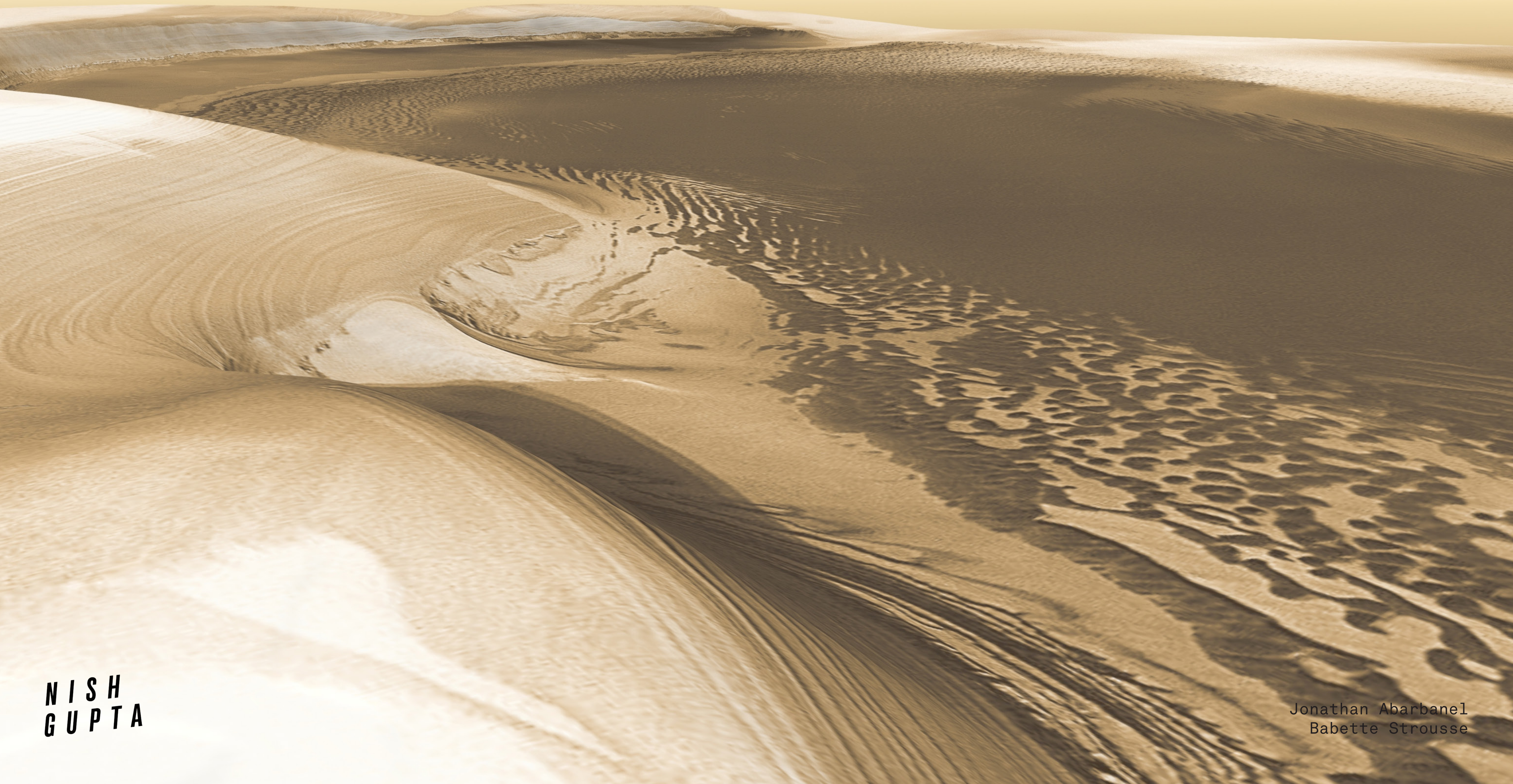
Research Summary

Mars - Secondary research



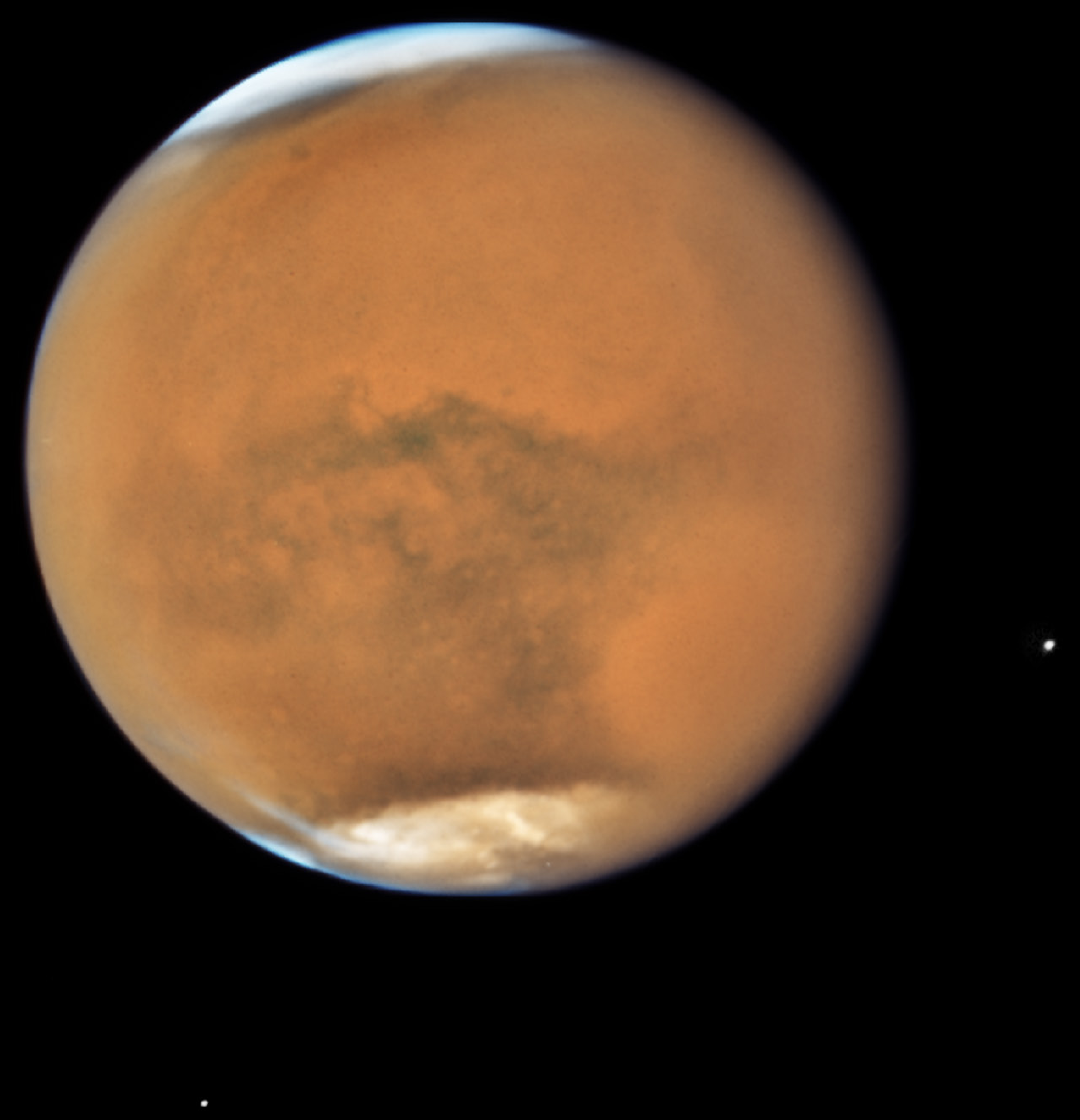
NISH GUPTA

Jonathan Abarbanel
Babette Strousse

The Red Planet

Facts.

1. Surface Area: 0.284 Earths
2. Mass: 0.107 Earths
3. Surface gravity: 0.3794 g
4. Surface pressure: 0.00628 atm
5. 95.97% carbon dioxide
   1.93% argon
   1.89% nitrogen
   0.146% oxygen
   0.0557% carbon
6. Days length: 24 hours, 37 minutes
7. Year length: 687 Earth days
8. Average surface Temp.: -81 degrees F
   (-63 degrees C)
9. Iron oxide prevalent on its surface
   gives it a reddish appearance



Why Mars?

150 scientific rational reasons

1. 90 day rover mission in 20 minutes. or 6months vs 2 hours.
2. Understand the biological relationship between Earth, Mars
3. Is there past or present alien life on Mars?
4. What happened on Mars? Catastrophic climate change.
5. Ice on Mars can speak history.
6. Humans become a two planet species.

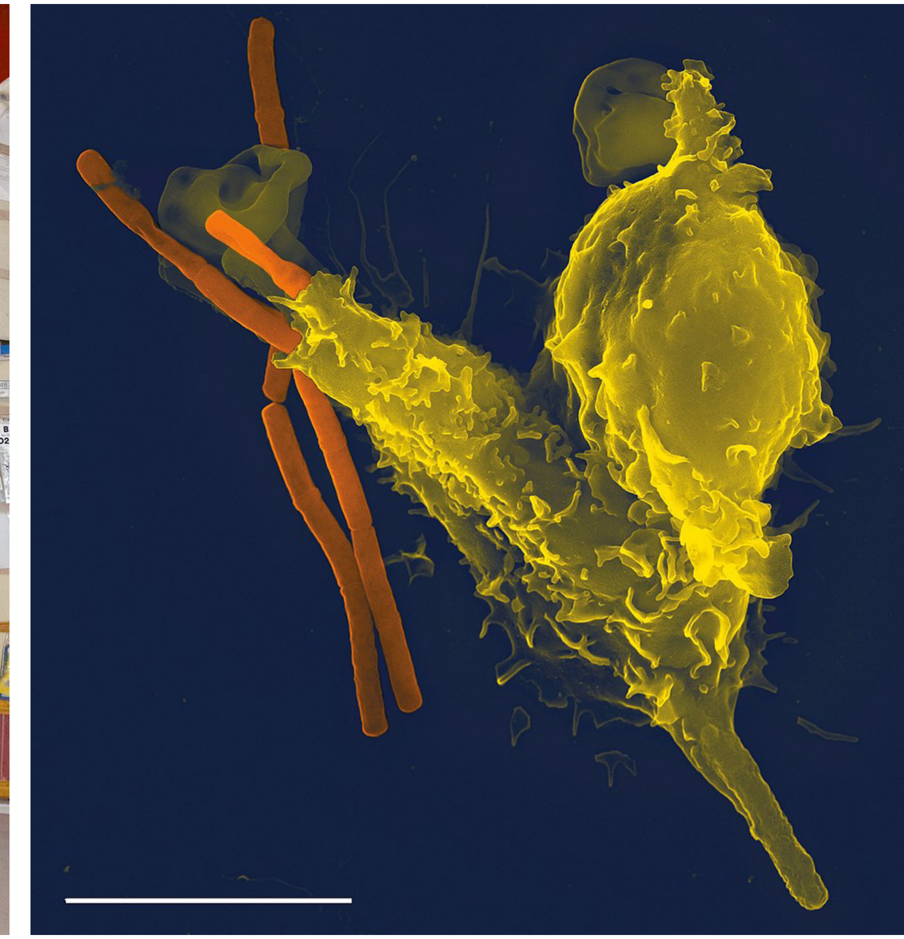
https://www.youtube.com/watch?v=YzhSmnGcSkE

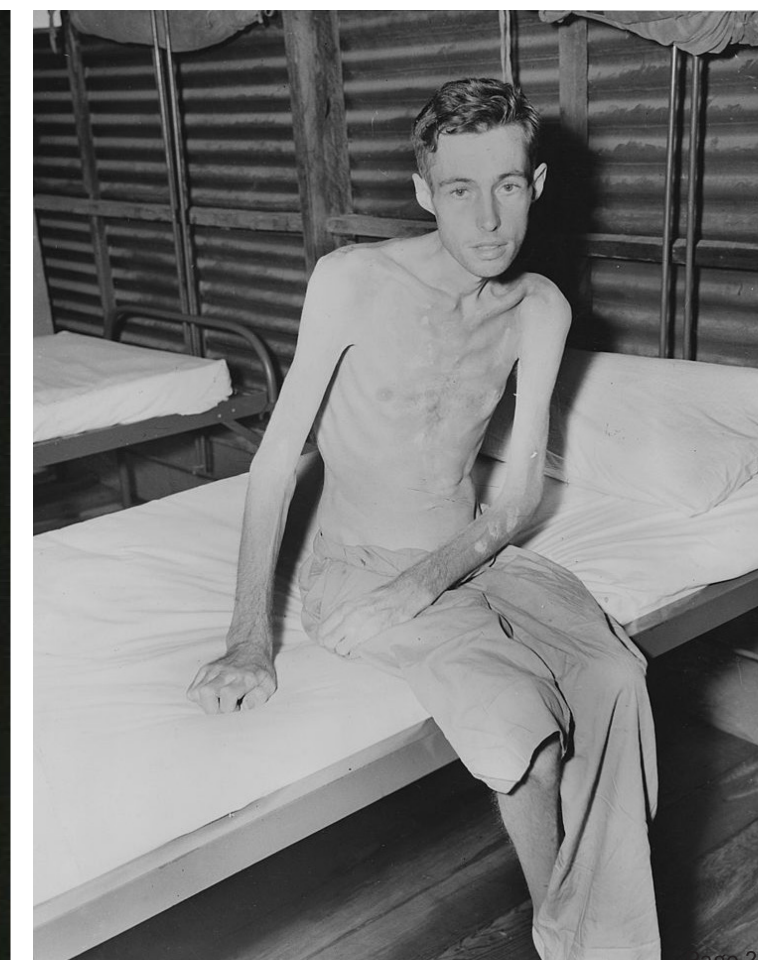
Dr. Joel Levine

Space travel complication

Humans are built for earth

Significant adverse effects of long-term weightlessness include muscle atrophy and deterioration of the skeleton, slowing of cardiovascular system functions, decreased production of red blood cells, balance disorders, eyesight disorders and changes in the immune system.





