EXODUS ORBITALS

“PROMETHEUS UNBOUND”

SETTLING ONE MILLION PEOPLE ON MARS BY 2050: A BOTTOM-UP APPROACH

THE GOAL:

1M OF PEOPLE ON MARS BY 2050

We have no previous experience on starting interplanetary colonies. It is going to be a vast, difficult undertaking.

WE MUST FACE MANY KNOWN “UNKNOWNS”

ENVIRONMENTAL

- Thin atmosphere
- Radiation
- Dust storms
- Low gravity

TECHNOLOGICAL

- Logistics
- Bootstrapping industry
- Closed loop ecosystem

SOCIETAL

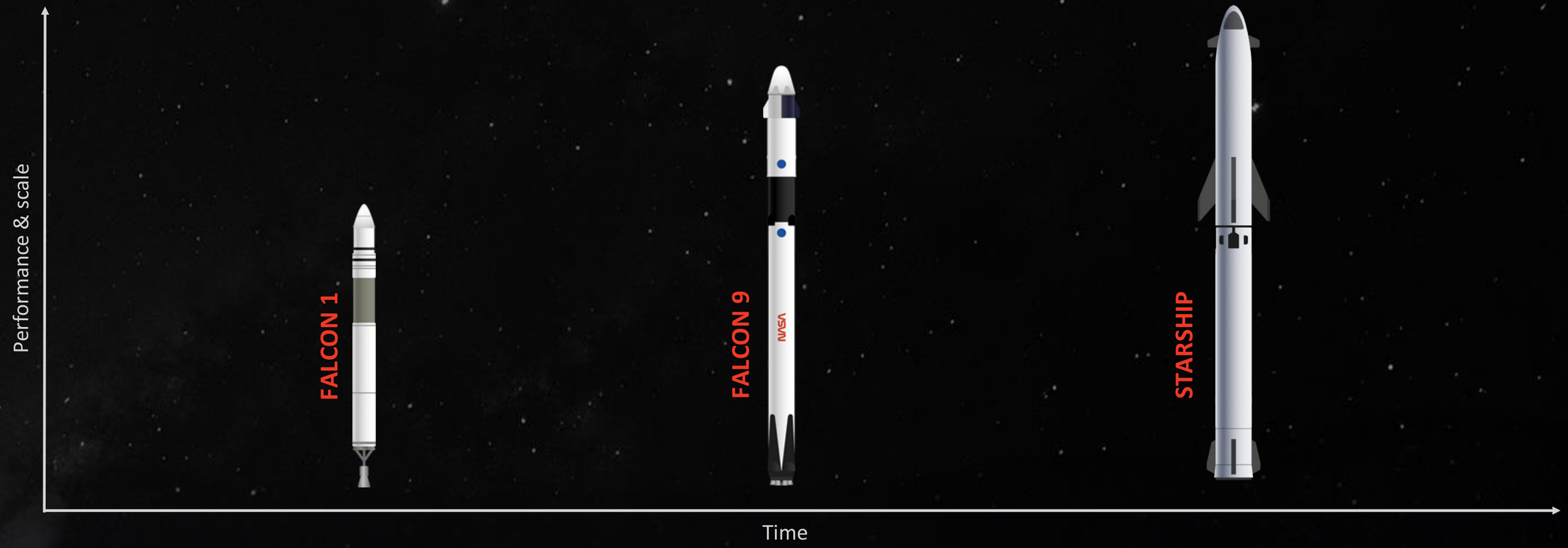
- What people to recruit?
- How to to train them?
- What culture to build?

… And many other unknown “unknowns”

