

Life support systems.

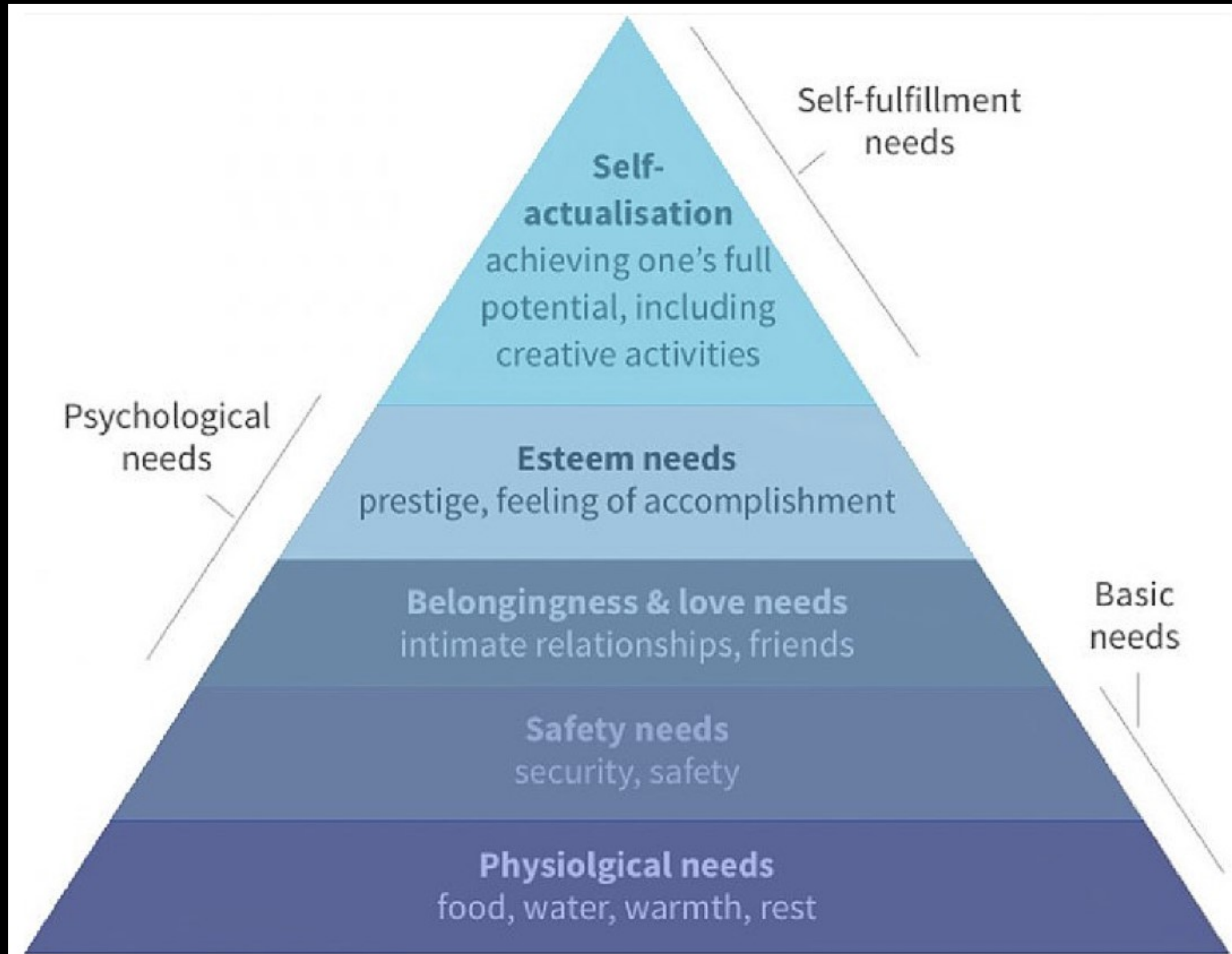
Air, water and shelter for space habitats.

Axsysnav is providing the CNES a database of organisations working towards enabling conditions for living in space.

An extrapolation from the work is presented: air, water and shelter for space habitats.

Data is sourced from space companies, papers and the author's experience.

Maslow pyramid of needs



Published by Abraham Maslow in his paper
"A Theory of Human Motivation".