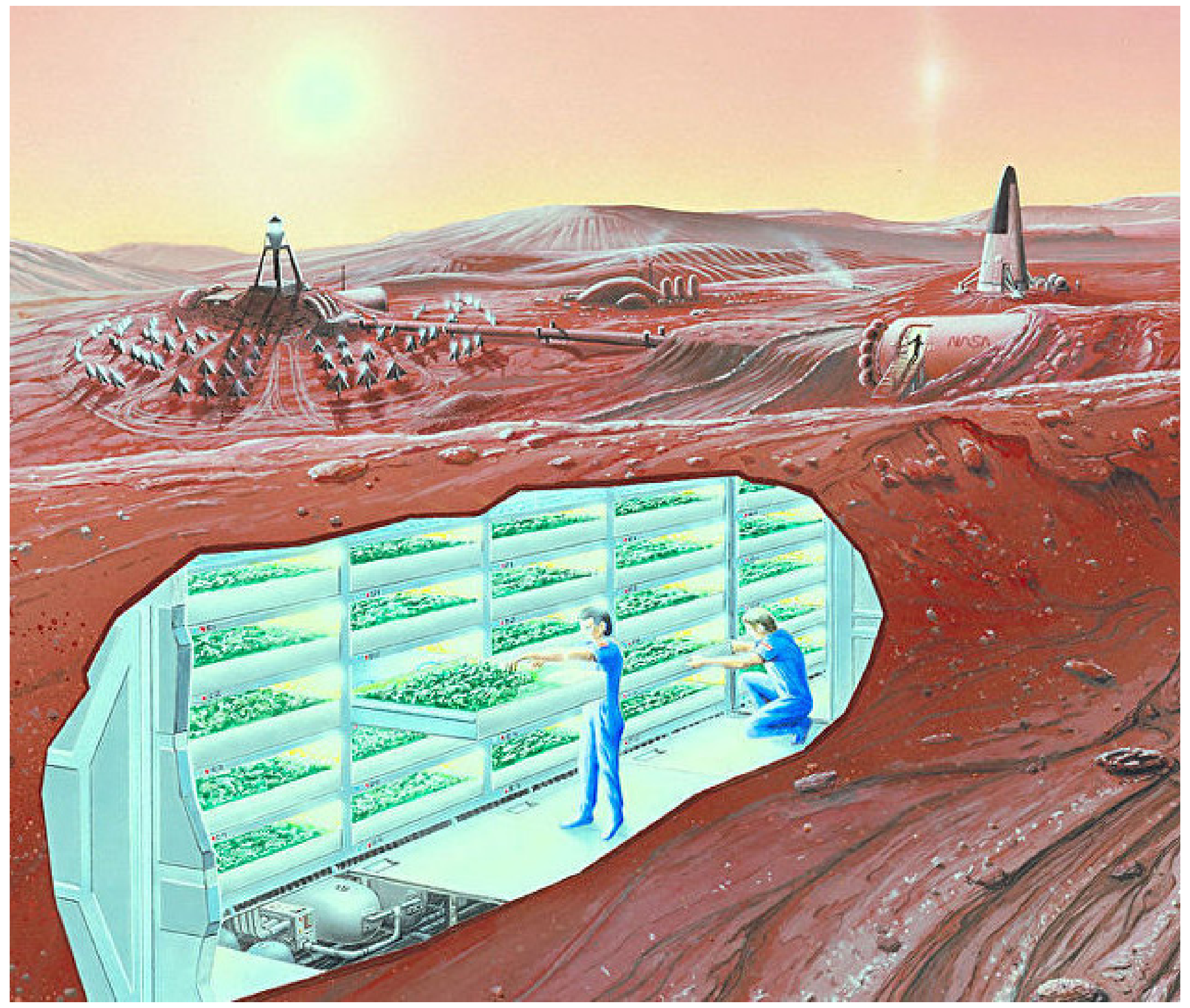
Existing Solutions

NASA Z-2 Suit

Certain radiations in space can penetrate human body and even metals like aluminium. Therefore many space suits use lead as a protective coating from harmful radiations. But space suits are usually heavy and restricts mobility

https://www.nasa.gov/feature/the-next-generation-of-suit-technologies/

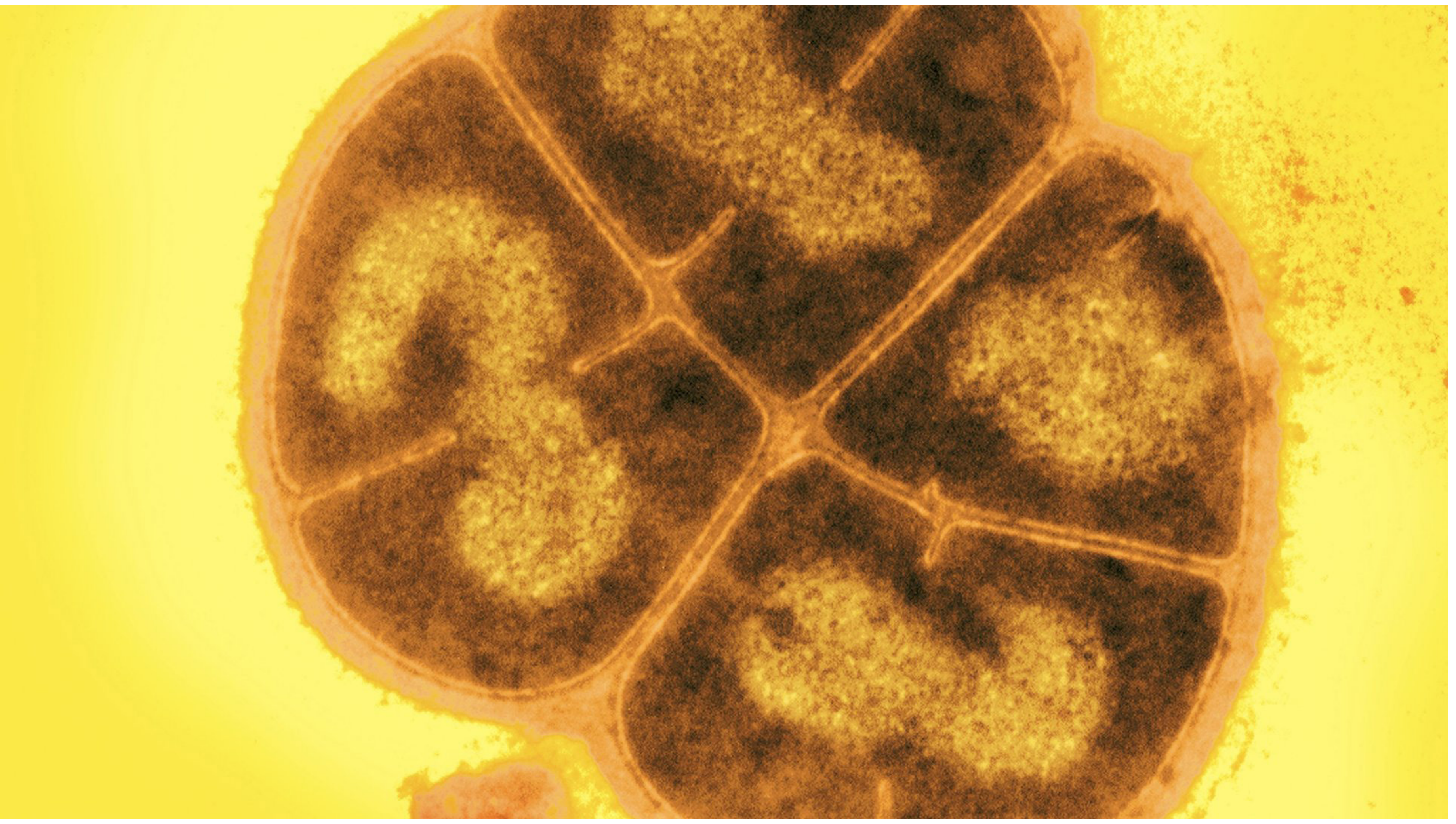
Underground Shelters



underground caves created by volcanic activity on Mars could be large enough to house even underground towns. The "lava tubes" could, be excellent hidden locations for future human habitats.

https://www.spaceflightinsider.com/missions/human-spaceflight/underground-towns-moon-mars-future-human-habitats-hidden-lava-tubes/

Synthetic Biology

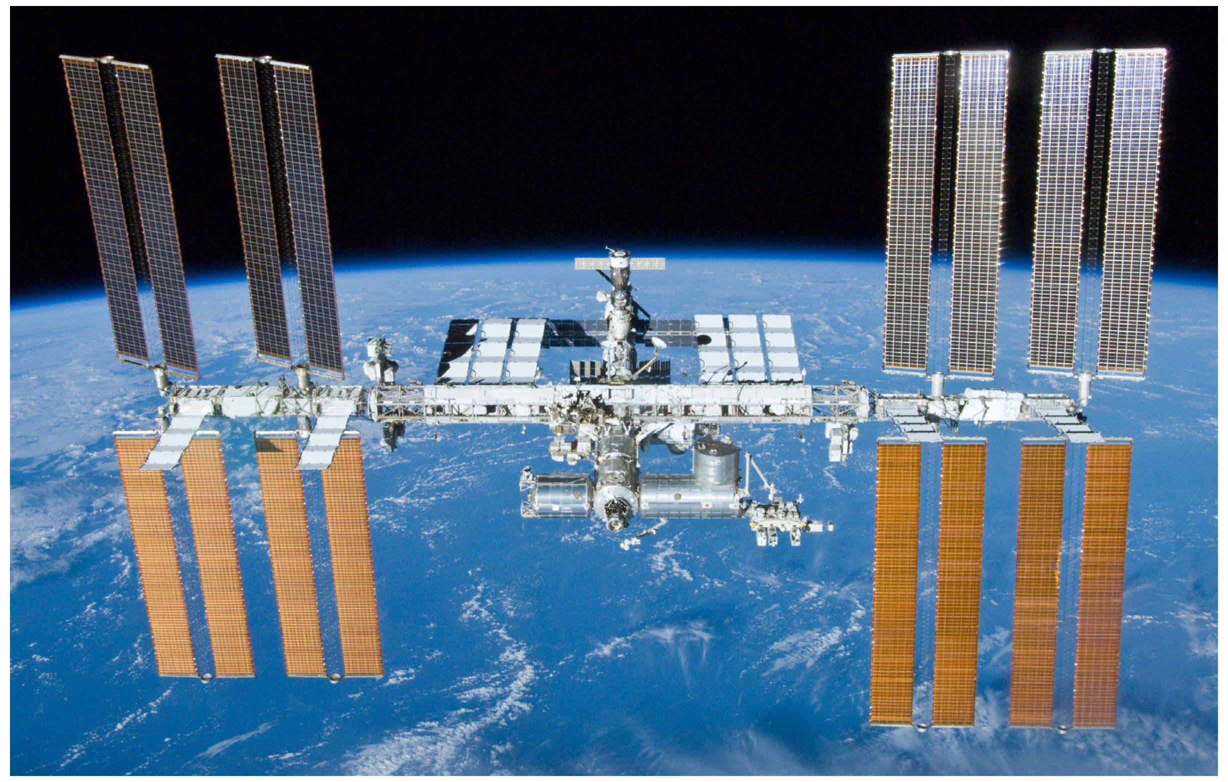


Genetically engineered humans for long space travel. Inspired from organisms on earth. Example- Deinococcus Radiodurans, an bacterium that has high resistance to extreme temperatures, pressure and can stay withstand radiation.

https://www.ted.com/talks/lisa_nip_how_humans_could_evolve_to_survive_in_space?referrer=playlist-what_would_it_be_like_to_live_on_another_planet

NASA’s Plan

Earth Reliant



Testing technologies and advancing human health and performance research that will enable deep-space, long-duration missions.

•Human health and behavioural research
•Advanced communications systems
•Environmental control and life support systems
•3-D printing
•Material handling tests

Proving Ground

NASA will learn to conduct complex operations in a deep space environment that allows crews to return to Earth in a matter of days. NASA will advance and validate capabilities required for human exploration of Mars.

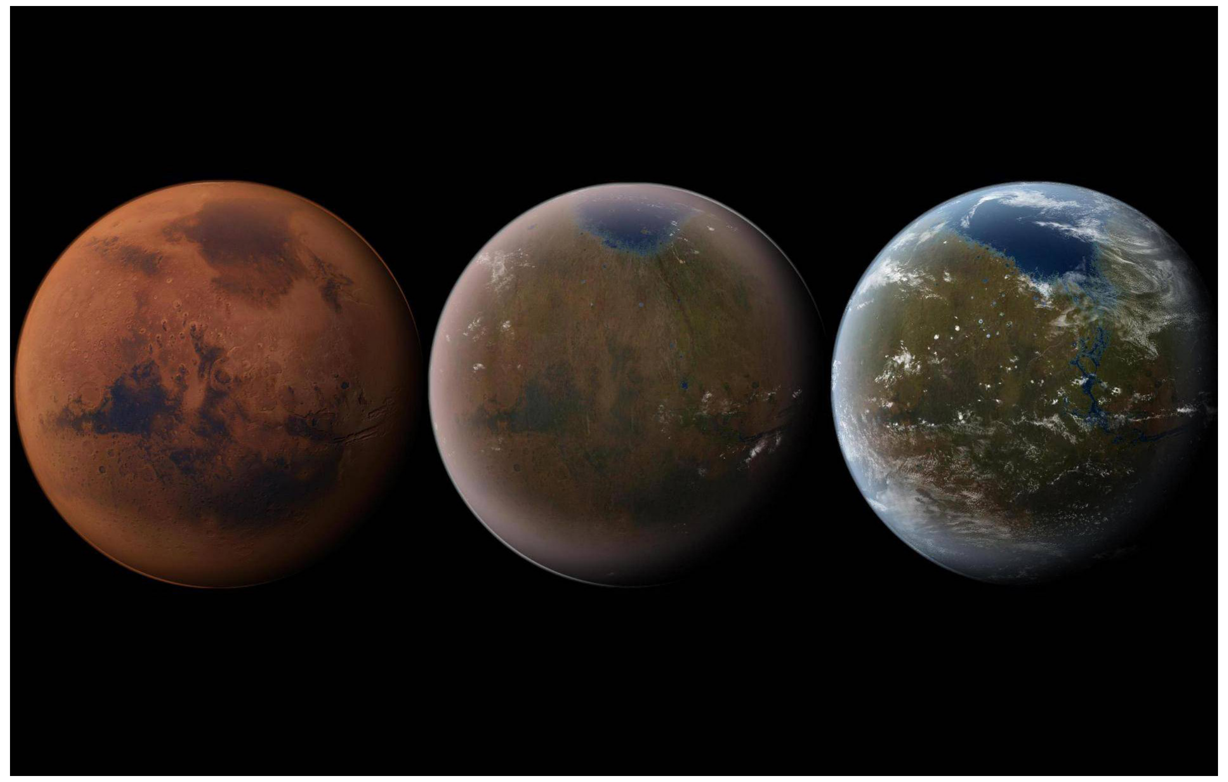
•The Asteroid Redirect Robotic Mission in 2020 that will collect a large boulder from a near-Earth asteroid.
•An initial deep-space habitation facility for longduration system testing
•Autonomous operations, including rendezvous and docking.
•Concepts to minimize resupply needs through reduction, reuse, and recycling of consumables, packaging, and materials.
•Other key operational capabilities required to become Earth Independent.

Earth Independent

Earth Independent activities build on what we learn on ISS and in cislunar space to enable human missions to the Mars vicinity, including the Martian moons, eventually the Martian surface.