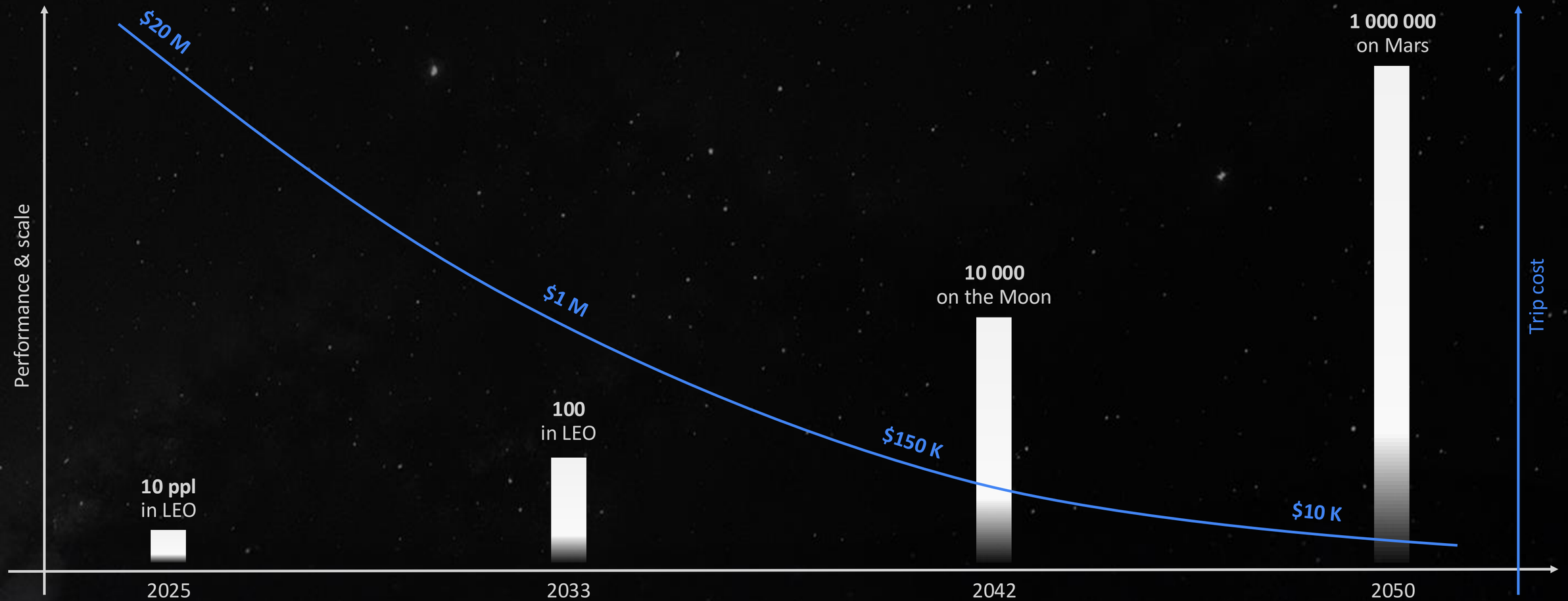
THE SOLUTION:

ITERATE TO DERISK AND SCALE

However, we have a proven approach to solve grand challenges: start small, scale up, iterate, repeat – as SpaceX did

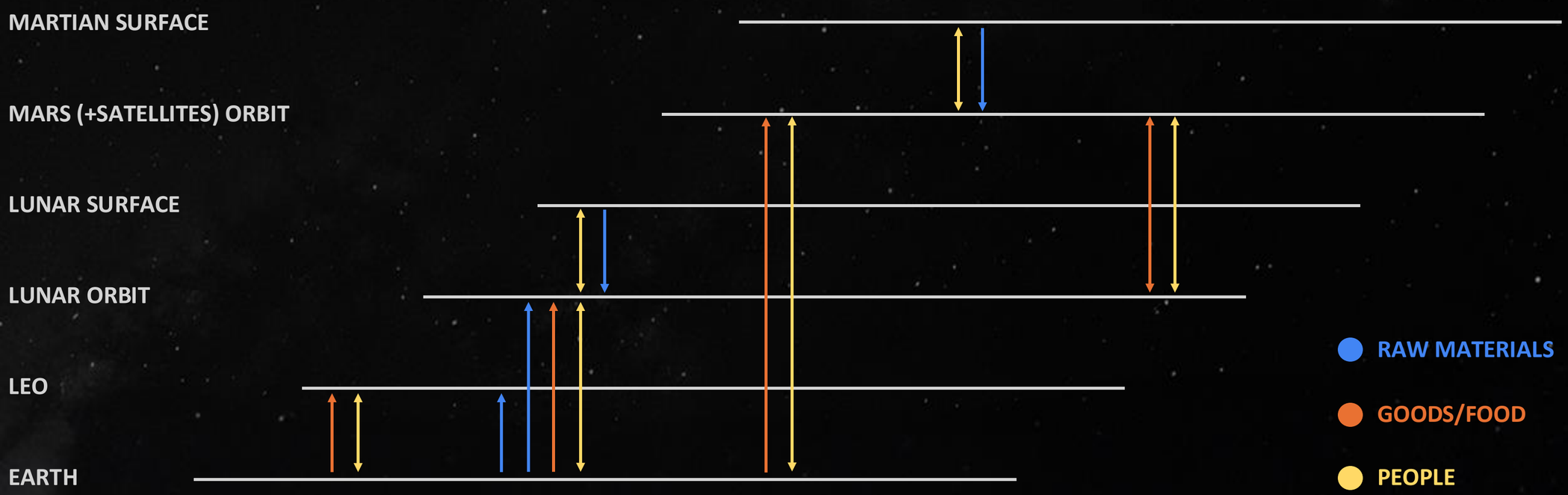


COST AND TIMELINES



PROBLEM DECOMPOSITION

- Don’t try to jump over the entire gap – too easy to fail!
- Instead, derisk through intermediate steps.
- Attempt only a subset of problems at each step.
- Then reuse the debugged solutions for the next step.
- Make each step financially self-sufficient as much as possible.