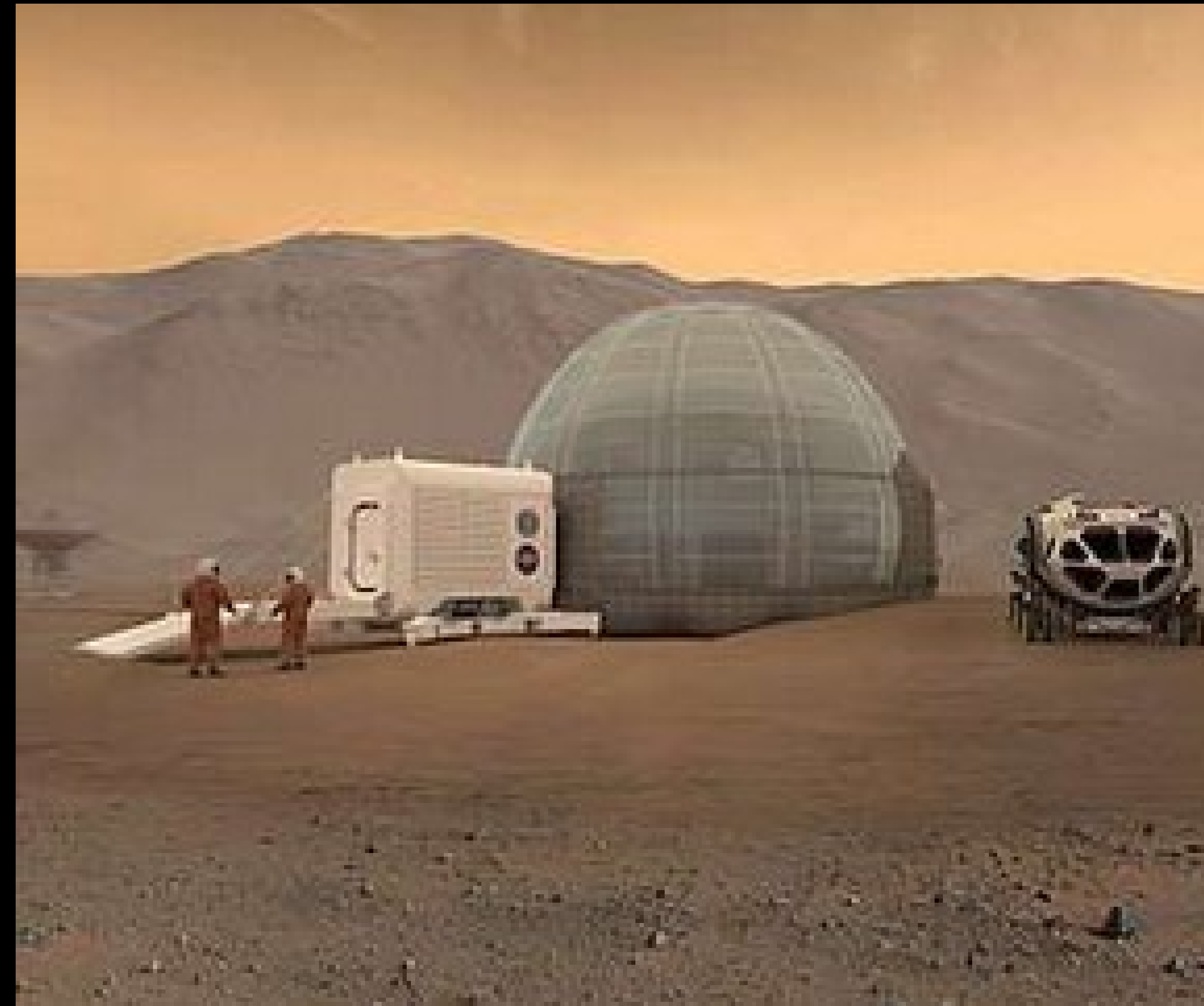
The Psychology Review #50 (1943).

Maslow > applied to space habitation

Motivated
community

Food, safety, shelter

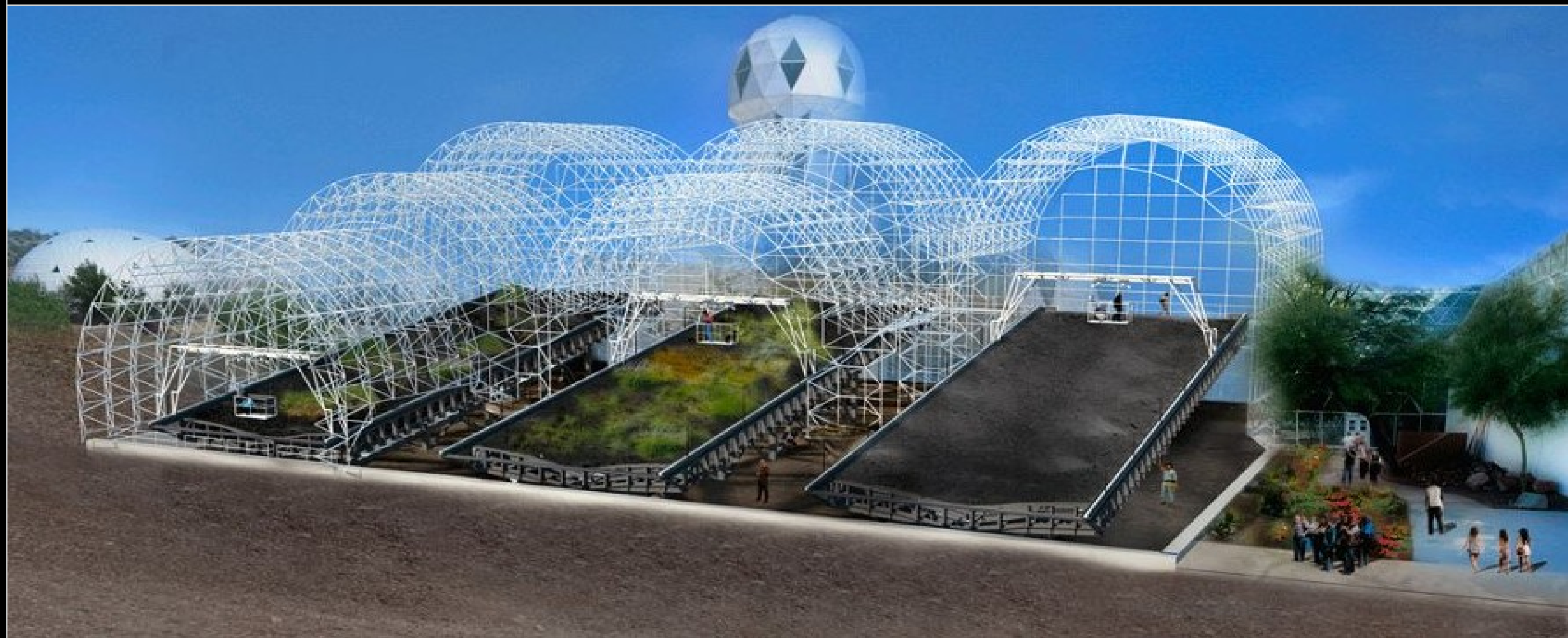
Air, water, energy



The Biosphere 2 (University of Arizona) is now the Landscape Evolution Observatory.


Each field is 30m by 11m, composed of regolith.
Studies water, carbon and energy recycling.