•Living and working within transit and surface habitats that support human life for years, with only routine maintenance
•Harvesting Martian resources to create fuel, water, oxygen, and building materials
•Leveraging advanced communication systems to relay data and results from science and exploration excursions with a 20-minute delay

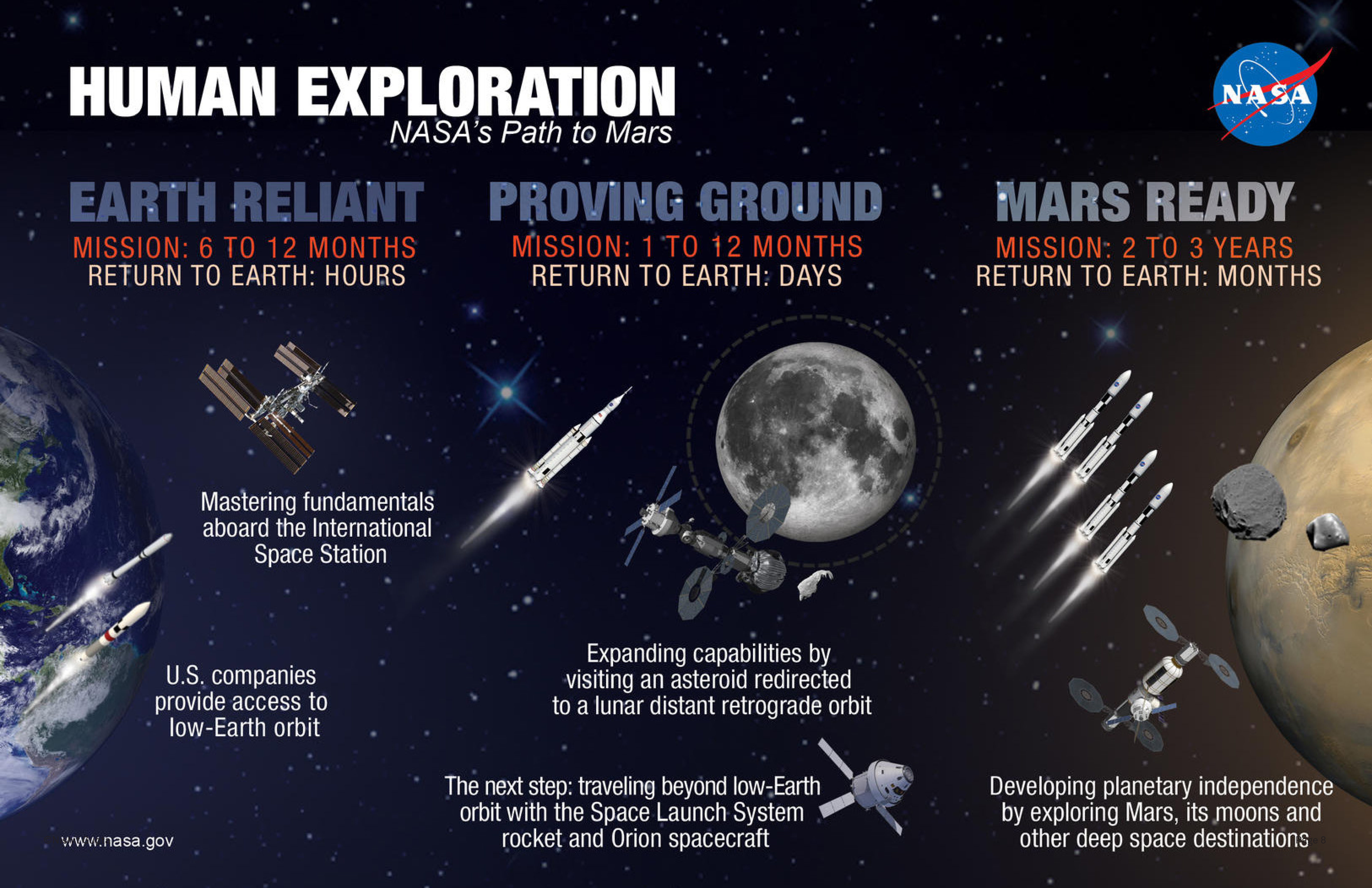
Mars Reliant



After humans successfully land on Mars and perform necessary scientific tests, they have to start terraforming the planet for future human travel.

•Heating Martian surface, producing green-house gasses will raise Martian temperature to that close to Earth’s.
•Fulfill basic needs of food and water
•Environment that is self-sustainable

https://www.nasa.gov/content/nasas-journey-to-mars

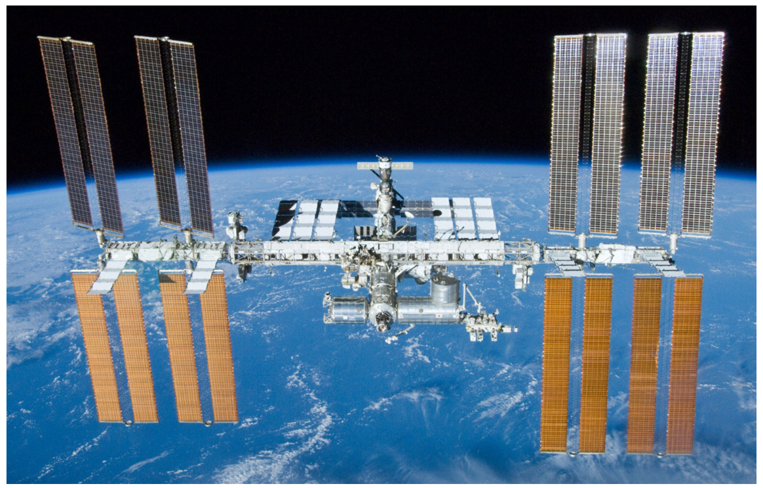

HUMAN EXPLORATION
NASA's Path to Mars
NASA
EARTH RELIANT
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS
PROVING GROUND
MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS
MARS READY
MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS
Mastering fundamentals aboard the International Space Station
U.S. companies provide access to low-Earth orbit
Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit
The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft
Developing planetary independence by exploring Mars, its moons and other deep space destinations
www.nasa.gov

Spacecraft	Launch Date	Operator	Mission[1]	Outcome[2]	Remarks	Carrier rocket[3]
1M No.1	10 October 1960	OKB-1 Soviet Union	Flyby	Launch failure	Failed to orbit	Molniya
1M No.2	14 October 1960	OKB-1 Soviet Union	Flyby	Launch failure	Failed to orbit	Molniya
2MV-4 No.1	24 October 1962	Soviet Union	Flyby	Launch failure	Booster stage ("Block L") disintegrated in LEO	Molniya
Mars 1 (2MV-4 No.2)	1 November 1962	Soviet Union	Flyby	Spacecraft failure	Communications lost before flyby	Molniya
2MV-3 No.1	4 November 1962	Soviet Union	Lander	Launch failure	Never left LEO	Molniya
Mariner 3	5 November 1964	NASA United States	Flyby	Launch failure	Payload fairing failed to separate	Atlas LV-3 Agena-D
Mariner 4	28 November 1964	NASA United States	Flyby	Successful	**The first flyby of Mars** on 15 July 1965	Atlas LV-3 Agena-D
Zond 2 (3MV-4A No.2)	30 November 1964	Soviet Union	Flyby	Spacecraft failure	Communications lost before flyby	Molniya
Mariner 6	25 February 1969	NASA United States	Flyby	Successful		Atlas SLV-3C Centaur-D
2M No.521 (1969A)[4]	27 March 1969	Soviet Union	Orbiter	Launch failure	Failed to orbit	Proton-K/D
Mariner 7	27 March 1969	NASA United States	Flyby	Successful		Atlas SLV-3C Centaur-D
2M No.522 (1969B)[4]	2 April 1969	Soviet Union	Orbiter	Launch failure	Failed to orbit	Proton-K/D
Mariner 8	9 May 1971	NASA United States	Orbiter	Launch failure	Failed to orbit	Atlas SLV-3C Centaur-D
Kosmos 419 (3MS No.170)	10 May 1971	Soviet Union	Orbiter	Launch failure	Never left LEO; booster stage burn timer set incorrectly	Proton-K/D
Mars 2 (4M No.171)	19 May 1971	Soviet Union	Orbiter	Successful	Entered orbit on 27 November 1971, operated for 362 orbits[5]	Proton-K/D
Mars 2 lander (SA 4M No.171)	19 May 1971	Soviet Union	Lander	Spacecraft failure	Deployed from Mars 2, failed to land during attempt on 27 November 1971	Proton-K/D
Mars 3 (4M No.172)	28 May 1971	Soviet Union	Orbiter	Successful	Entered orbit on 2 December 1971, operated for 20 orbits[6][7]	Proton-K/D
Mars 3 lander (SA 4M No.172)	28 May 1971	Soviet Union	Lander	Partial failure	**The first lander on Mars**, landed on 2 December 1971; contact lost 14.5 seconds after transmission start	Proton-K/D
Prop-M Rover rover (SA 4M No.172)	28 May 1971	Soviet Union	Rover	Spacecraft failure	Failed to deploy	Proton-K/D
Mariner 9	30 May 1971	NASA United States	Orbiter	Successful[8]	**The first orbiter of Mars.** Entered orbit on 14 November 1971, deactivated 516 days after entering orbit	Atlas SLV-3C Centaur-D
Mars 4 (3MS No.52S)	21 July 1973	Soviet Union	Orbiter	Spacecraft failure	Failed to perform orbital insertion burn	Proton-K/D
Mars 5 (3MS No.53S)	25 July 1973	Soviet Union	Orbiter	Partial failure	Failed after 9 days in Mars orbit; returned 180 frames	Proton-K/D
Mars 6 (3MP No.50P)	5 August 1973	Soviet Union	Lander Flyby	Spacecraft failure	Contact lost upon landing, atmospheric data mostly unreadable. Flyby bus collected data.[9]	Proton-K/D
Mars 7 (3MP No.51P)	9 August 1973	Soviet Union	Lander Flyby	Spacecraft failure	Separated from coast stage prematurely, failed to enter Martian atmosphere	Proton-K/D
Viking 1 orbiter	20 August 1975	NASA United States	Orbiter	Successful	Operated for 1385 orbits	Titan IIIE Centaur-D1T
Viking 1 lander	20 August 1975	NASA United States	Lander	Successful	**The first lander successfully returning data**, deployed from *Viking 1* orbiter, operated for 2245 sols	Titan IIIE Centaur-D1T
Viking 2 orbiter	9 September 1975	NASA United States	Orbiter	Successful	Operated for 700 orbits	Titan IIIE Centaur-D1T
Viking 2 lander	9 September 1975	NASA United States	Lander	Successful	Deployed from *Viking 2* orbiter, operated for 1281 sols (11 Apr 1980)	Titan IIIE Centaur-D1T
Phobos 1 (1F No.101)	7 July 1988	Soviet Union	Orbiter Phobos lander	Spacecraft failure	Communications lost before reaching Mars; failed to enter orbit	Proton-K/D-2
Phobos 2 (1F No.102)	12 July 1988	Soviet Union	Orbiter Phobos lander	Partial failure	Orbital observations successful, communications lost before landing	Proton-K/D-2
Mars Observer	25 September 1992	NASA United States	Orbiter	Spacecraft failure	Lost communications before orbital insertion	Commercial Titan III
Mars Global Surveyor	7 November 1996	NASA United States	Orbiter	Successful	Operated for seven years	Delta II 7925
Mars 96 (M1 No.520) (Mars-8)[4]	16 November 1996	Rosaviakosmos Russia	Orbiter Penetrators	Launch failure	Never left LEO	Proton-K/D-2
Mars Pathfinder	4 December 1996	NASA United States	Lander	Successful	Landed at 19.13°N 33.22°W on 4 July 1997[10]	Delta II 7925
Sojourner	4 December 1996	NASA United States	Rover	Successful	**The first rover on another planet**, operated for 84 days[11]	Delta II 7925
Nozomi (PLANET-B)	3 July 1998	ISAS Japan	Orbiter	Spacecraft failure	Ran out of fuel before reaching Mars	M-V
Mars Climate Orbiter	11 December 1998	NASA United States	Orbiter	Spacecraft failure	Approached Mars too closely during orbit insertion attempt due to unit conversion error and burned up in the atmosphere	Delta II 7425
Mars Polar Lander	3 January 1999	NASA United States	Lander	Spacecraft failure	Failed to land	Delta II 7425
Deep Space 2	3 January 1999	NASA United States	Penetrator	Spacecraft failure	Deployed from MPL, no data returned	Delta II 7425
Mars Odyssey	7 April 2001	NASA United States	Orbiter	Operational	Expected to remain operational until 2025.	Delta II 7925
Mars Express	2 June 2003	ESA Europe	Orbiter	Operational	Enough fuel to remain operational until 2026.	Soyuz-FG/Fregat
Beagle 2	2 June 2003	ESA Europe	Lander	Lander failure	No communications received after release from Mars Express. Orbital images of landing site suggest a successful landing, but two solar panels failed to deploy, obstructing its communications.	Soyuz-FG/Fregat
Spirit (MER-A)	10 June 2003	NASA United States	Rover	Successful	Landed on January 4, 2004. Operated for 2208 sols	Delta II 7925
Opportunity (MER-B)	8 July 2003	NASA United States	Rover	Successful	Landed on January 25, 2004. Operated for 5351 sols	Delta II 7925H
Rosetta	2 March 2004	ESA Europe	Gravity assist	Successful	Flyby in February 2007 en route to 67P/Churyumov–Gerasimenko[12]	Ariane 5G+
Mars Reconnaissance Orbiter	12 August 2005	NASA United States	Orbiter	Operational	Entered orbit on March 10, 2006	Atlas V 401
Phoenix	4 August 2007	NASA United States	Lander	Successful	Landed on May 25, 2008. End of mission November 2, 2008	Delta II 7925
Dawn	27 September 2007	NASA United States	Gravity assist	Successful	Flyby in February 2009 en route to 4 Vesta and Ceres	Delta II 7925H
Fobos-Grunt	8 November 2011	Roskosmos Russia	Orbiter Phobos sample	Spacecraft failure	Never left LEO (intended to depart under own power)	Zenit-2M
Yinghuo-1	8 November 2011	CNSA PR China	Orbiter	Failure Lost with Fobos-Grunt	To have been deployed by Fobos-Grunt	Zenit-2M
Curiosity (Mars Science Laboratory)	26 November 2011	NASA United States	Rover	Operational	Landed on August 6, 2012	Atlas V 541
Mars Orbiter Mission (*Mangalyaan*)	5 November 2013	ISRO India	Orbiter	Operational	Entered orbit on 24 September 2014. Mission extended till 2020.[13]	PSLV-XL
MAVEN	18 November 2013	NASA United States	Orbiter	Operational	Orbit insertion on September 22, 2014[14]	Atlas V 401
ExoMars Trace Gas Orbiter	14 March 2016	ESA/Roscosmos Europe/Russia	Orbiter	Operational	Entered orbit on October 19, 2016	Proton-M/Briz-M
Schiaparelli EDM lander	14 March 2016	ESA Europe	Lander	Spacecraft failure	Carried by the ExoMars Trace Gas Orbiter. Although the lander crashed,[15][16] engineering data on the first five minutes of entry was successfully retrieved.[17][18]	Proton-M/Briz-M
InSight & MarCO	5 May 2018[19][20]	NASA United States	Lander & two CubeSats flyby	Operational	Landed on November 26, 2018.	Atlas V 401