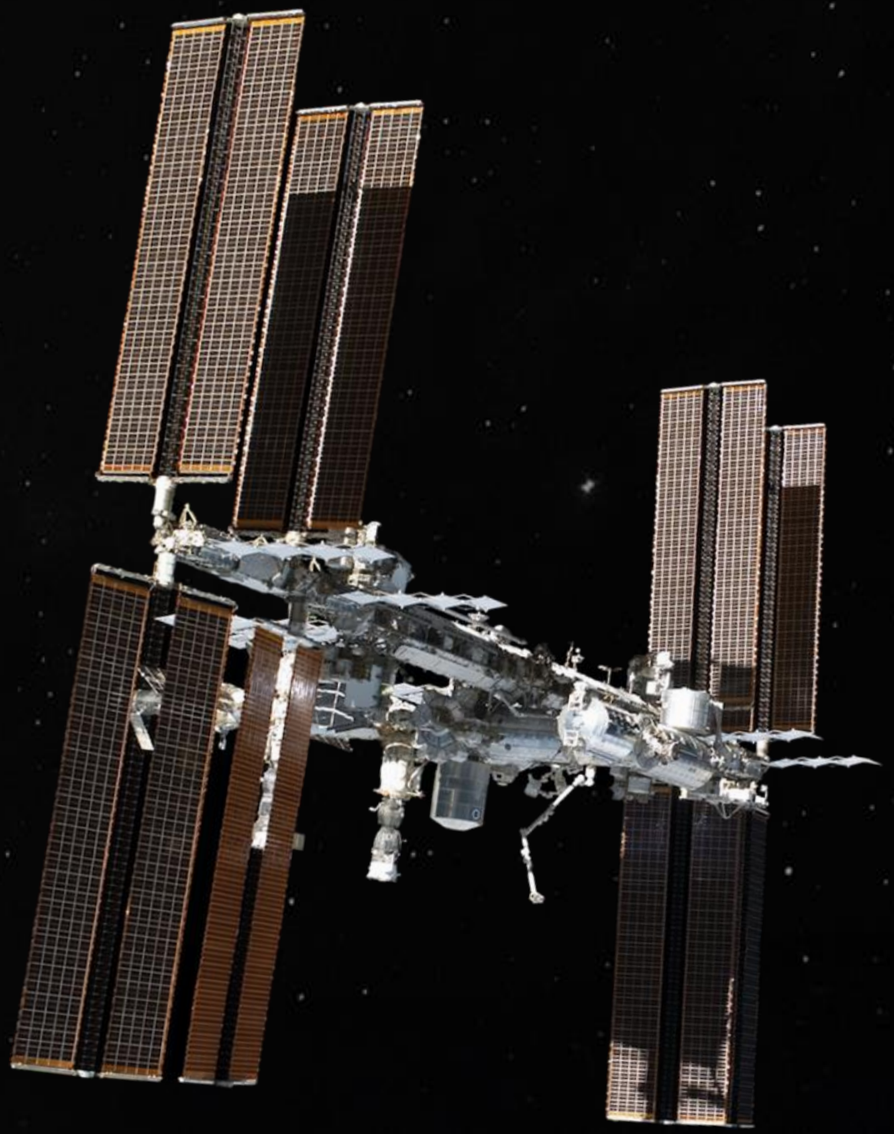
ITERATION STRUCTURE

WHAT: Each step/base site consists of 2 segments: **orbital** & **surface one(s)**. Orbital segment is designed to be similar for all destinations. Surface segments are designed more specifically
for each location.

WHY: Orbital segment can serve as a support base for surface bridgeheads. If one surface base fails to thrive, fallback to orbit segment and retry at different location – instead of retreating all the way to Earth.

THE STARTING POINT

The first step is the most difficult one – we do not have a robust small-scale extraterrestrial colony to scale up… or do we?



