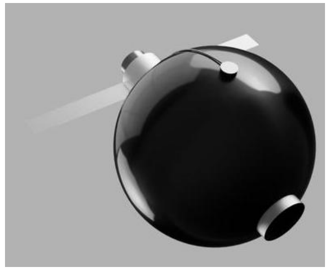
- Use Nuclear Electric Propulsion (NEP), slower transfers but more DV efficient than Holman, Use Uranium from the moon? (South Pole Aitken Basin)
- DV < 3 km/s to NRHO (starting full) and < 3 km/s back (near empty). DV from Earth surface is about 14 km/s by comparison (~25x fuel use)
- Heat from NEP keeps water liquid
- Minimal pressure allows a thin composite water tank
- Spin gravity keeps water pipe pressurized
- First break apart the H20 into H2 and O2 for the ion engine (increases ISP)
- At an ISP of 2000s >**900 T** of water can be delivered to NRHO with 2 T remaining to support the return to Phobos
    - Much higher ISPs may be possible
- Run cost of $20M amortizing the cost of the Phobos Water Tanker (PWT) over 20 runs + cost of water production in Phobos

900T can power 28 round trips of Blue Moon Mk2



10T Dry Phobos Water Tanker:

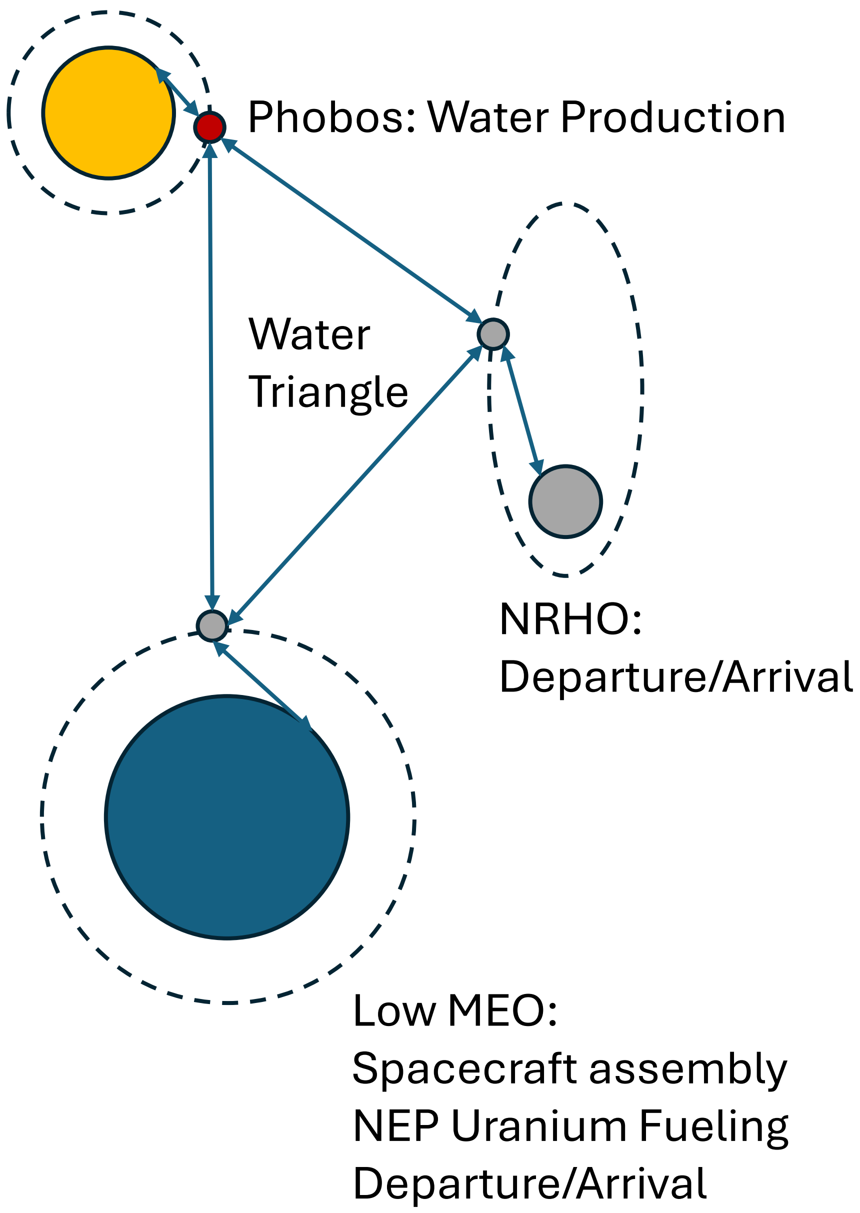




NEP ref: https://www.sciencedirect.com/science/article/pii/S2352484722014123

Trade Routes

- Assume Mars and Phobos are rich in water
- From Mars to Phobos: Nitrogen, Argon, Uranium
- From Phobos to Mars: ?
- From Phobos to Moon: Water, Mars sourced Uranium
- From Moon to Phobos: ?
- From Earth to LMEO: Spacecraft, supplies