Mars exploration

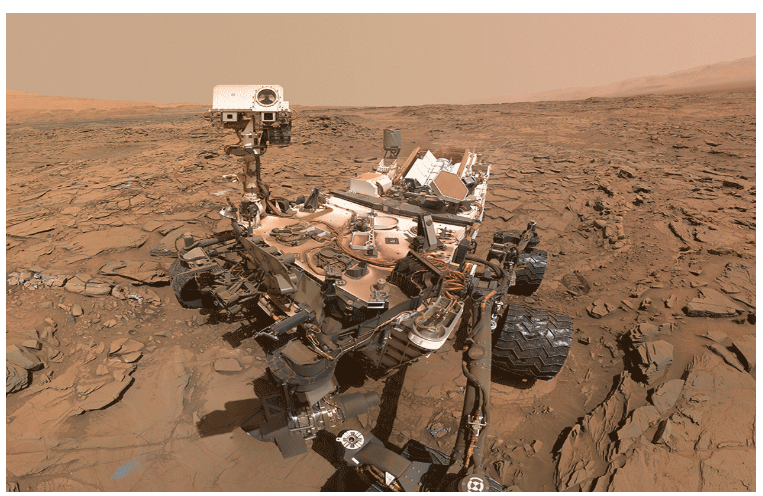
In 5 steps

Earth Reliant

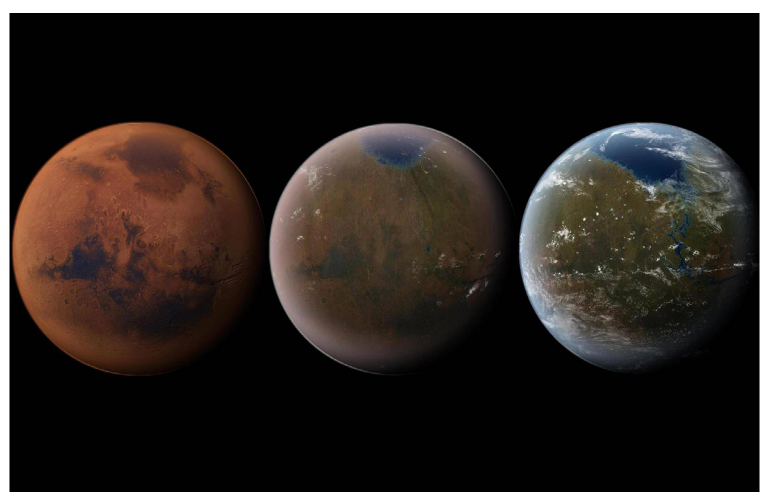


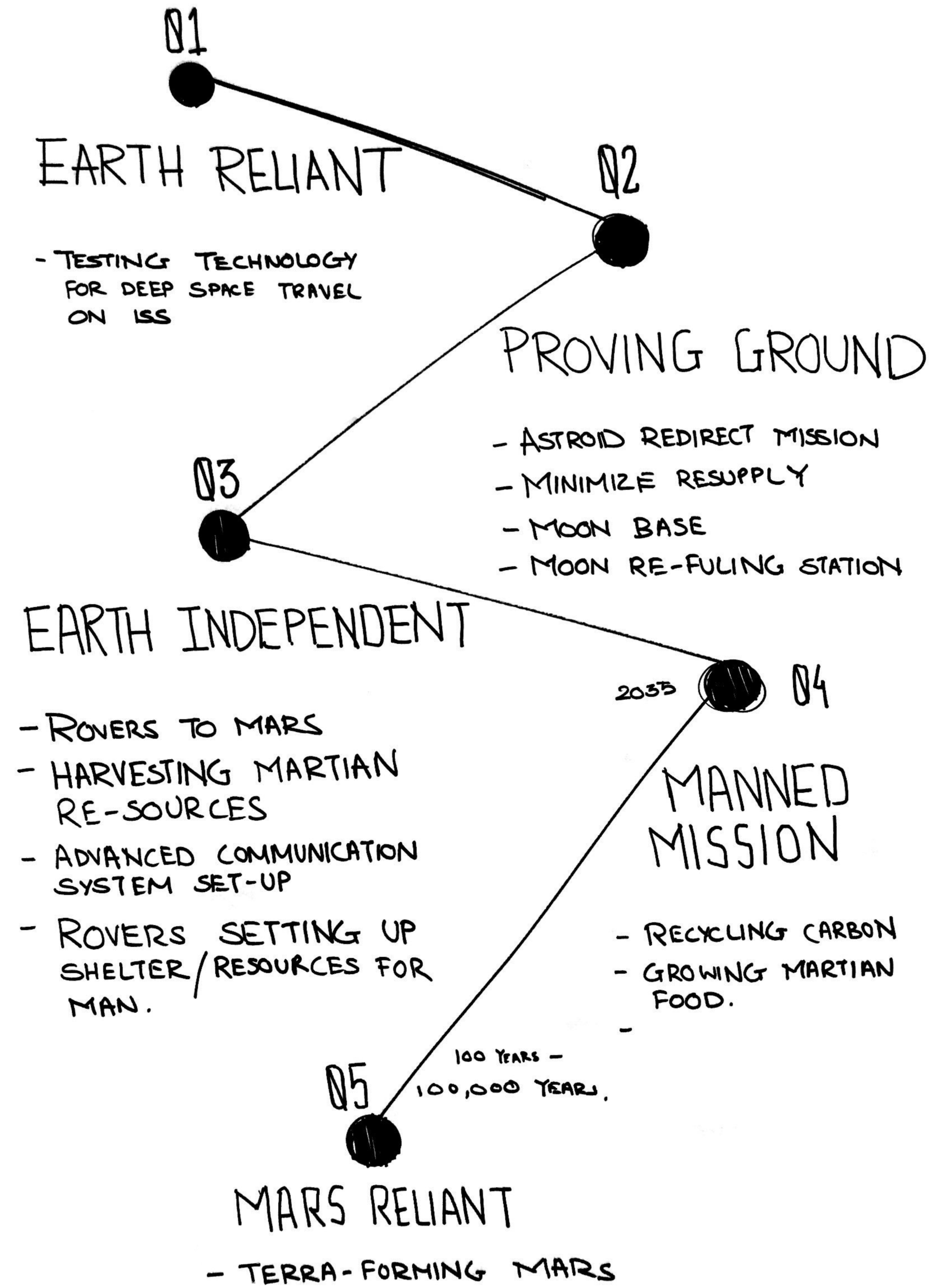
Proving Ground

Earth Independent



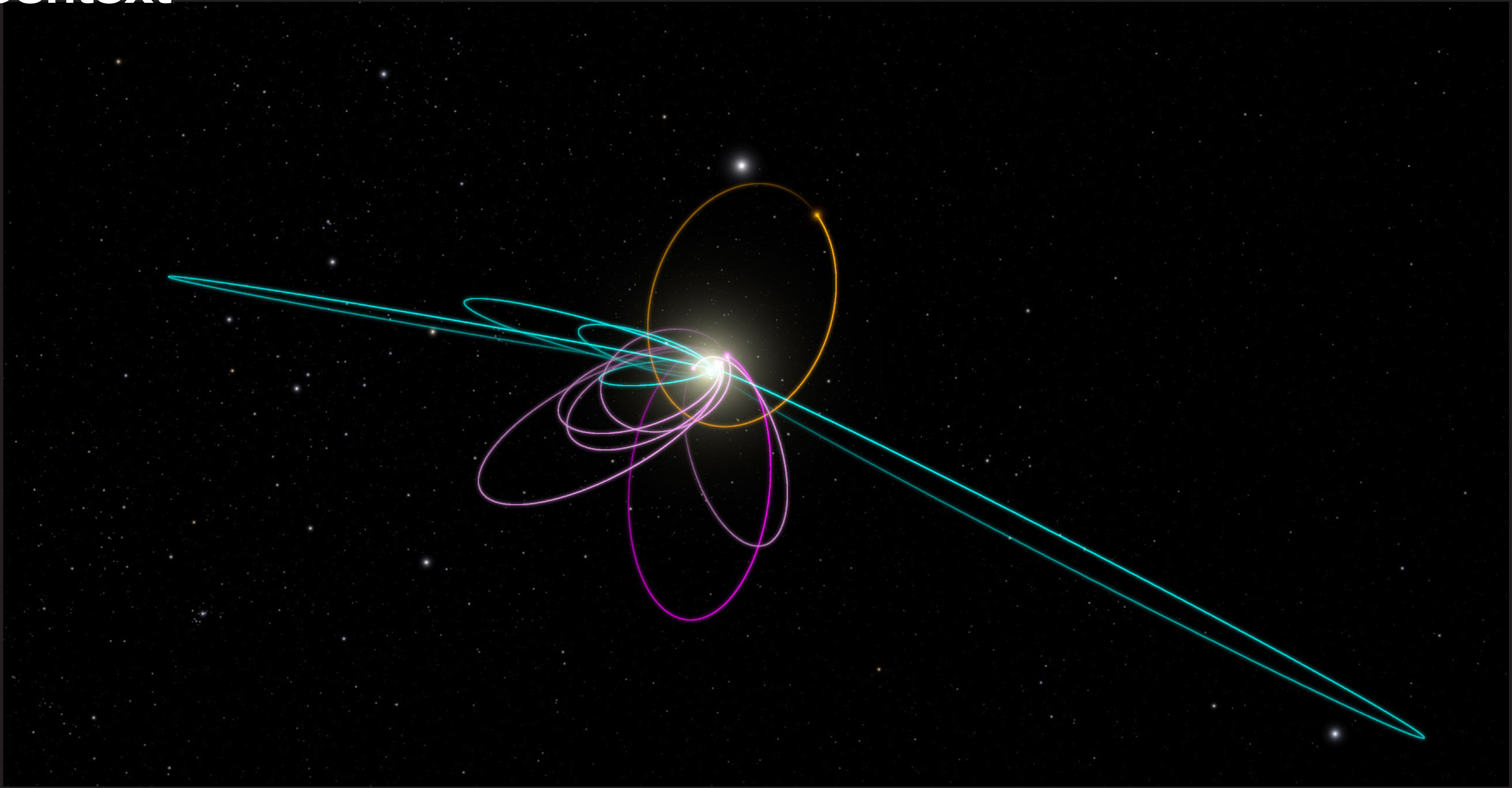
Mars Reliant





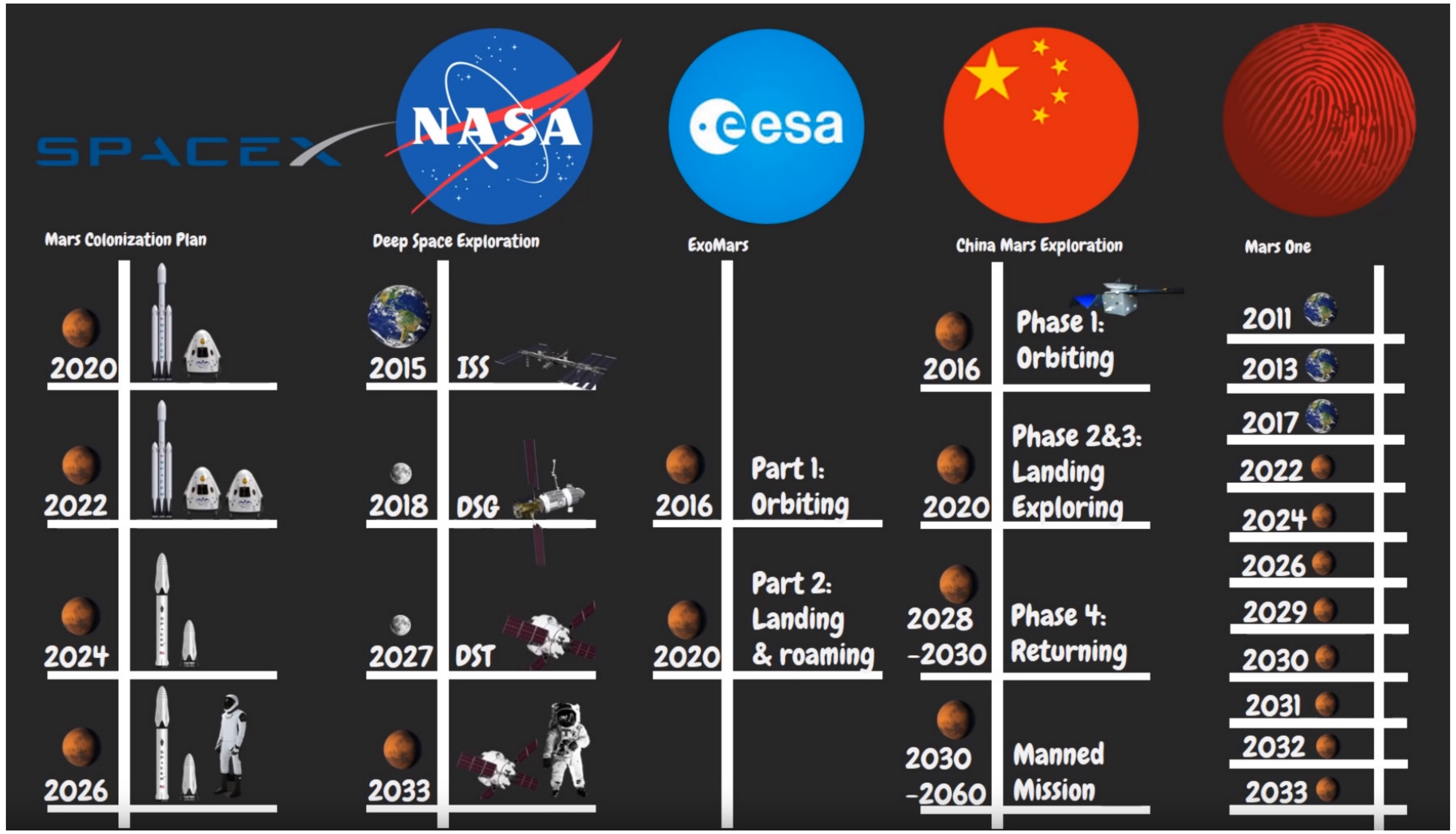
Mission	Earth Reliant Phase 1	Earth Reliant Phase 2	Earth Reliant Phase 3	Earth Dependent	Earth Independent	Mars Reliant
Year	2033	2035	2038	2040	2050	3000
Consumer	Astronauts Scientists	Astronauts Scientists	Labor Astronauts Scientists	Visitors Labor Astronauts Scientists	Government Visitors Labor Astronauts Scientists	Businesses Residents Government Visitors
Food	Earth dried food	80% Hydroponics 20% Earth dried food	100% Hydroponics with closed loop carbon cycle	100% Hydroponics with closed loop carbon cycle	100% Hydroponics Martian plants experimentation	Martian plants
Shelter	Base setup by drones. Inflatables that protect from radiation, likely to be underground.	Underground shelter in caves and lava tubes 3D printers	Buildings with Martian soil bricks. Preferably underground. 3D printers	Buildings with Martian bricks, metals and various other elements 3D printers	Martian houses on surface (closed system) Genetic changes 3D printers	Martian houses on surface (open system)
Water	Small scale de-humidifier	WAVAR	WAVAR	WAVAR	WAVAR Local techniques	Consumable Martian water
Breathing	Oxygen tanks	MOXIE	MOXIE	MOXIE	MOXIE Genetic changes	Breathable Martian atmosphere
Primal needs	Homeostasis	Homeostasis	Homeostasis Safety + Security	Homeostasis Safety + Security Love and Belonging	Homeostasis Safety + Security Love and Belonging Self Esteem	Martian needs of hierarchy
Miscellaneous	Earth equipment	Earth equipment specially designed for Mars	Earth equipment specially designed for Mars	Using Martian materials to design equipment	Using Martian materials to design equipment	Made on Mars