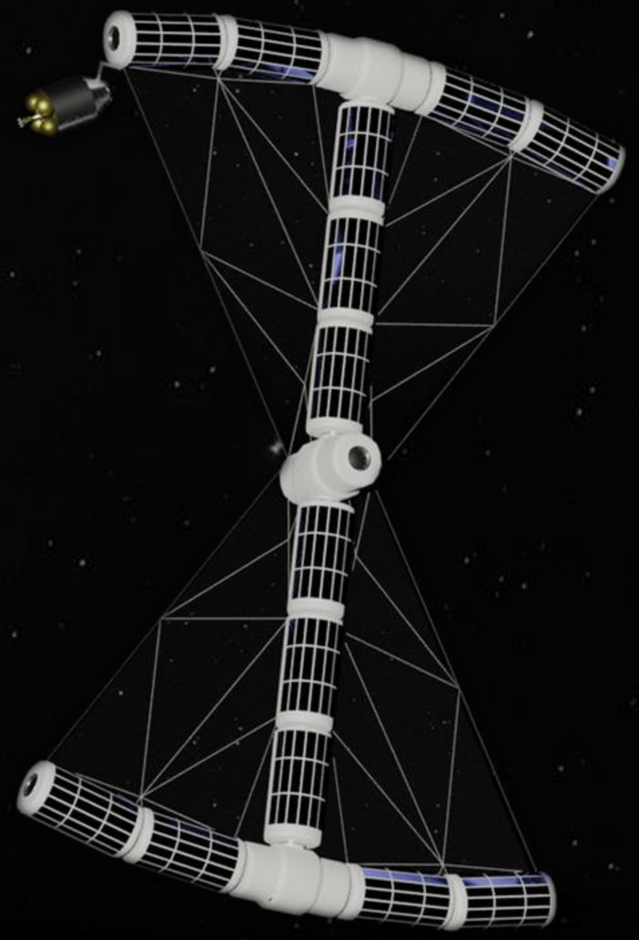
ISS GAPS TO COVER

- Smal crew size: (5-10 ppl)
- Radiation good for LEO only
- Closed-loop on water, but needs resupply
- Very limited onboard manufacturing
- Microgravity-only environment
- Requires highly trained crew
- Expensive to operate and support
- Depends on Earth for repairs and upgrades

…but a starting point nevertheless!

ITERATION 1:

LOW EARTH ORBIT



SCALE*

- **1550 tonnes wet mass**
- **75m diameter**
- **18 crew size (3x of ISS)**
- 5x in number of space stations

WHY IT IS IMPORTANT?

- Allows to get answers for Mars colony
- Feasible to build today with Starship
- Use proven tech to derisk the operations
- Test waters with larger teams in space

CAPABILITIES TO DEVELOP

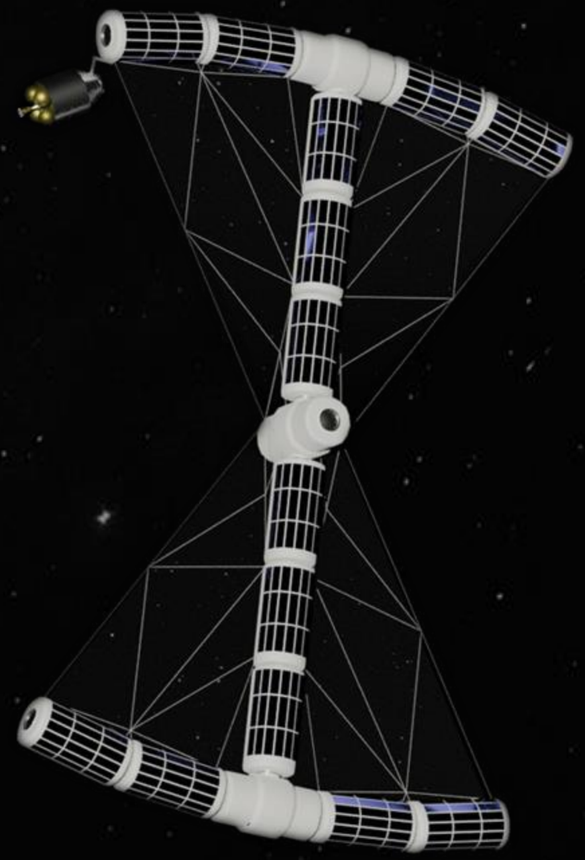
- **In-space assembly and construction**
- **Artificial gravity at Moon and Mars levels**
- Partial self-sufficiency on food and water
- More industrial/agricultural capabilities

**https://github.com/DarkStar1982/prometheus_unbound/blob/master/subprojects/vanaheim.md*

ITERATION 1:

BUSINESS MODEL

Space hotel: using hospitality industry as template.
Operate like a luxury hotel with unique experience.



COSTS FOR DESIGN ABOVE
(12 revenue-generating passengers, 6 crew)

- Assembly and construction cost for design at $1000/kg price point
  - Total construction cost: **$1.7B**
  - Additional launches delivering consumables: **$0.7B**
  - Operational costs ($64M/annual over 25 years): **$1.6B**

Total cost over lifetime: **$4.0B**

REVENUE PROJECTIONS

- Assuming gross profit of 3x of the lifetime costs (66% gross margin)
  - Total gross revenue: **$12B**
  - Annual gross revenue: **$480M**
  - Monthly gross revenue: **$52M***
  - Gross revenue per passenger-month: **$4.3M**
  - Gross revenue per passenger-day: **$144K**

7-day trip price per person: **$1M**

*With station utilization factor of 10 months per year and and subtracting 17 months of initial construction cost and 6 months of commissioning (non-operational time).