Biosphere 2



ISS	<p>Oxygen onboard the ISS is extracted from water that is flown up from the Earth.</p> <p>CO₂ extracted from the air in the ISS by the Atmosphere Revitalization life support system, then converted to oxygen using a Sabatier reactor (Umpqa). Hydrogen from methane.</p> <p>A pilot project (ARTEMISS) is creating oxygen and edible biomass using photosynthesis on waste products.</p>
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ESA	ESA also has an In-Situ Resource Utilisation (ISRU) programme whose aim is to extract oxygen and water from the moon's resources.
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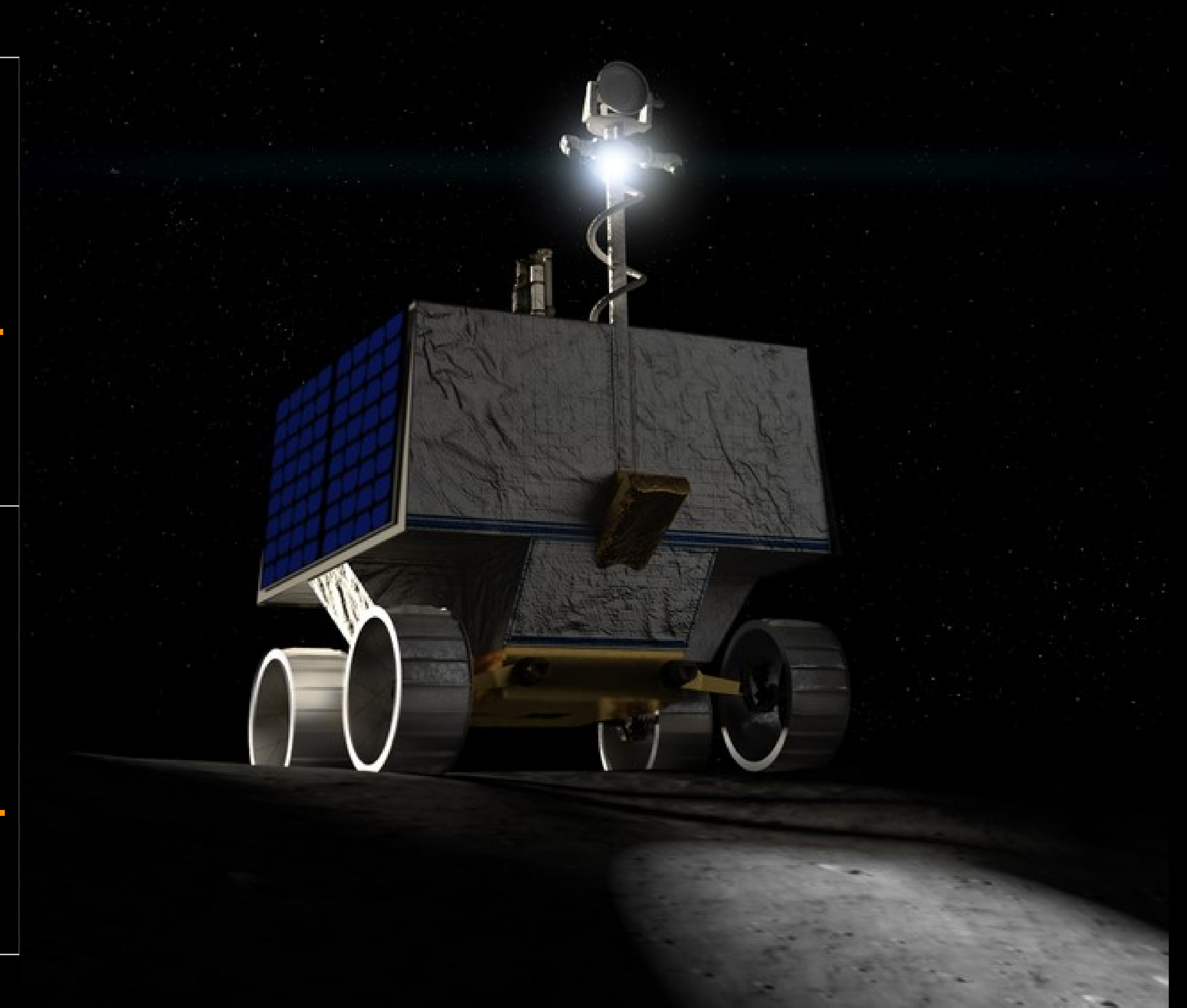
ISS	Humans in space need 2 litres of water per day. Water has to be lifted to the ISS, no current technology to recycle waste water. ISS reservoirs use microbial check valves to keep the water fit for human consumption.
Lunar surface	Since solar radiation chemically breaks down water ice on the surface, many deep wells contain water ice. Heliostats are planned to sublimate hidden ice into water vapour, Estimated 60% cheaper than excavating from the surface.
	