Context



Time

2035 vs 2045



https://www.youtube.com/watch?v=kUakut5W9WY&list=PL-lyTTg5Ycyl-LS7OBvxeNXFyAJ_I2vqJO&index=2&t=422s

Consumer

Scientist

https://www.nasa.gov/content/technolo-
gy-z-2-prototype-suit-cover-layer-design-6/#.
XOJqd8hKj-g

Tourist

Activity

Scientific vs Recreational

Food

Hydroponics

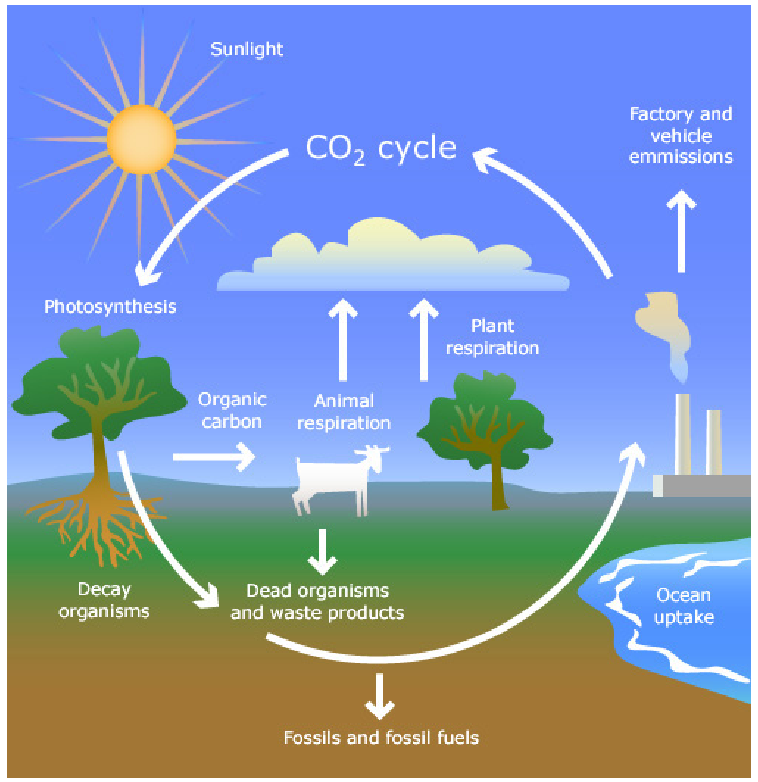
Hydroponics = growing plants without soil.

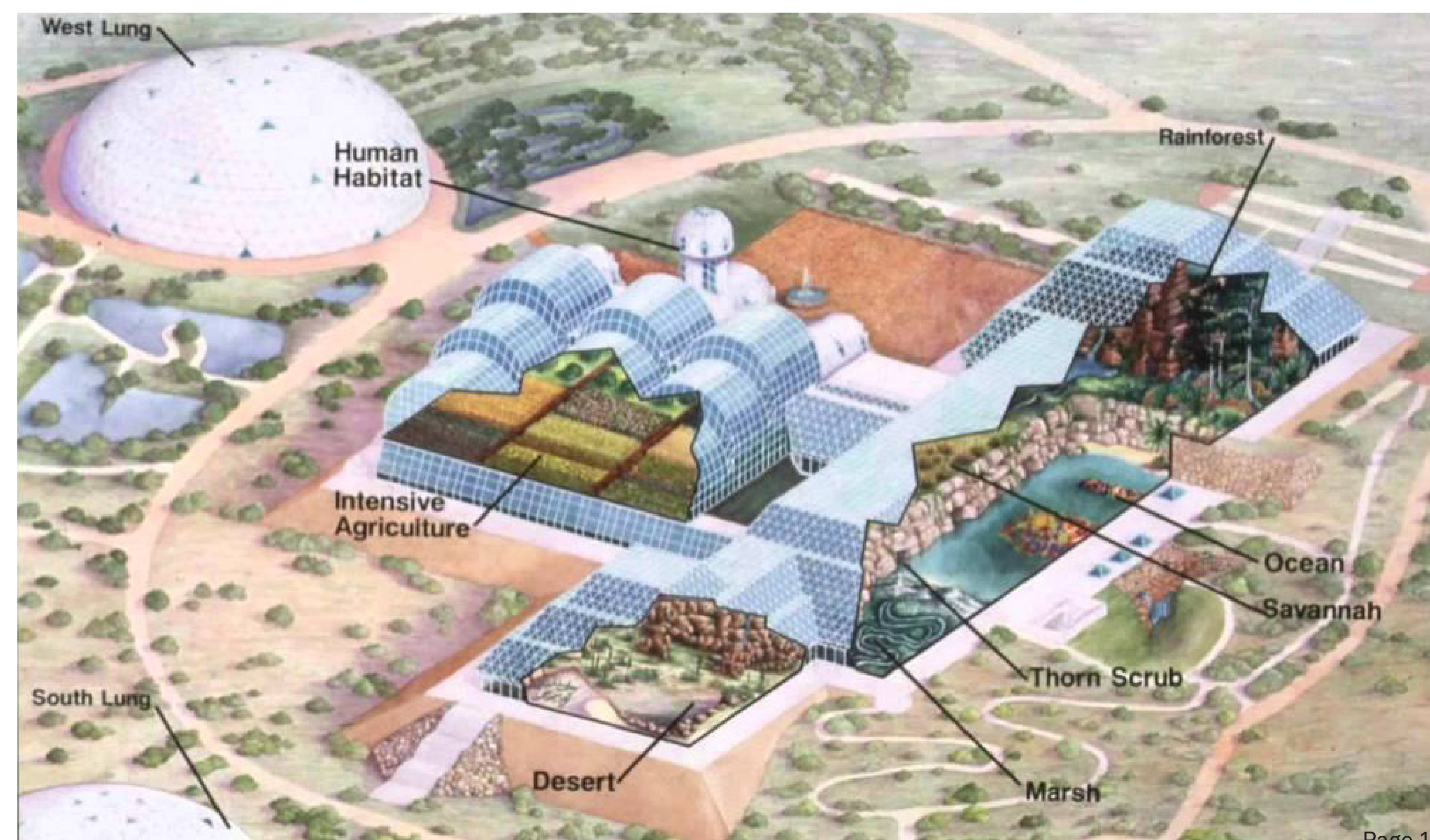
They could grow crops that would not only supplement a healthy diet, but also remove toxic carbon dioxide from the air inside their spacecraft and create life-sustaining oxygen.

https://www.nasa.gov/missions/science/biofarming.html

Food

Biosphere - Carbon recycling



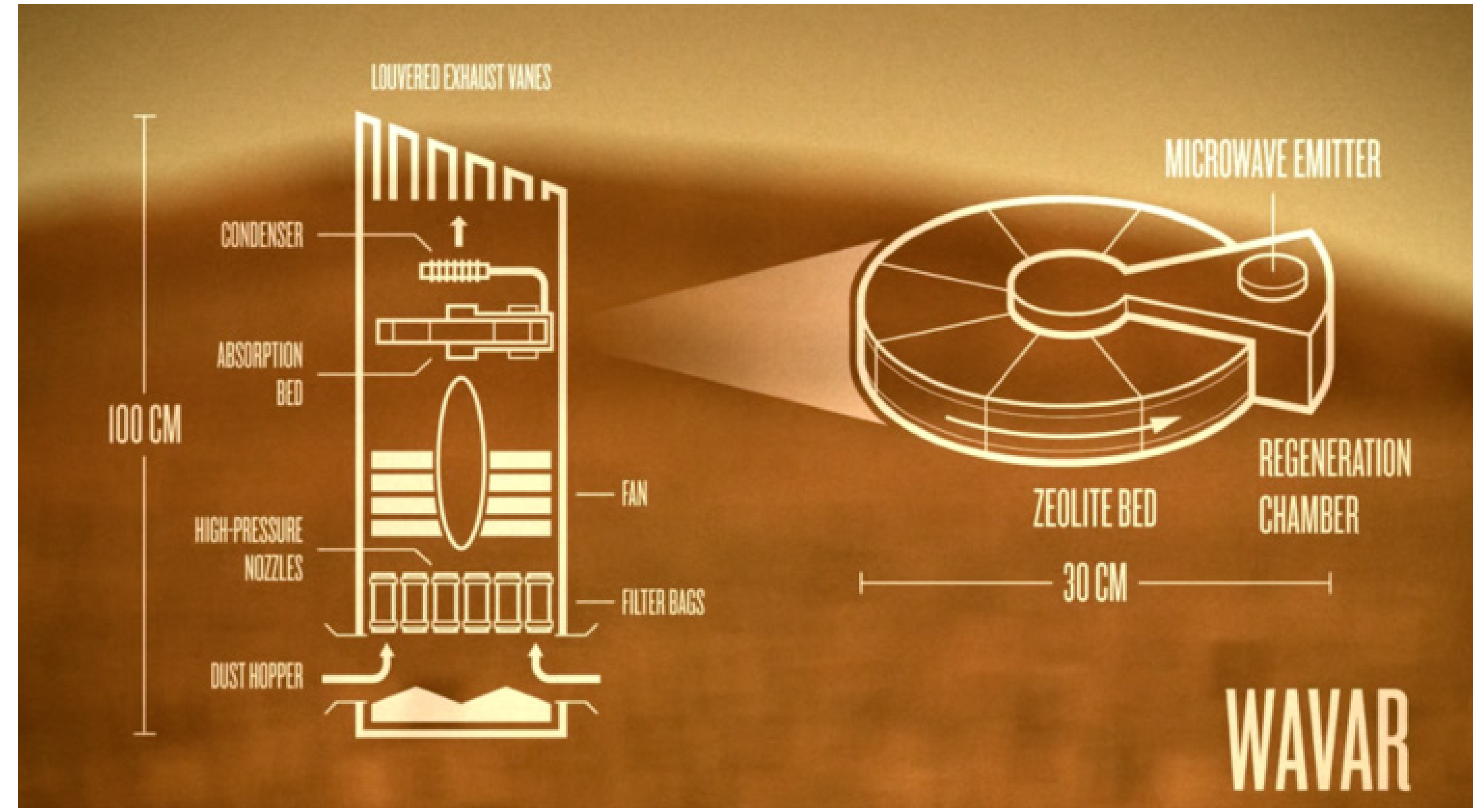


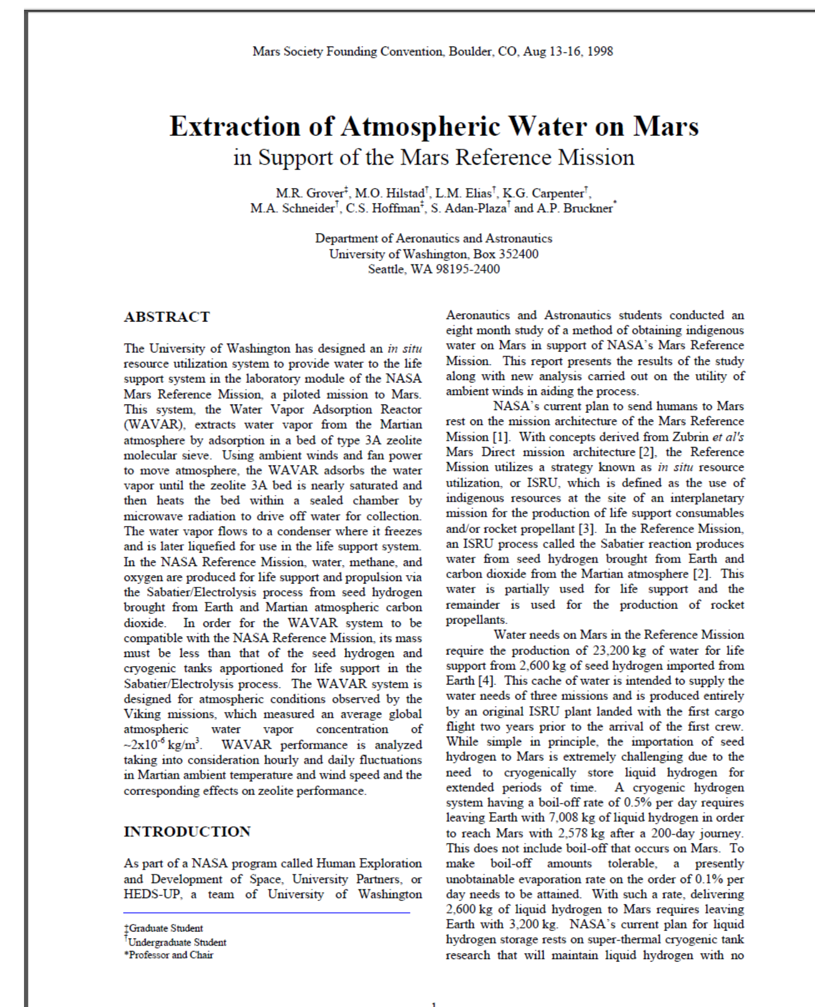
https://www.ted.com/talks/jane_poynter_life_in_biosphere_2?referrer=playlist-what_would_it_be_like_to_live_on_another_planet#t-13235

Water

WAVAR
Water-Vapor Adsorption Reactor

A process that has been studied for its potential in directly extracting water from the atmosphere of Mars by alternately blowing air over a zeolite adsorption bed and heating the bed to extract the adsorbed water.





Mars Society Founding Convention, Boulder, CO, Aug 13-16, 1998

Extraction of Atmospheric Water on Mars
in Support of the Mars Reference Mission

M.R. Grover‡, M.O. Hilstad†, L.M. Elias†, K.G. Carpenter†,
M.A. Schneider†, C.S. Hoffman‡, S. Adan-Plaza† and A.P. Bruckner*

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Seattle, WA 98195-2400

ABSTRACT

The University of Washington has designed an *in situ* resource utilization system to provide water to the life support system in the laboratory module of the NASA Mars Reference Mission, a piloted mission to Mars. This system, the Water Vapor Adsorption Reactor (WAVAR), extracts water vapor from the Martian atmosphere by adsorption in a bed of type 3A zeolite molecular sieve. Using ambient winds and fan power to move atmosphere, the WAVAR adsorbs the water vapor until the zeolite 3A bed is nearly saturated and then heats the bed within a sealed chamber by microwave radiation to drive off water for collection. The water vapor flows to a condenser where it freezes and is later liquefied for use in the life support system. In the NASA Reference Mission, water, methane, and oxygen are produced for life support and propulsion via the Sabatier/Electrolysis process from seed hydrogen brought from Earth and Martian atmospheric carbon dioxide. In order for the WAVAR system to be compatible with the NASA Reference Mission, its mass must be less than that of the seed hydrogen and cryogenic tanks apportioned for life support in the Sabatier/Electrolysis process. The WAVAR system is designed for atmospheric conditions observed by the Viking missions, which measured an average global atmospheric water vapor concentration of $\sim 2 \times 10^{-6}$ kg/m^3. WAVAR performance is analyzed taking into consideration hourly and daily fluctuations in Martian ambient temperature and wind speed and the corresponding effects on zeolite performance.