ITERATION 1:
LOGISTICS

“IN-SITU” LEO PRODUCTION:

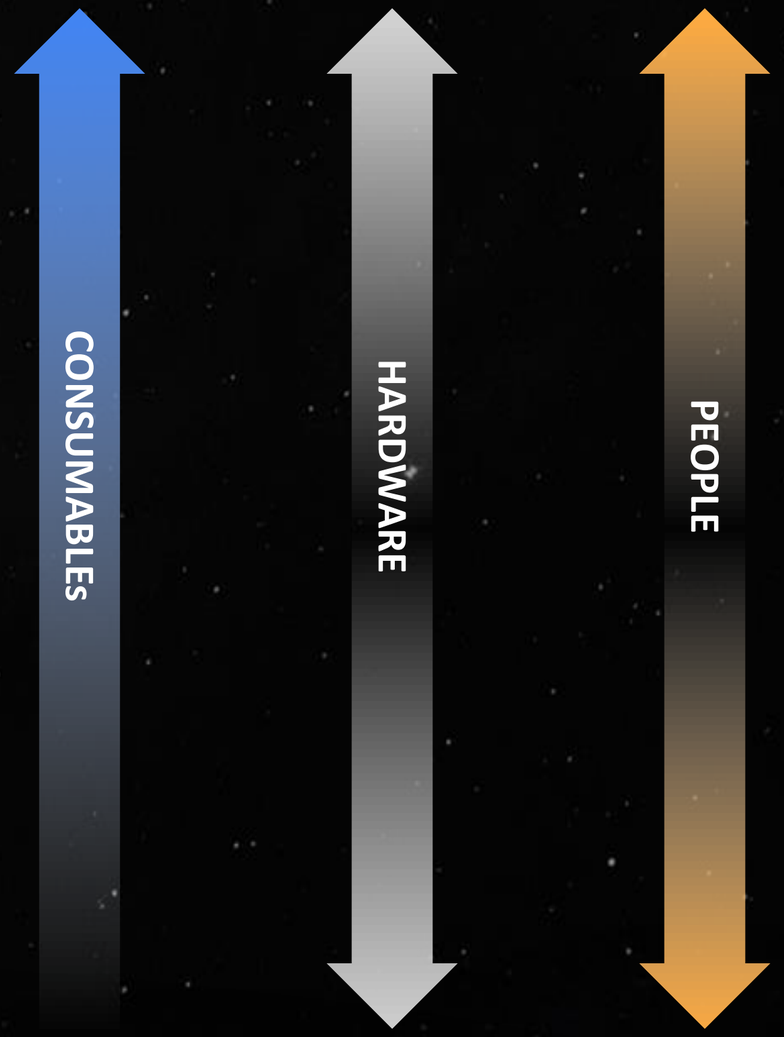
- Food production + water recycled
- Some of the hardware parts

SHIPPED FROM EARTH FIRST:

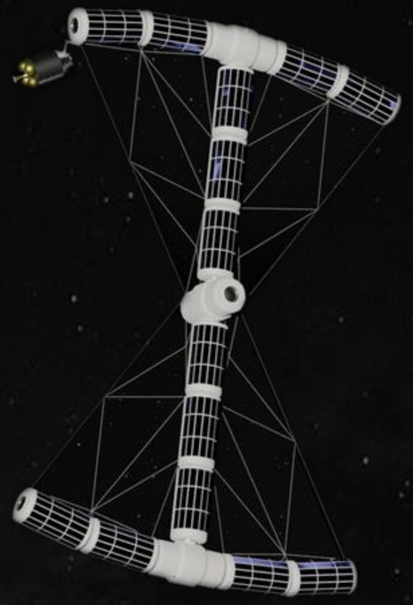
- Water
- Food
- Other perishables
- Industrial hardware
- Tourists

EXPORTED TO EARTH:

- Luxury/Fashion
- Niche products (ZBLAN fibers)
- Experiences
- Microgravity-specific technologies
- Unique IP content:
  - Entertainment
  - Sports



ITERATION 2:
MOON



ORBITAL HABITAT SEGMENT
(80% population)

- 5x in crew size vs LEO segment (100 people)
- 15x in number of habitat units (75)

CAPABILITIES

- **Deep space radiation shielding**
- **1-g artificial gravity level!**
- Improved onboard manufacturing
- Food production + water recycling

SURFACE SEGMENT
(20% population)

- **Mining & Manufacturing**
  - Water ice mining
  - Lunar regolith mining
  - Metal oxide smelting
  - Power stations
- **Tourism-oriented activities**
  - Surface habitats
  - Recreation and travel facilities

ITERATION 2:

BUSINESS MODEL

Building Lunar Tourism Industry – taking inspiration from mountaineering in Himalayas

People are thirsty for new destinations. There are plenty of attractions to see and visit on the Moon – from Lunar mountains to Apollo landing sites. All that required is infrastructure and means to make it economical.