Source: Moon

Lunar
surface

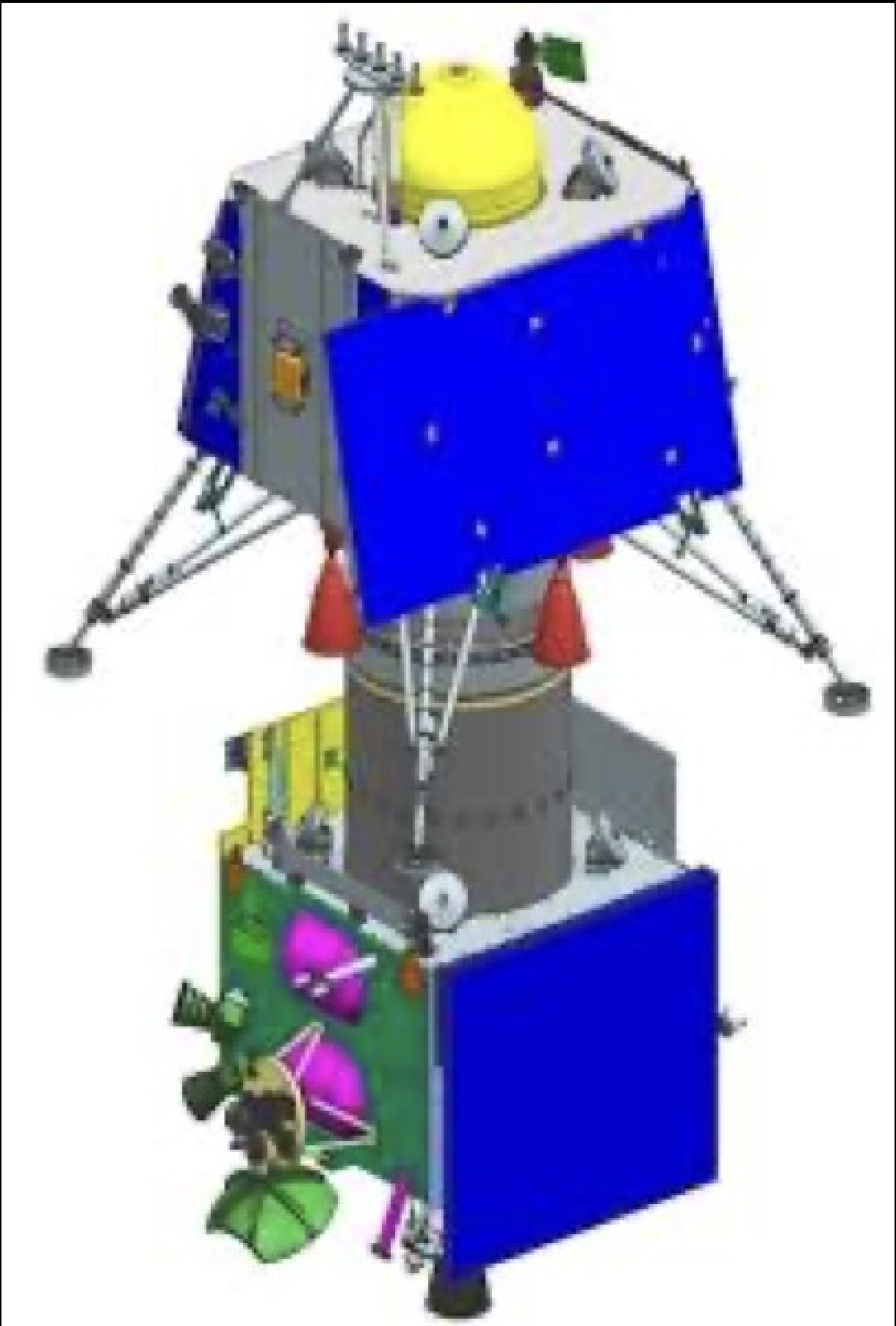
NASA VIPER mission will roam around the Moon's south pole looking for surface water ice in the shadows. Lands in December 2022.

Water is present in two forms, water ice and mineral-bound water. The latter is formed when oxygen atoms trapped lunar silicates combine with protons in the solar wind: X-OH.
$$2 \text{ X-OH} \rightarrow \text{X-O-X} + \text{H}_2\text{O}.$$



Source: NASA

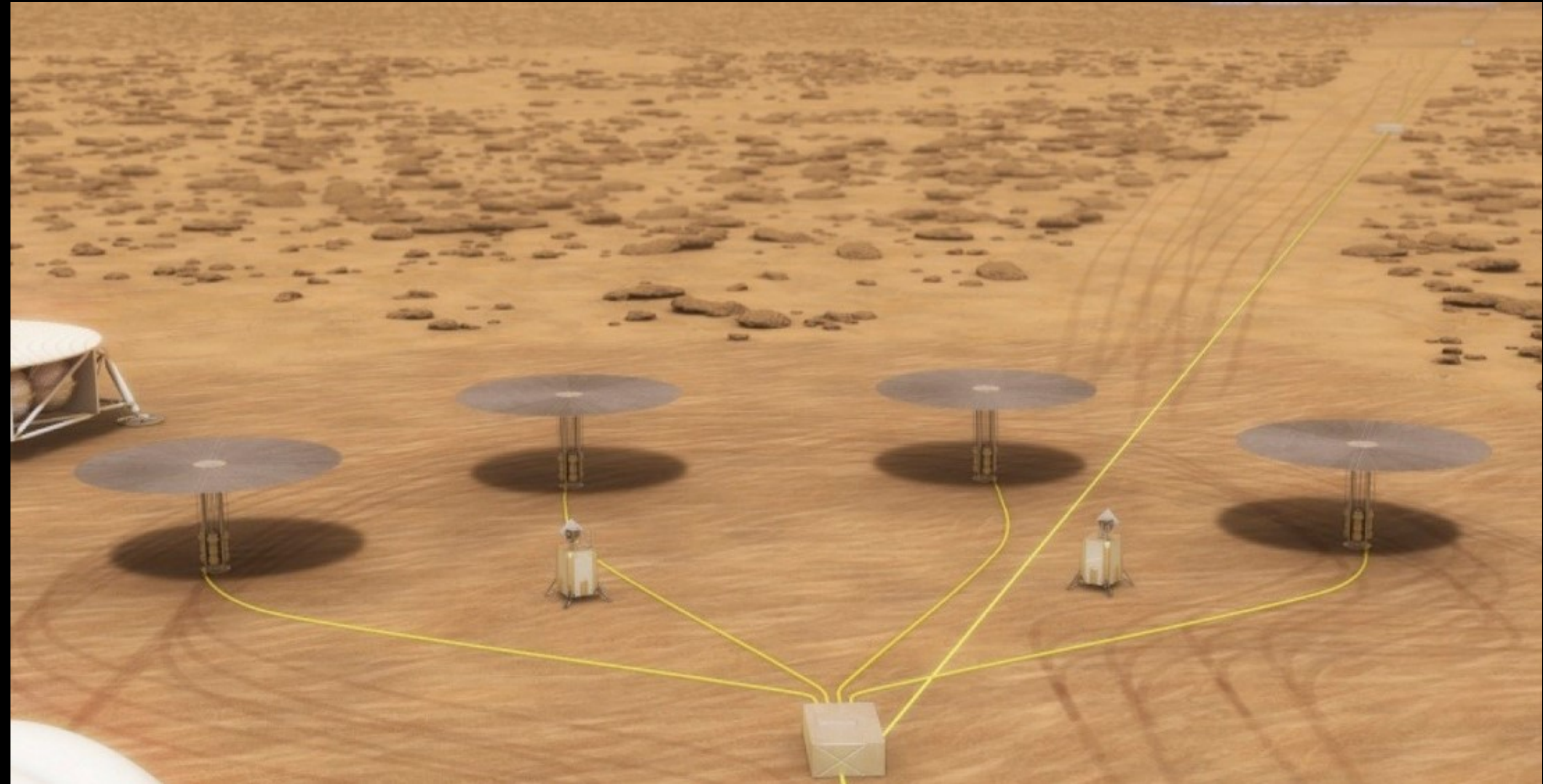
Lunar surface	<p>The Chandrayaan-1 probe from ISRO hosted the NASA M3 (Moon Mineralogy Mapper) spectrometer that found water erosion on the surface of the moon.</p> <p>In August 2018 NASA confirmed that is had detected the presence of surface water ice at the lunar poles. 600 million MT estimated (c.f. Lunar Prospector NASA mission).</p>
Lunar surface	<p>Chandrayaan-2 was developed by ISRO to map the lunar surface and search for water. Consists of a rover, lander and orbiter.</p> <p>Hard landing experienced on 6 September 2019.</p> <p>The lander and rover have not responded to ISRO and NASA attempts at communication. The orbiter will continue its seven year mission.</p>