INTRODUCTION

As part of a NASA program called Human Exploration and Development of Space, University Partners, or HEDS-UP, a team of University of Washington Aeronautics and Astronautics students conducted an eight month study of a method of obtaining indigenous water on Mars in support of NASA's Mars Reference Mission. This report presents the results of the study along with new analysis carried out on the utility of ambient winds in aiding the process.

NASA's current plan to send humans to Mars rest on the mission architecture of the Mars Reference Mission [1]. With concepts derived from Zubrin *et al's* Mars Direct mission architecture [2], the Reference Mission utilizes a strategy known as *in situ* resource utilization, or ISRU, which is defined as the use of indigenous resources at the site of an interplanetary mission for the production of life support consumables and/or rocket propellant [3]. In the Reference Mission, an ISRU process called the Sabatier reaction produces water from seed hydrogen brought from Earth and carbon dioxide from the Martian atmosphere [2]. This water is partially used for life support and the remainder is used for the production of rocket propellants.

Water needs on Mars in the Reference Mission require the production of 23,200 kg of water for life support from 2,600 kg of seed hydrogen imported from Earth [4]. This cache of water is intended to supply the water needs of three missions and is produced entirely by an original ISRU plant landed with the first cargo flight two years prior to the arrival of the first crew. While simple in principle, the importation of seed hydrogen to Mars is extremely challenging due to the need to cryogenically store liquid hydrogen for extended periods of time. A cryogenic hydrogen system having a boil-off rate of 0.5% per day requires leaving Earth with 7,008 kg of liquid hydrogen in order to reach Mars with 2,578 kg after a 200-day journey. This does not include boil-off that occurs on Mars. To make boil-off amounts tolerable, a presently unobtainable evaporation rate on the order of 0.1% per day needs to be attained. With such a rate, delivering 2,600 kg of liquid hydrogen to Mars requires leaving Earth with 3,200 kg. NASA's current plan for liquid hydrogen storage rests on super-thermal cryogenic tank research that will maintain liquid hydrogen with no

‡Graduate Student
†Undergraduate Student
*Professor and Chair

Breathing

MOXIE - Mars Oxygen In-Situ Resource Utilization Experiment

MOXIE will demonstrate a way that future explorers might produce oxygen from the Martian atmosphere for propellant and for breathing.

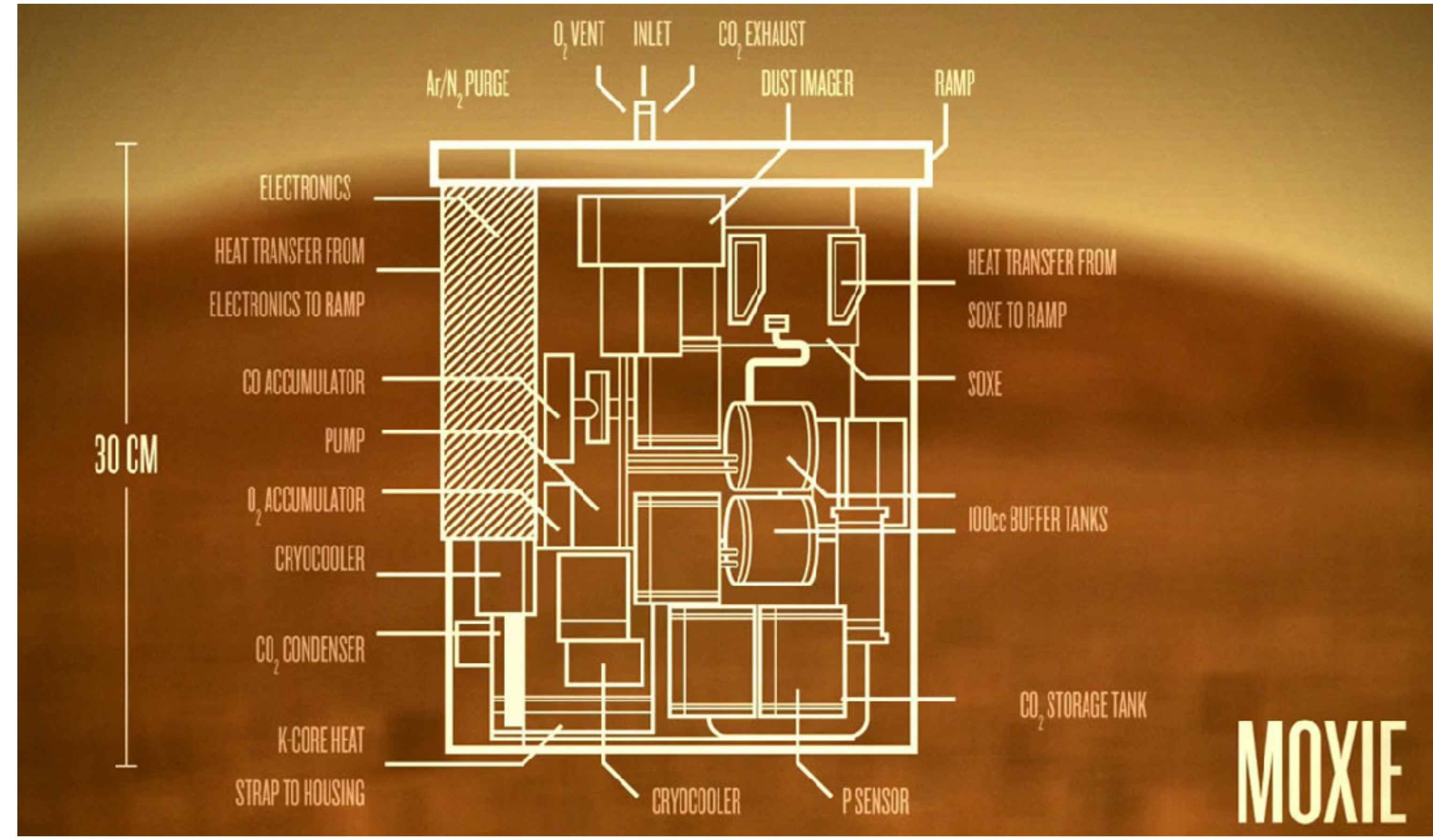
1. **MOXIE Makes Oxygen on Mars**
   Carbon dioxide makes up ~96% of the gas in Mars' atmosphere. Oxygen is only 0.13%, compared to 21% in Earth's atmosphere.

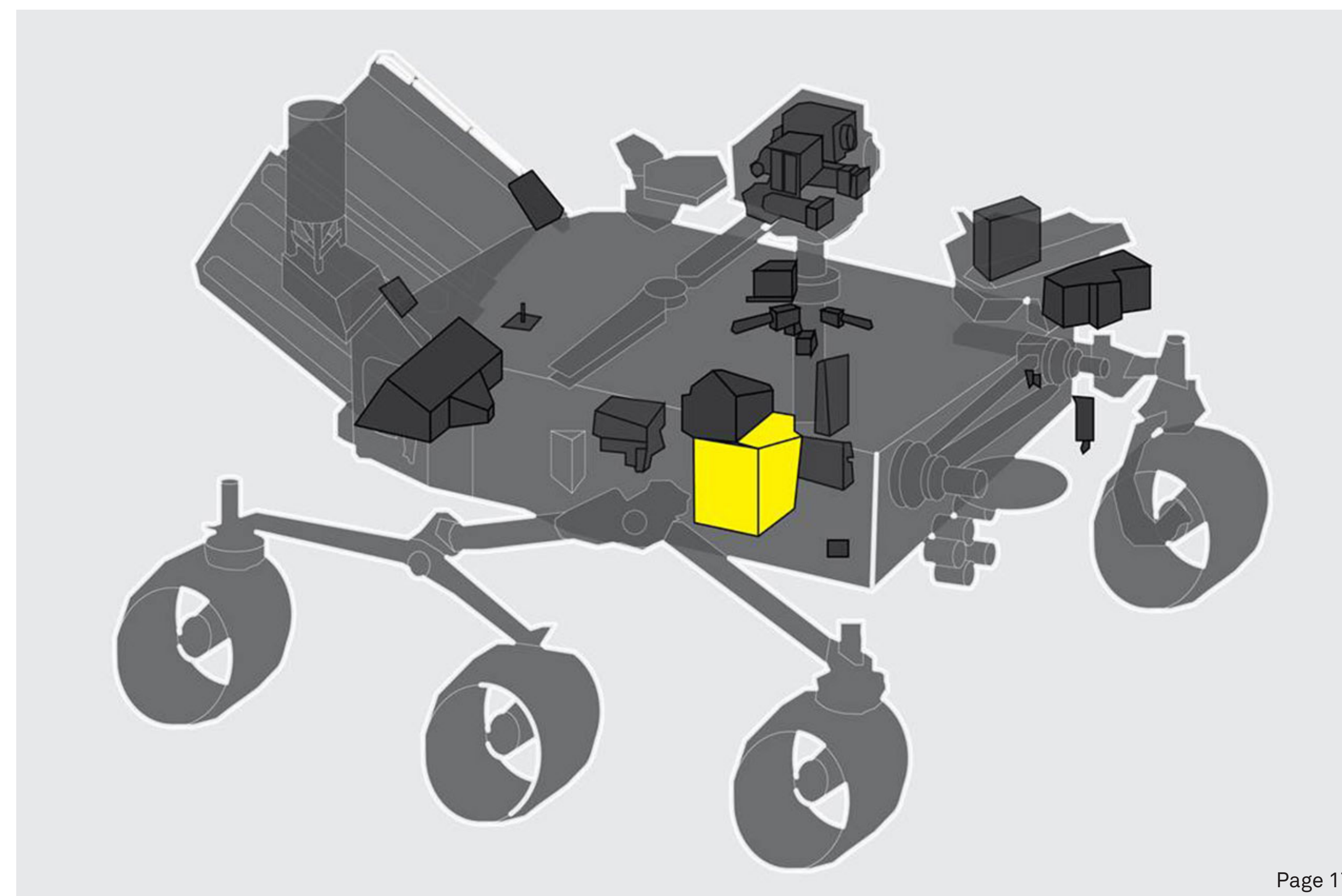
2. **MOXIE Is a Test Model**
   MOXIE is the size of a car battery. Future oxygen generators that support human missions on Mars must be about 100 times larger.

3. **MOXIE Helps Future Explorers**
   To launch off of Mars, human explorers need about 33 to 50 tons (30 to 45 metric tons) of fuel, about the weight of a Space Shuttle.

4. **MOXIE Breathes like a Tree**
   MOXIE makes oxygen like a tree does. It inhales carbon dioxide and exhales oxygen.

5. **Homemade on Mars**
   Homemade liquid oxygen on Mars could supply more than ¾ of the propellant humans need for exploration on the Red Planet.