TAKING FROM EARTH…

- 700,000 total annual traffic. Team size from 5 to 25 ppl
- Around 800 attempts to summit Everest (at $15,000/person)
- **Total annual revenue - $360M (Nepal only)**

…AND APPLYING TO MOON

- Around 300 Moon landings per year.
- Per-person price is $150,000 and team size of 10.
- **Gross annual revenue of $450M**

ITERATION 2:
LOGISTICS

MINED FROM SURFACE:
water + silica, metals from lunar regolith

LUNAR SURFACE

RAW MATTER

PEOPLE

PRODUCED “IN-SITU” IN ORBIT

- Water
- Food
- Other perishable supplies
- Spare parts

LUNAR ORBIT

HARDWARE

PEOPLE

SHIPPED FROM EARTH

- Complex industrial goods
- Tourists and crew

EXPORTED TO EARTH

- Experiences!
- Luxury goods
- Arts and culture
- Entertainment

EARTH

ITERATION 3:
MARS

ORBITAL HABITAT SCALE

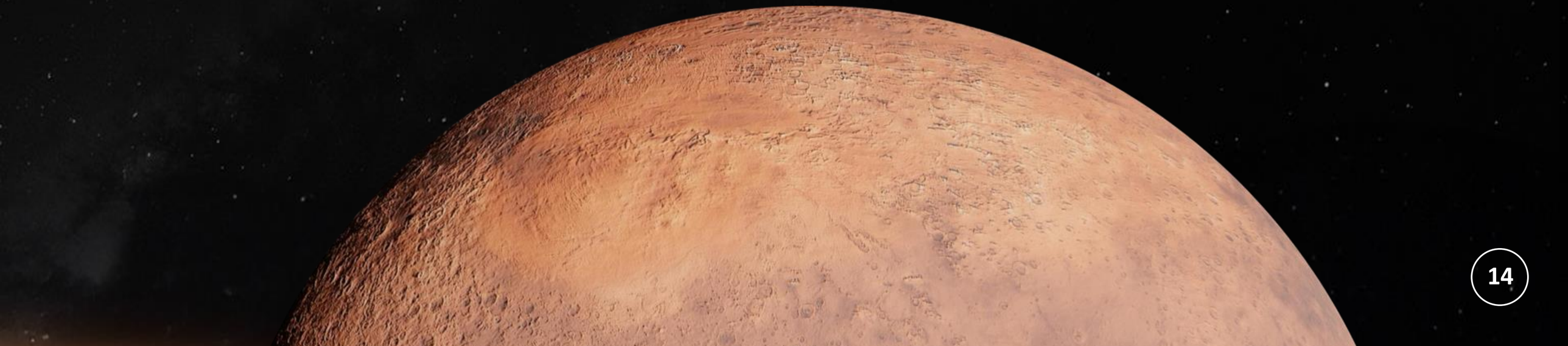
- 5x scale on crew size vs Moon (500 people)
- 20x scale on number of habitat units (1500)

ORBITAL SEGMENT
(80% population)

- Advanced manufacturing: pharmaceuticals, electronics
- **Large-scale orbital farming**
- **Asteroid mining (on Phobos/Deimos)**

SURFACE SEGMENT:
(20% population)

- CO_2, H_2O from Martian regolith
- Metal oxides and silica smelters
- Chemical plants (ammonia + propellants)
- Surface-dependent manufacturing facilities.



ITERATION 3:

BUSINESS MODEL

Take inspiration from New World development - abundance of land and resources, but low on labor. Shareholder-tenant model: Shareholders buy bids for development of the specific locations for some purposes (mining, manufacturing, agriculture), tenants (or team of tenants) develop them.

INITIAL ASSUMPTIONS: TENANTS

- Cost of one-way ticket: **$10k***
- Recruit 1 million tenants for **$10B** cash inflow

INITIAL ASSUMPTIONS: SHAREHOLDERS

- Cost of bid to own a stake: **$1M***
- Recruit 10k landowners for **$10B** cash inflow

Example: using the $20B amount as collateral, borrow another $20B at 25-year term loan at 5%.
We have now $40B to establish a self-sufficient colony and build the foundations of infrastructure and society

Taking the following countries as example (Cyprus, Malta, Macau with population 0.5-1.5M), hypothetical Martian colony budget would be approximated as following:

- Total expenditures: **$10B**
- Total revenues: **$12B**

- Net exports: **$15B**
- Net imports: **$13.6B**

Trade balance: **$1.4B****

**loan repayment back to Earth
*2025-dollar cost

ITERATION 3:
LOGISTICS

MINED & MANUFACTURED ON SURFACE:

volatiles, silica, metals, plastics

MARTIAN SURFACE

PRODUCED IN ORBIT:

- Food
- Other supplies
- Basic manufactured goods

RAW MATTER

PEOPLE

SHIPPED FROM MOON:

- Professional astronauts
- Space-related goods

PEOPLE

HARDWARE

MARS ORBIT

LUNAR ORBIT

SHIPPED FROM EARTH:

- Colonists/immigrants
- Financial capital
- Consumer goods
- Advanced industrial goods
- Advanced materials
- Precision equipment

HARDWARE

PEOPLE

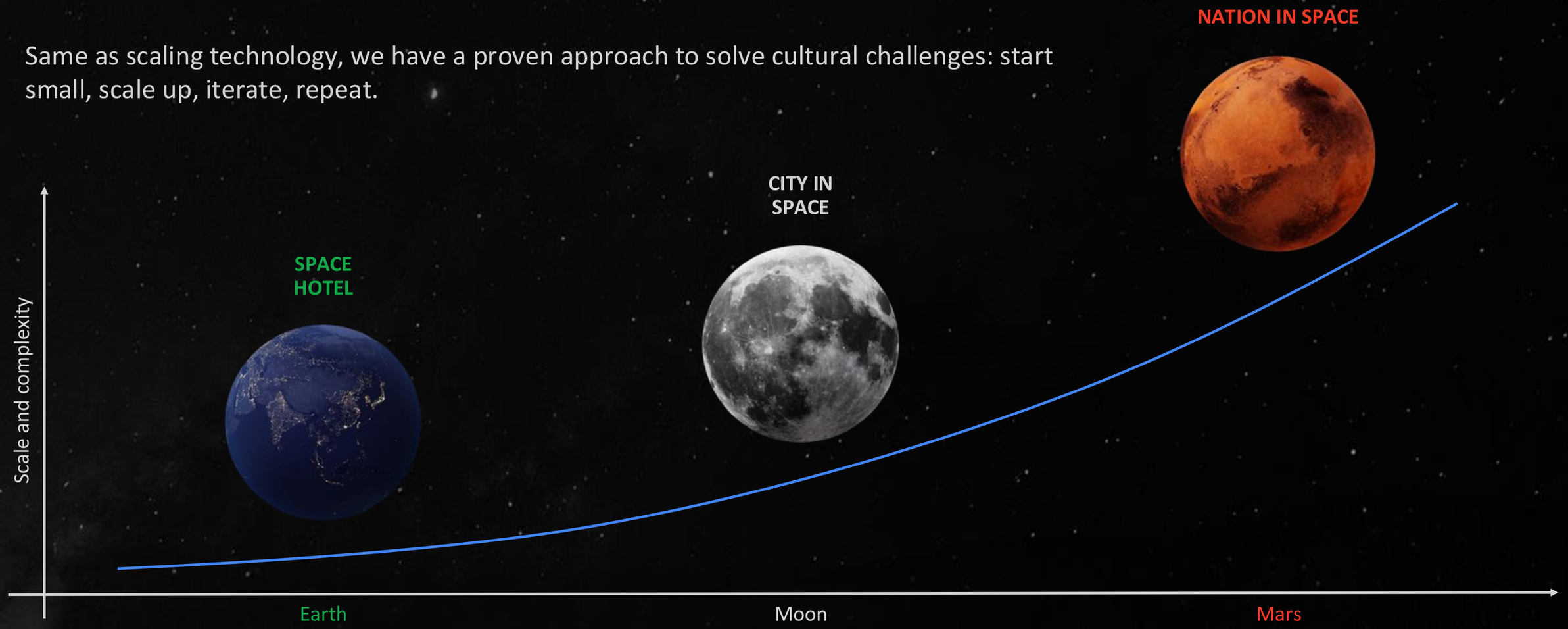
PRODUCED ON MARS, EXPORTED TO EARTH:

- Unique goods and IP
- Emigrants

EARTH

SCALING UP CULTURE & GOVERNANCE

Same as scaling technology, we have a proven approach to solve cultural challenges: start small, scale up, iterate, repeat.



ITERATION 1:

LOW EARTH ORBIT

Use best corporate culture examples from hospitality industry – think hotel or cruise ships

TAKE EXAMPLES FROM CRUISE SHIPPING INDUSTRY:

Mostly safe, but Accidents can happen.

Crew attends to the passengers but takes command in case of emergencies.

Passengers are trained in basics of spaceflight operations, including emergencies: fire-fighting, loss of pressure.