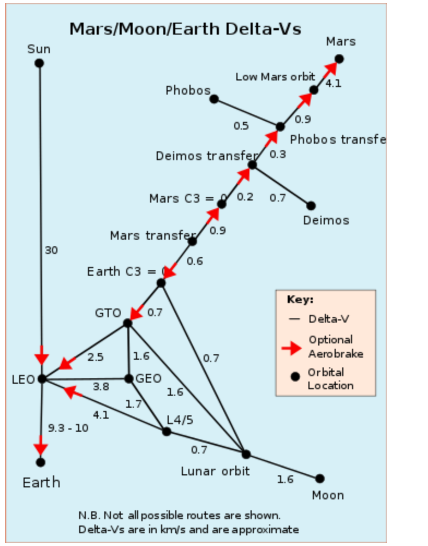
Phobos Cruiser (2060)

Reuse radiation shield water for fuel

Up to 100 crew possible

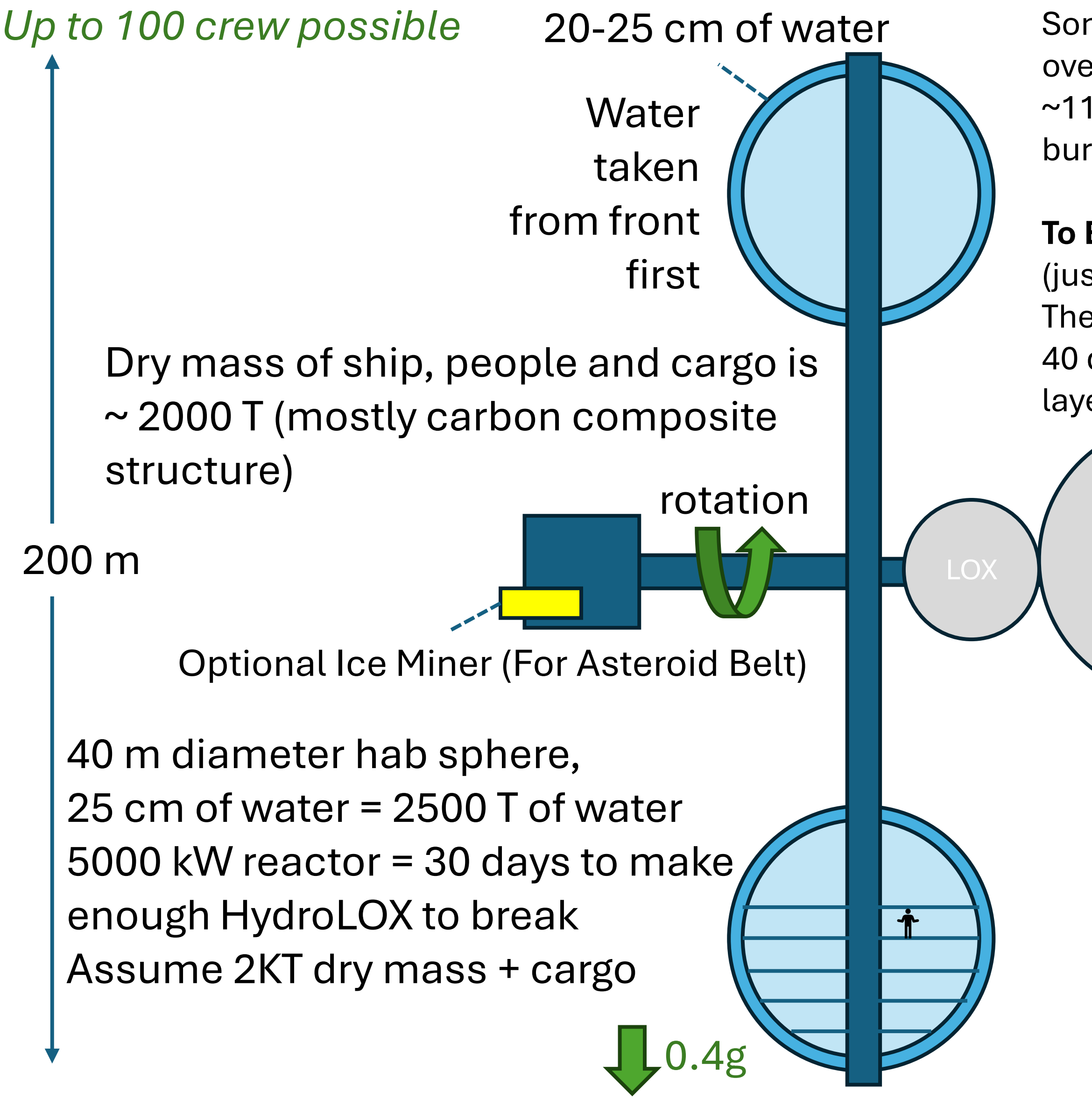
To Phobos: 3 water tankers from Phobos fill ship in LEO
Water layer, LOX and LH2 tanks start full (~5000 T), then all burned to get to MTO
LOX & LH2 empty during most of flight to Phobos
Some water is then converted to HydroLOX near Phobos Orbit over 30 days for the burn into Phobos
~1100 T of water (and wastewater) is dumped before Phobos burn. Water is refilled at Phobos with Phobos water