https://mars.nasa.gov/mars2020/mission/instruments/moxie/

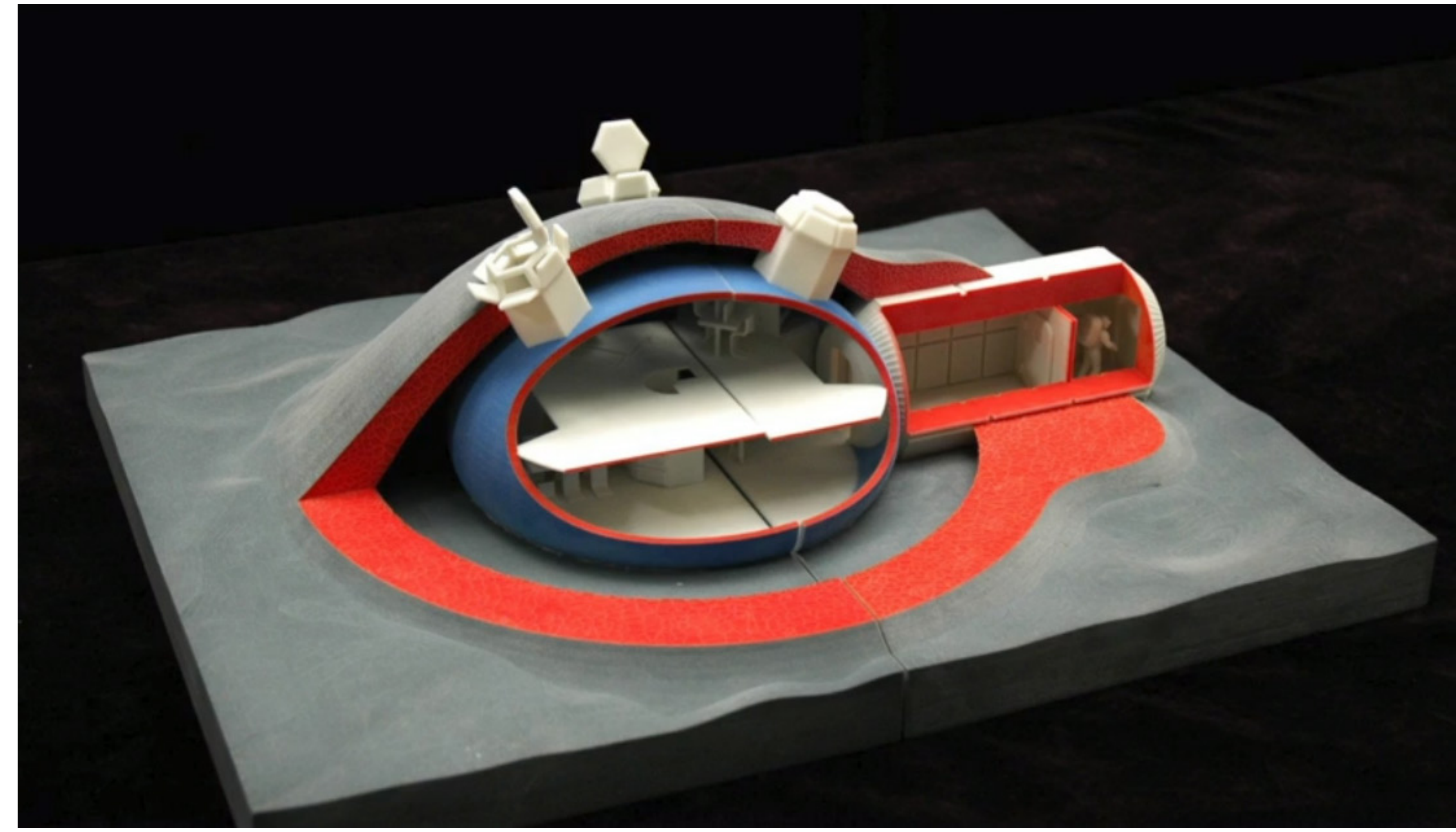
Shelter

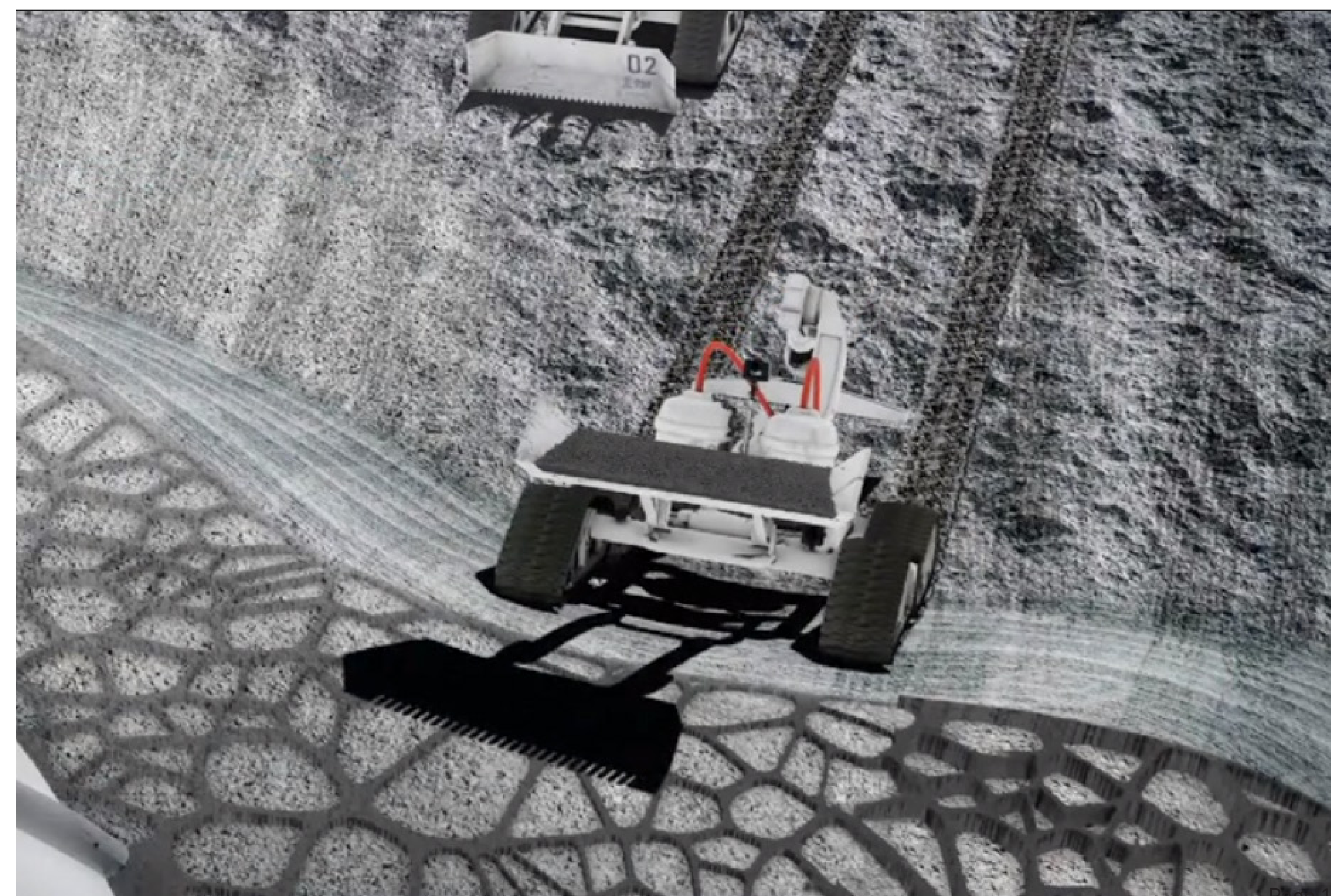
Living space and clothing

It is very expensive to send materials to Mars, If a human shelter hast to be sent to Mars from Earth, It has to be light and packed in a compact fashion.

Inflatables seem to be an ideal choice but they are fragile. We need protection from solar radiation, winds/storms and asteroid impacts.

Caves and lava tubes seem to be the best place to set up shelters.





https://www.ted.com/talks/xavier_de_kestelier_adventures_of_an_interplanetary_architect?referrer=playlist-what_would_it_be_like_to_live_on_another_planet

Shelter

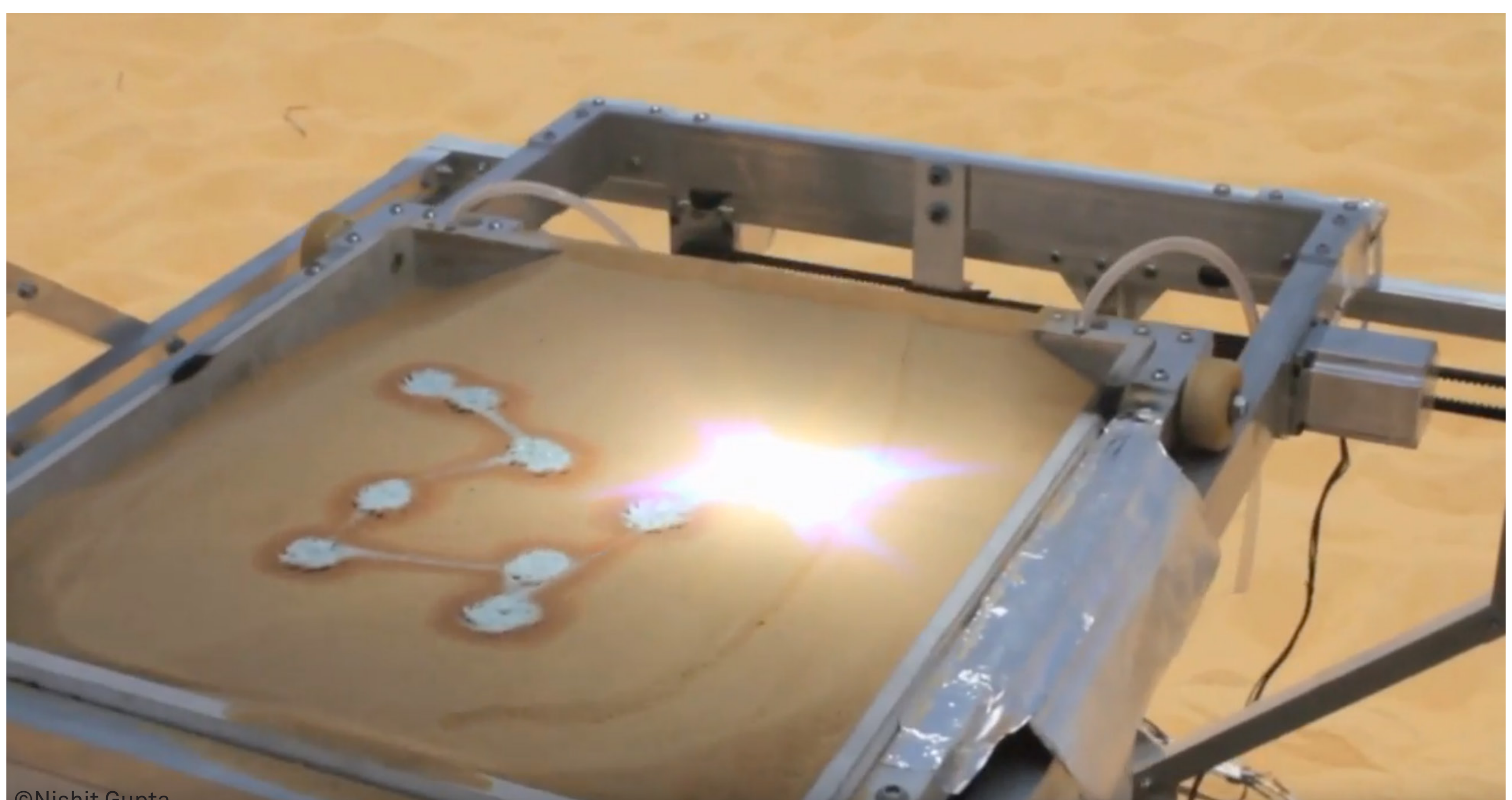
Building with local materials

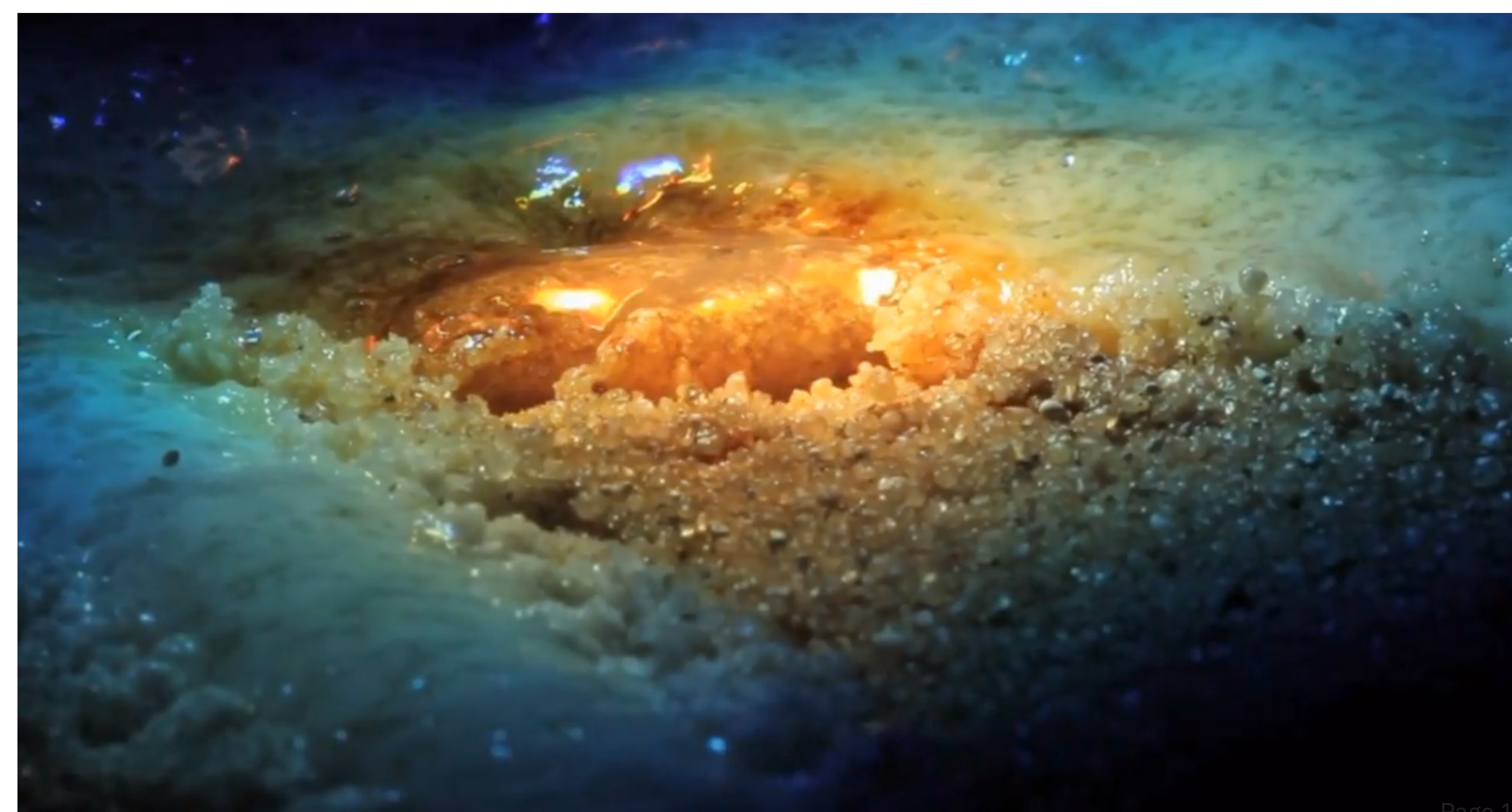
German designer Markus Kayser has built a 3D-printing machine that uses sunlight and sand to make glass objects in the desert.

The Solar Sinter, the device uses a large Fresnel lens to focus a beam of sunlight, creating temperatures between 1400 and 1600 degrees Celsius. This is hot enough to melt silica sand and build up glass shapes, layer by layer, inside a box of sand mounted under the lens.

https://www.dezeen.com/2011/06/28/the-solar-sinter-by-markus-kayser/

https://www.youtube.com/watch?v=Lqv-JiUydd7E



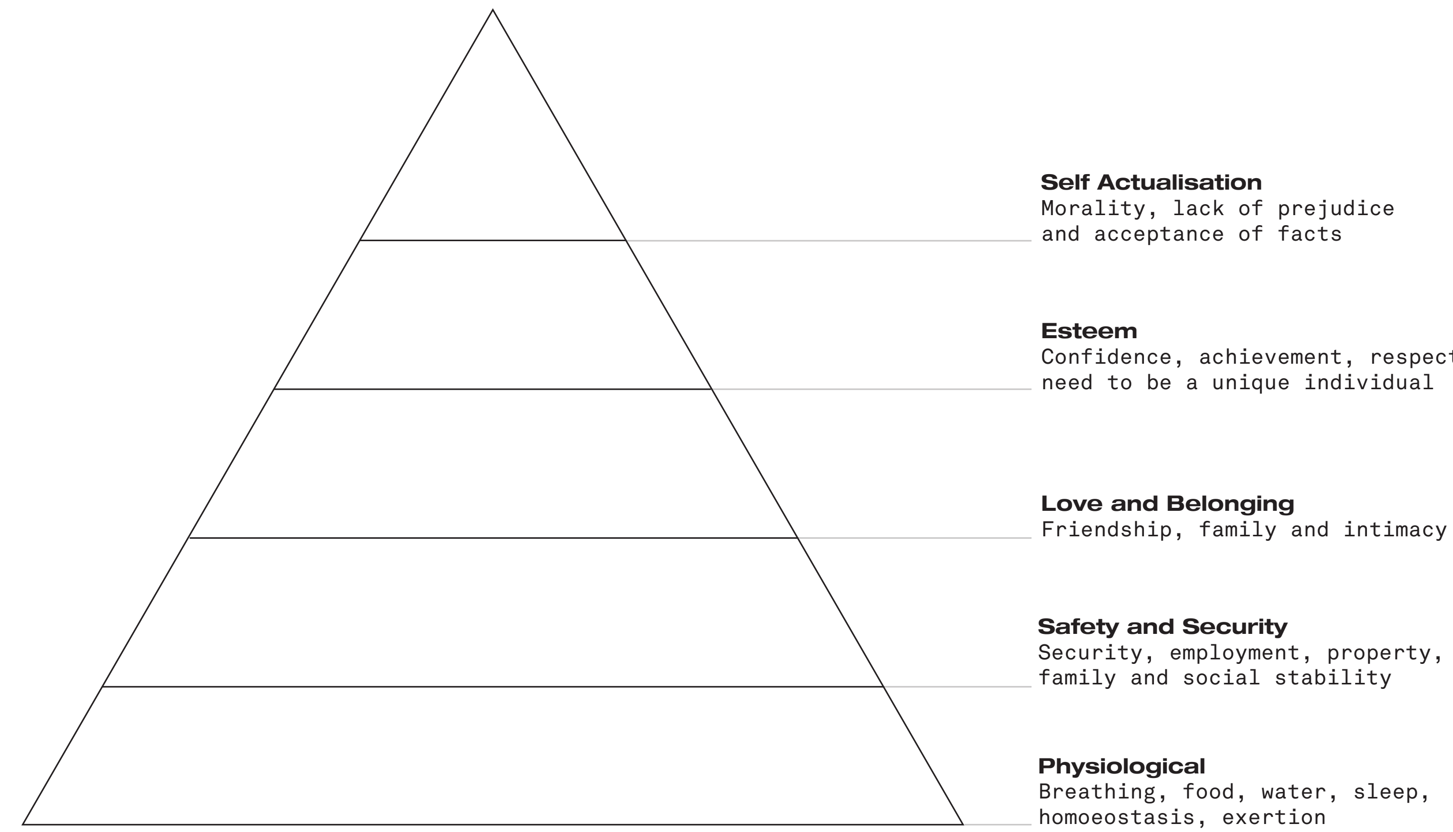


Are we ready?