ITERATION 2:

ITERATION II: LUNAR ORBIT & SURFACE

Mountaineering tourism as model for client service relationships: customers pay and crew serves, but they better follow the crew if they want not do die!

TAKE EXAMPLE FROM SHERPA PEOPLE:

Space is a harsh environment: mistakes are deadly - develop a space-native culture.

Cooperate, not compete or boss around people – build egalitarian, meritocratic society

Customers rotate on short-term, crew on long-term – build up institutional knowledge and experience.

ITERATION 3:

MARS ORBIT & SURFACE

Mars: building a self-sufficient civilization: building up on historical experience with better ethical foundations

TAKING INSPIRATION FROM AGE OF DISCOVERY…

Ambitious people got opportunity for wealth and power

Marginalized communities got a place for fresh start

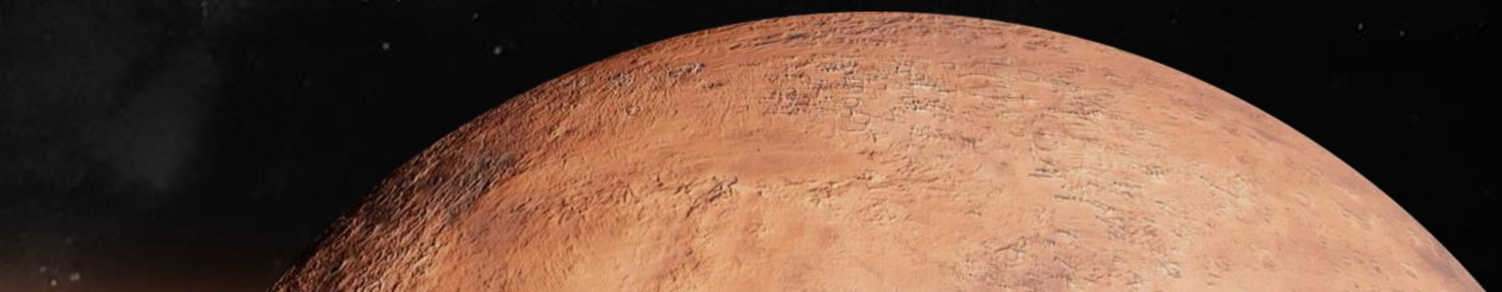
Existing political powers got room to grow their domain

…AND APPLYING TO MARS

Build better foundation using lessons learned on Earth

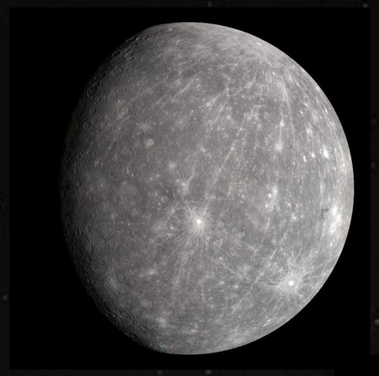
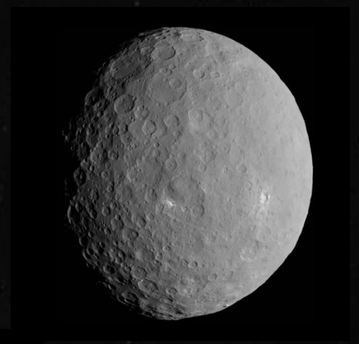
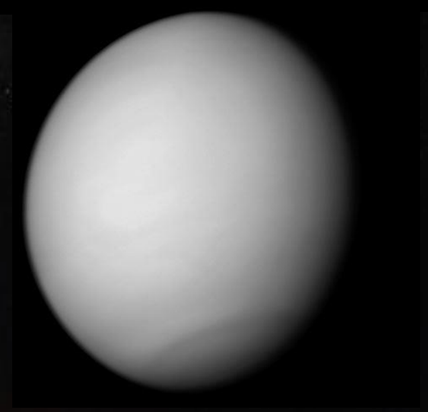
Don’t try for utopia, add incremental improvements

Build an open, expansion-oriented culture.

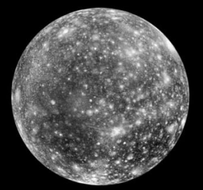
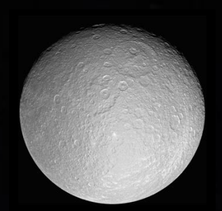
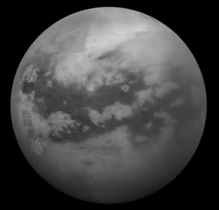


BEYOND MOON AND MARS

Opportunities in Solar System are not limited to just Moon and Mars: most of the smaller planetary bodies (asteroids and planetary satellites) are suitable for settlement – once we master the social and technological foundations.



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LE HENAFF

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HOLCZER

ILYA
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DENNIS
SILIN

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