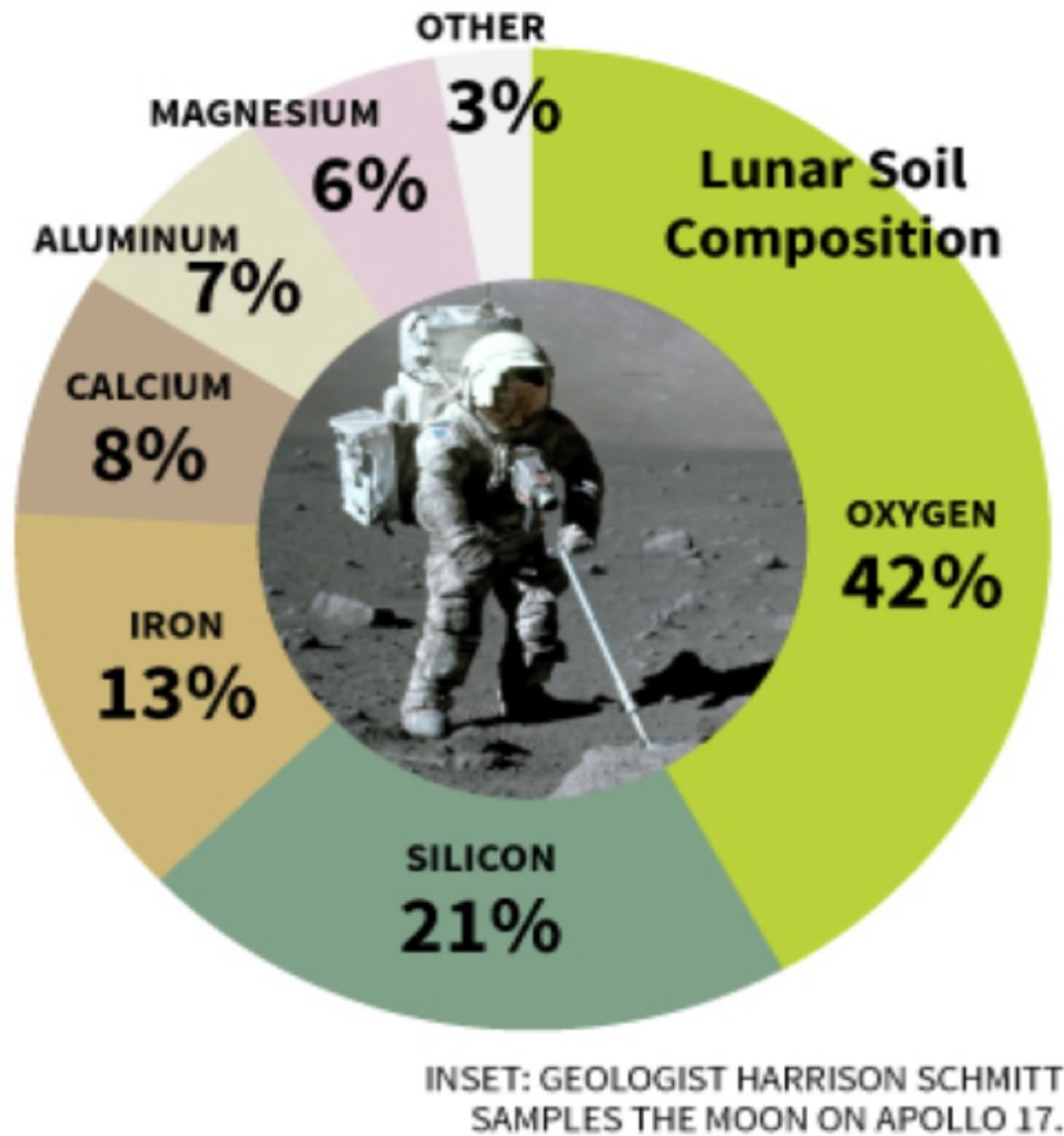


Source: ISRO

NASA Kilopower

The Kilopower Reactor Using Stirling Technology (KRUSTY) was demonstrated on earth in 2018. 10kW for 10 years. Designed to allow ISRU to produce local propellants.





source space.com

The most abundant elements are oxygen and silicon on the lunar surface.