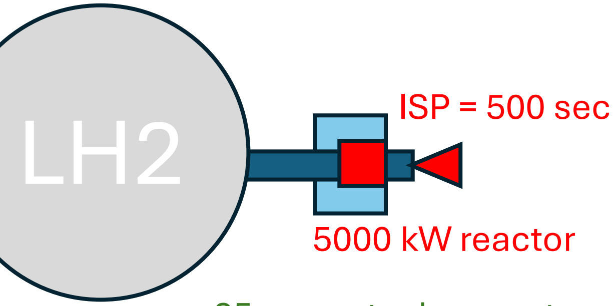
To Earth: water tank is full, LOX and LH2 tanks are partly full (just 2500 T of fuel needed for ETO).
The burn to ERO empties the LOX and LH2 tanks
40 days before LEO the reactor makes the rest of the water layer to LOX and LH2 for the burn into LEO



LEO <-> MTO =3.8 km/s
(sizes LOX/LH2 tanks)

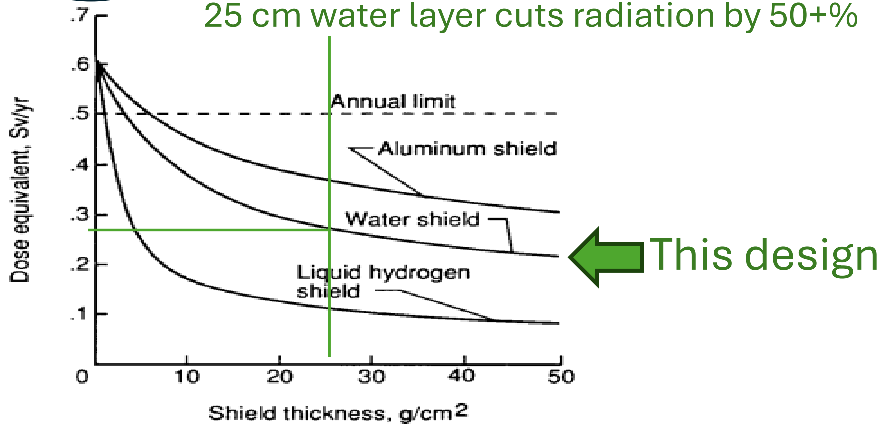
MTO <-> Phobos = 2.4 km/s
(sizes Water needs)





Dry mass of ship, people and cargo is ~ 2000 T (mostly carbon composite structure)

40 m diameter hab sphere,
25 cm of water = 2500 T of water
5000 kW reactor = 30 days to make enough HydroLOX to break
Assume 2KT dry mass + cargo



https://ntrs.nasa.gov/api/citations/19900008219/downloads/19900008219.pdf

Low Altitude Mars Sightseeing (2060)

- For a small DV from and back from Phobos, a group of sightseers could spend a day flying very low (100 km) over most of the features on Mars.

Habitation of sealed ice caverns after being mined for ice (2070?)

- After 30 years of ice mining these caverns may be available for habitation.
- Temps would need to be raised to 20 F, and O2 replenished as it leaks out to allow for helmets-off living.
- Spin gravity habitats would compliment to open space, providing 1/3 g apartment like living.