Concrete, metals, fibreglass, silica glass, ceramics and Helium-3.

Such a rich and diverse source is sufficient allow the construction of surface shelters.

China	2019: Chang'e 4 landed on far side of the moon. Yutu-2 rover has so far traveled 289 meters across the Von Kármán crater.
	2020: Chang'e 5 and 6 will be 2kg sample return missions.
	Chang'e 7 will survey the south pole.
	Chang'e 8 start of lunar base by the south pole, whilst collaborating with ESA (US policy excludes cooperation).

**NASA
NextSTEP-2**

NextSTEP-2 includes all steps from mission definition to in-space evaluation.

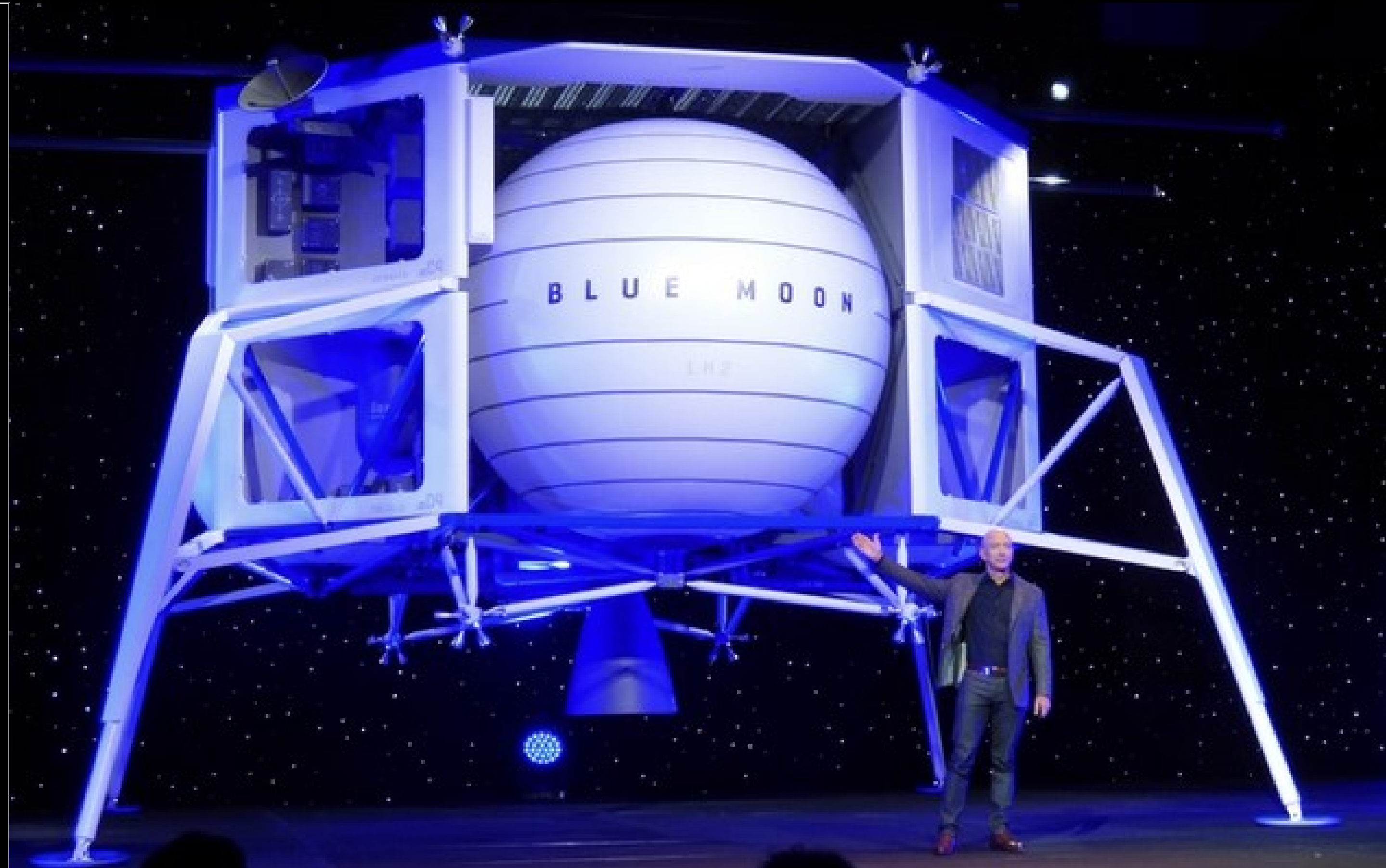
NASA has also opened a call for Artemis lunar landers. Sending of the first woman and next man to the moon by 2024.



Source: NASA

Blue Origin

Blue Origin (Jeff Bezos) is partnering with OHB and MT Aerospace on the Blue Moon cargo ship.



Source: Jeff Foust

Bigelow
Aerospace

Olympus is a concept for a large space station, 2250 m³ volume.

NASA also funding Boeing, SNC, Northrop Grumman, Lockheed Martin.



Source: Reuters

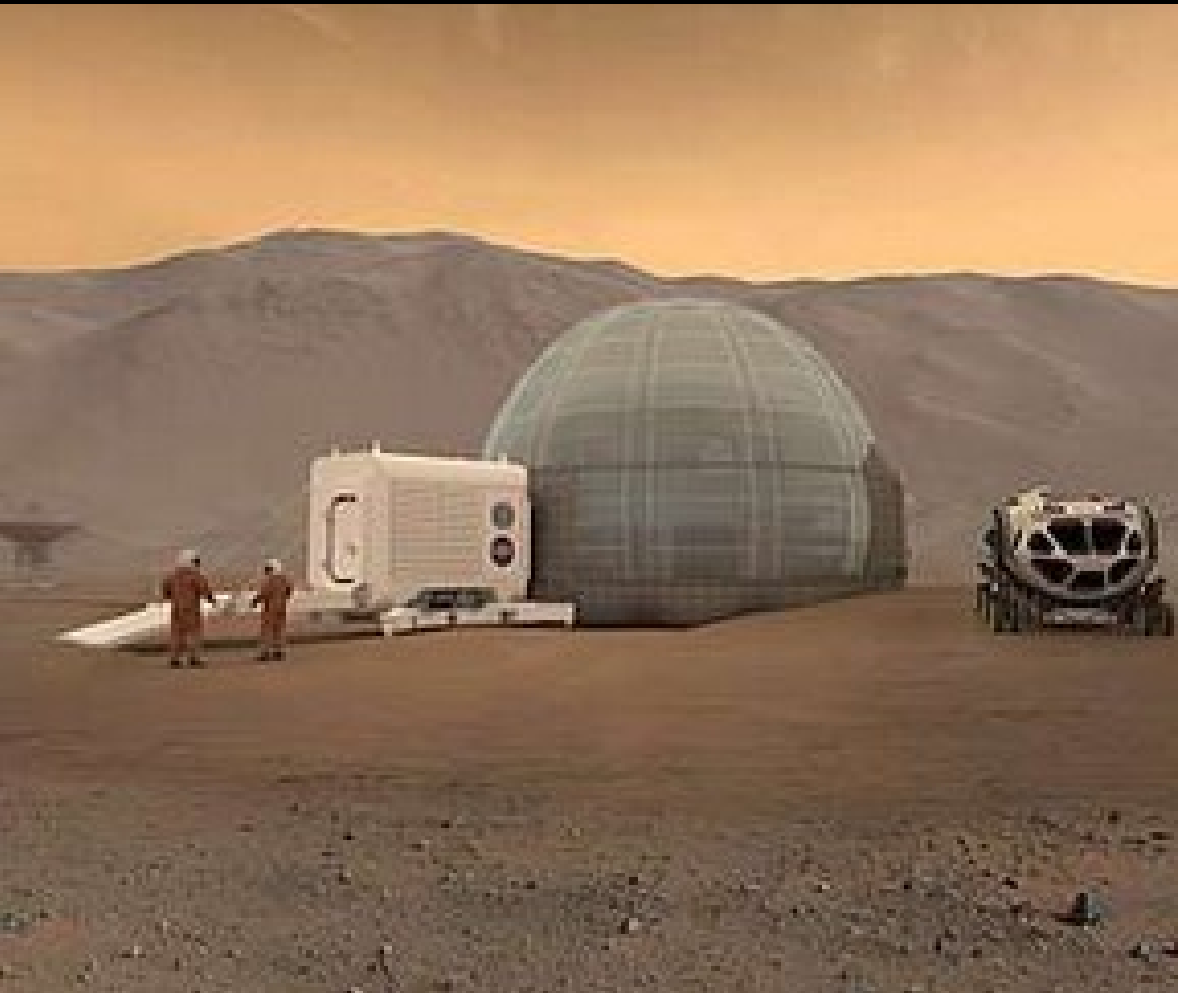
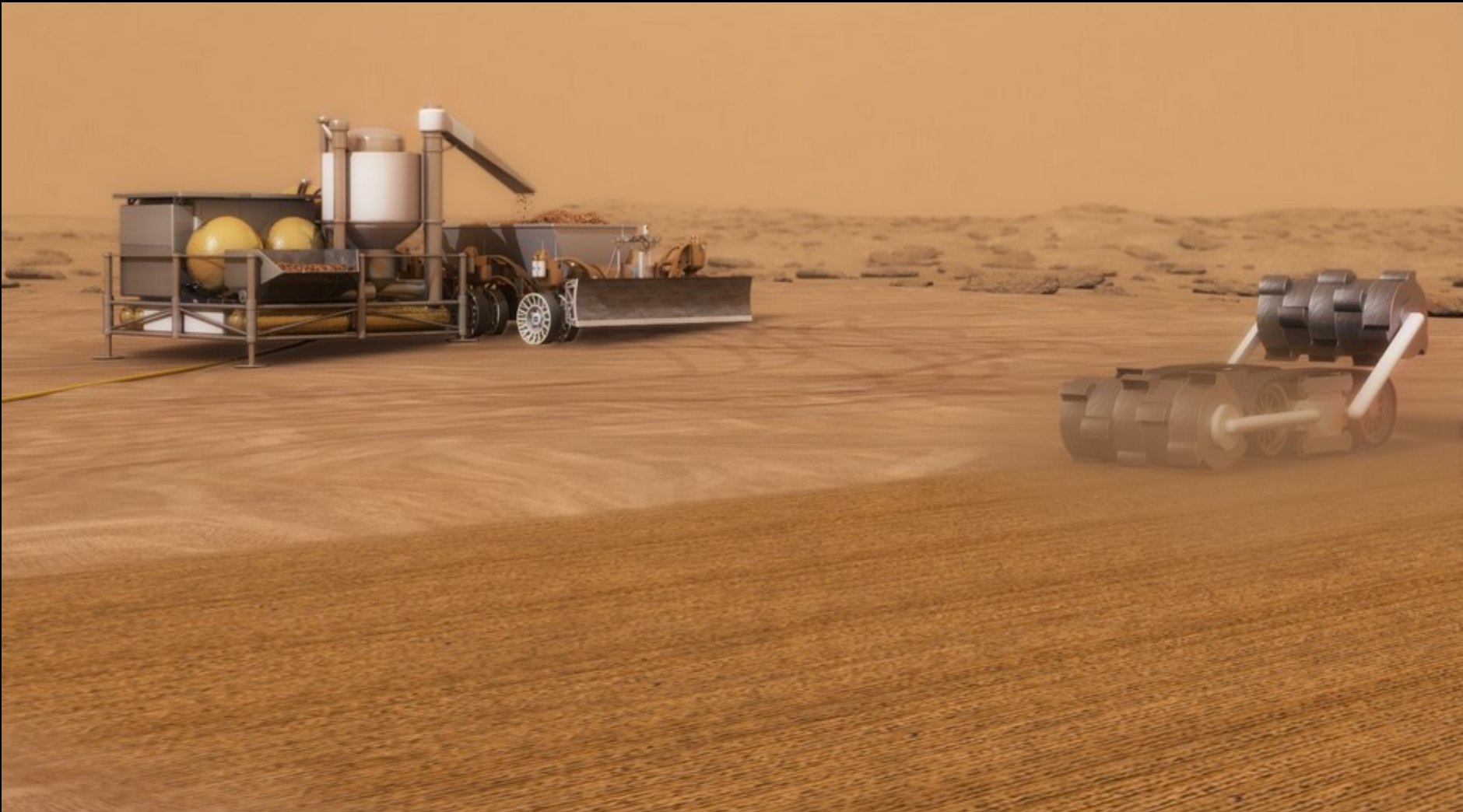
NASA
+
Space-X
+
China

Many early-stage projects.
This one shows water extraction.

STPI report \$217B thru 2037 for
SLS, Orion, Gateway and DST.

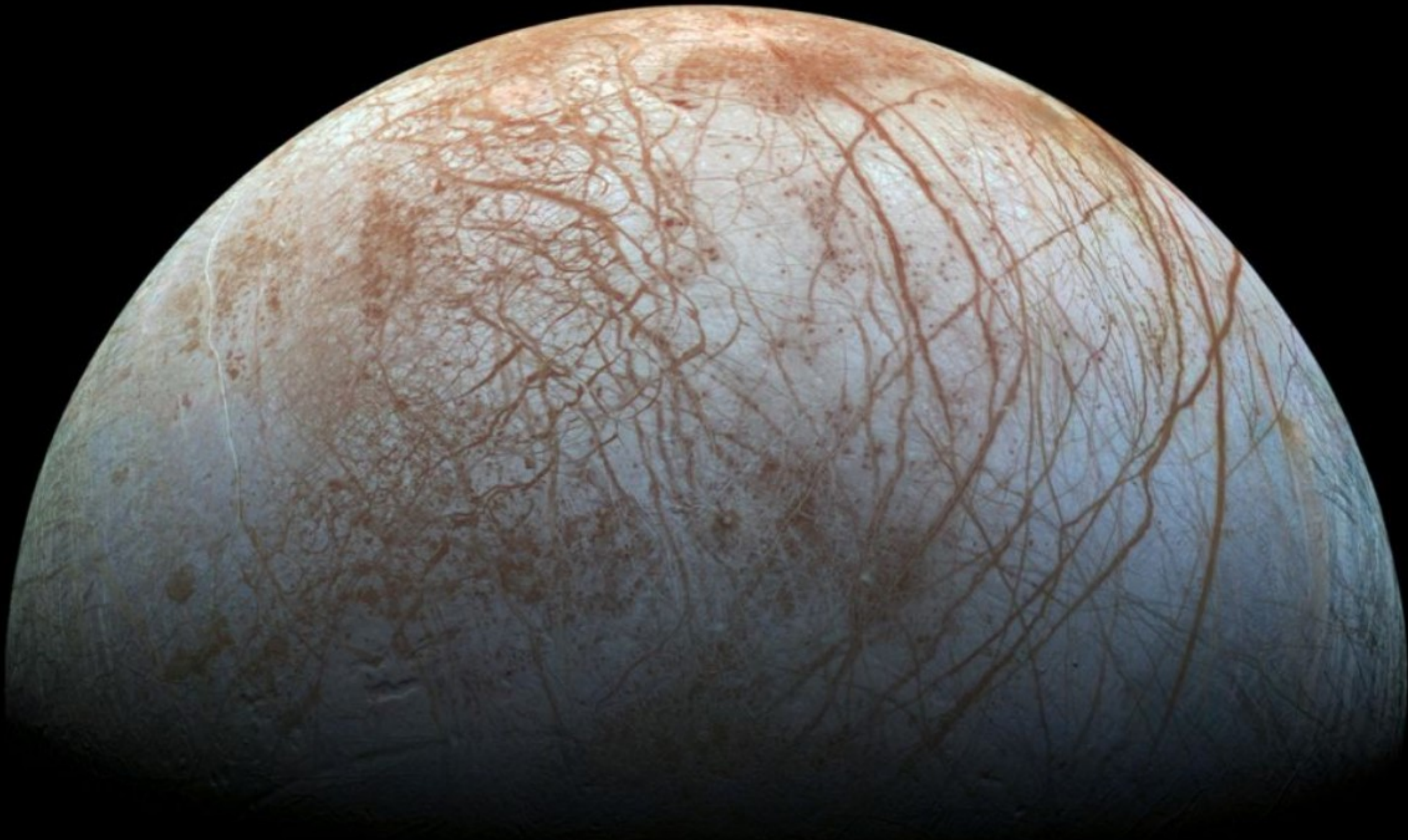
NASA prizes, \$700K for 3D
habitat printing.

Space-X Starship.



Source: NASA

ESA	<p>ESA JUICE mission will investigate the moons of Jupiter.</p> <p>Europa has a water ocean beneath the surface ice. More water than the Earth.</p> <p>Saturn’s moons Titan and Enceladus are also potentially inhabitable.</p>
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Thank You.

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