Food
Water
Shelter
Air

Missing:

Social Stability
Family
Love and Belonging



Isolation/Confinement

Stimulation and relaxation

The theory of optimal arousal suggests that human beings are motivated to maintain a balance between stimulation and relation.

NASA has learned that behavioural issues among groups of people crammed in a small space over a long time, no matter how well trained they are inevitable.

Types of problems you may encounter are a decline in mood, cognition, morale, or interpersonal interaction. You could also develop a sleep disorder.
Depression could occur.Fatigue is inevitable given that there will be times with heavy workload and shifting schedules.

https://www.nasa.gov/hrp/bodyinspace

Effective solutions

For known physiological issues

Certain radiations in space can penetrate human body and even metals like aluminium. Therefore many space suits use lead as a protective coating from harmful radiations. But space suits are usually heavy and restricts mobility

Genetically engineered humans for long space travel. Inspired from organisms on earth. Example- Deinococcus Radiodurans, an bacterium that has high resistance to extreme temperatures, pressure and can stay withstand radiation.

https://www.nasa.gov/image-feature/exploration-development-suits-0

Psychological Issues

Role of mental health in space flight

Confined environments with limited social interactions can lead to psychological stress and strain. This can cause anxiety and depression which can lead to human error.

Mental health will play a major role in the 9 months it takes to travel to Mars and living on a deserted planet to conduct difficult and highly technical scientific research and findings.

Solitary confinement

The Guardian

This article is more than **7 months old**

More than 4,000 mentally ill inmates held in solitary in US – report

A Yale law school survey found that prisoners with mental health problems are kept in isolation for at least 22 hours a day

Ed Pilkington *in New York*

Wed 10 Oct 2018 09.00 EDT

More than 4,000 prisoners with serious mental illness are being held in solitary confinement in US prisons, according to new research, despite the knowledge that holding people in isolation exacerbates mental problems and can even trigger them.

https://www.theguardian.com/us-news/2018/oct/10/mental-health-inmates-solitary-confinement-us-prisons

A Mentally Ill Man in Solitary Cut Off a Body Part at the Broward County Jail

Eric Balaban, ACLU National Prison Project
& Stephanie Wylie, Litigation Fellow, ACLU National Prison Project
MARCH 28, 2019 | 5:00 PM

TAGS: Medical and Mental Health Care, Prisoners' Rights

Around midnight on Sept. 5, 2018, guards responded to prisoners banging on their cell doors inside a lockdown unit at Broward County Jail's main facility in downtown Ft. Lauderdale, Florida. They went to the solitary cell of J.I.* and made a gruesome discovery.

"I have a real medical emergency," J.I. told an officer. "I just cut my penis off and flushed it down the toilet. I have no need for it anymore."

J.I. had used a razor blade to cut himself. This grisly act of self-mutilation is just the latest chapter in a series of tragic incidents involving seriously mentally ill prisoners at the jail.

https://www.aclu.org/blog/prisoners-rights/medical-and-mental-health-care/mentally-ill-man-solitary-cut-body-part-broward

Psychologist testifies on the risks of solitary confinement

October 2012, Vol 43, No. 9
Print version: page 10

The nation's roughly 80,000 inmates in solitary confinement are "at grave risk of psychological harm," Craig Haney, PhD, APA member and professor of psychology at University of California, Santa Cruz, told the Senate Judiciary Subcommittee on the Constitution, Civil Rights and Human Rights. "The conditions of confinement are far too severe to serve any kind of penological purpose," he said.

Haney, who was appointed this year to a National Academy of Sciences committee studying the causes and consequences of high rates of incarceration in the United States, has interviewed hundreds of prison staff and inmates and toured and inspected dozens of U.S. prisons. At a June 19 hearing, he showed pictures to illustrate solitary confinement's harsh conditions, including filthy cells that are "scarcely larger than a king-sized bed," he said. As a result of the endless monotony and lack of human contact, "for some prisoners ... solitary confinement precipitates a descent into madness." Many inmates experience panic attacks, depression and paranoia, and some suffer hallucinations, he said.

Former inmate Anthony Graves, who spent 18 years on death row, including 10 in solitary confinement for a murder he didn't commit, drove home Hanley's points. "I would watch guys come to prison totally sane, and in three years they don't live in the real world anymore," he said. One fellow inmate, Graves said, "would go out into the recreation yard, get naked, lie down and urinate all over himself. He would take his feces and smear it all over his face."

Graves, who was exonerated in 2010, said he still feels the effects of the decade spent in solitary confinement. "I haven't had a good night sleep since my release," he said. "I have mood swings that cause emotional breakdowns."

Such long-term effects are common, Haney said. "One of the very serious psychological consequences of solitary confinement is that it renders many people incapable of living anywhere else." Then, when prisoners are released into cells or back into society, they are often overwhelmed with anxiety. "They actually get to the point where they become frightened of other human beings," he said.

—Sadie Dingfelder

https://www.apa.org/monitor/2012/10/solitary

Simulation

Mars 500

The European space agency choose 6 men to be isolated in a simulated spaceship for 520 days. Some crew members reported being depressed and others reported insomnia.

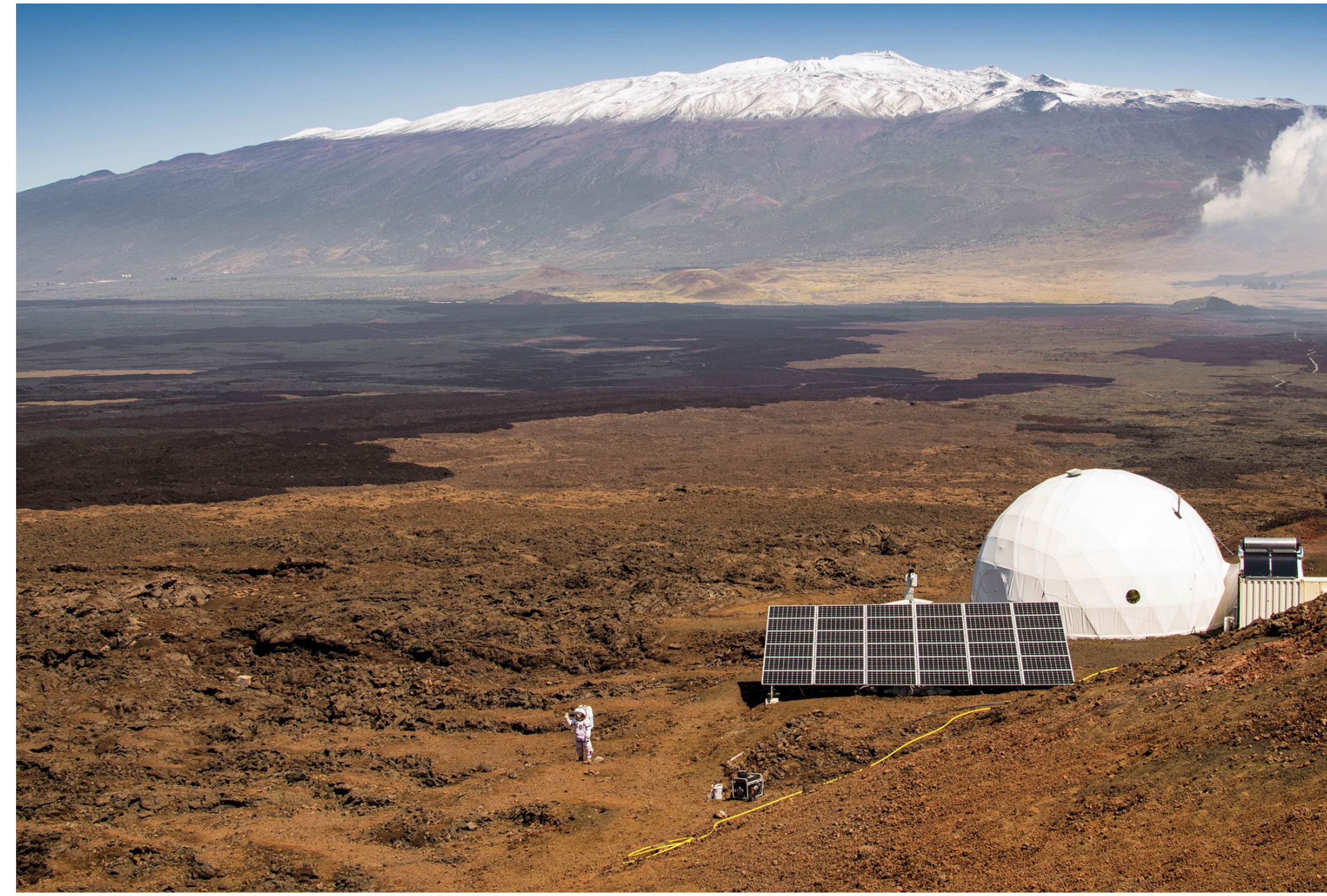
https://www.youtube.com/watch?v=OL-9cpxuN7NY

Simulation

HI-SEAS

Hawaii Space Exploration Analog and Simulation is a Habitat on an isolated Mars-like site on the Mauna Loa side of the saddle area on the Big Island of Hawaii at approximately 8200 feet above sea level.

The HI-SEAS site has Mars-like geology which allows crews to perform high-fidelity geological field work and add to the realism of the mission simulation.



https://hi-seas.org/

Simulation

Confined space - 1 year at the ISS

Former NASA astronaut Scott Kelly spent over 340 days on the International Space Station conducting over 400 research experiments.

ISS travels around the earth 16 times a day.
Space stations/ships are noisy. Lack of sleep and depression.

Phone calls to celebrities, family. Care packages and surprise gifts help astronauts stay mentally healthy

https://www.youtube.com/watch?v=OL-9cpxuN7NY

ISS caution

Behavioural - Acute psychosis

BEHAVIORAL - ACUTE PSYCHOSIS
(ISS MED/3A - ALL/FIN) Page 1 of 3 pages

> NOTE
> Contact Surgeon before giving any medication marked with an asterisk. In an emergency or during Loss of Signal, begin appropriate treatment; then call Surgeon as soon as possible.

ALSP (red)

1. Unstow:
   - Drug Subpack
   - Gray Tape
   - Bungees
   - Towels

2. Talk with the patient while you are restraining him.
   Explain what you are doing, and that you are using a restraint to ensure that he is safe.
   Restrain patient using Gray Tape around wrists, ankles, and use a bungee around the torso.
   If necessary to restrain the head, place a rolled towel under the neck and restrain with Gray Tape.

AMP (blue)

3. Administer 10 mg °ŦHaldol (Haloperidol) Oral (P4-B6) - Potent tranquilizer

   If patient is uncooperative with taking oral dose of Haldol (Haloperidol), give °ŦHaldol (Haloperidol) IM as noted in step 4.

   Possible side effects
   Low blood pressure, rapid heart rate, headache, involuntary movements; increased body temperature

> NOTE
> Backup CMO should remain with restrained crewmember at all times. Confirm presence of radial and pedal pulses. If pulses are weak or faint, loosen restraints.

ALSP (red)

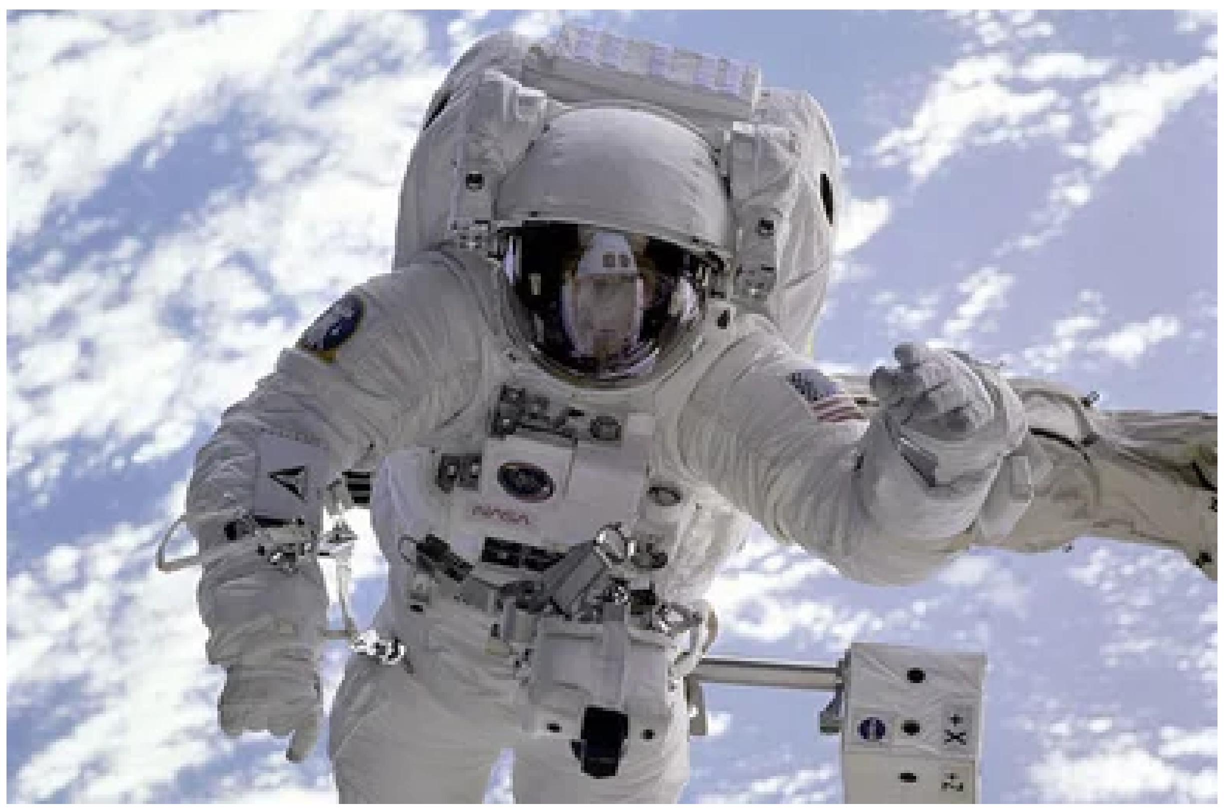
4. Administer 5 mg/ml of °ŦHaldol (Haloperidol) Injectables IM (Drug 27,28).
   Refer to {INJECTIONS - INTRAMUSCULAR} (SODF: ISS MED: INJECTIONS/IV).

Mental health in outer space

Mental Health in Outer Space

NASA says there have been no behavioral emergencies on U.S. space flights—yet

By Nathaniel P. Morris on March 14, 2017



Credit: NASA

In 2007, a woman named Lisa Nowak drove 900 miles to the Orlando airport,

https://blogs.scientificamerican.com/guest-blog/mental-health-in-outer-space/?redirect=1

6/1/2019 Isolation and hallucinations: the mental health challenges faced by astronauts | Science | The Guardian

The Guardian

Isolation and hallucinations: the mental health challenges faced by astronauts

Why the mental health of astronauts is one of the biggest hurdles when it comes to successful space missions

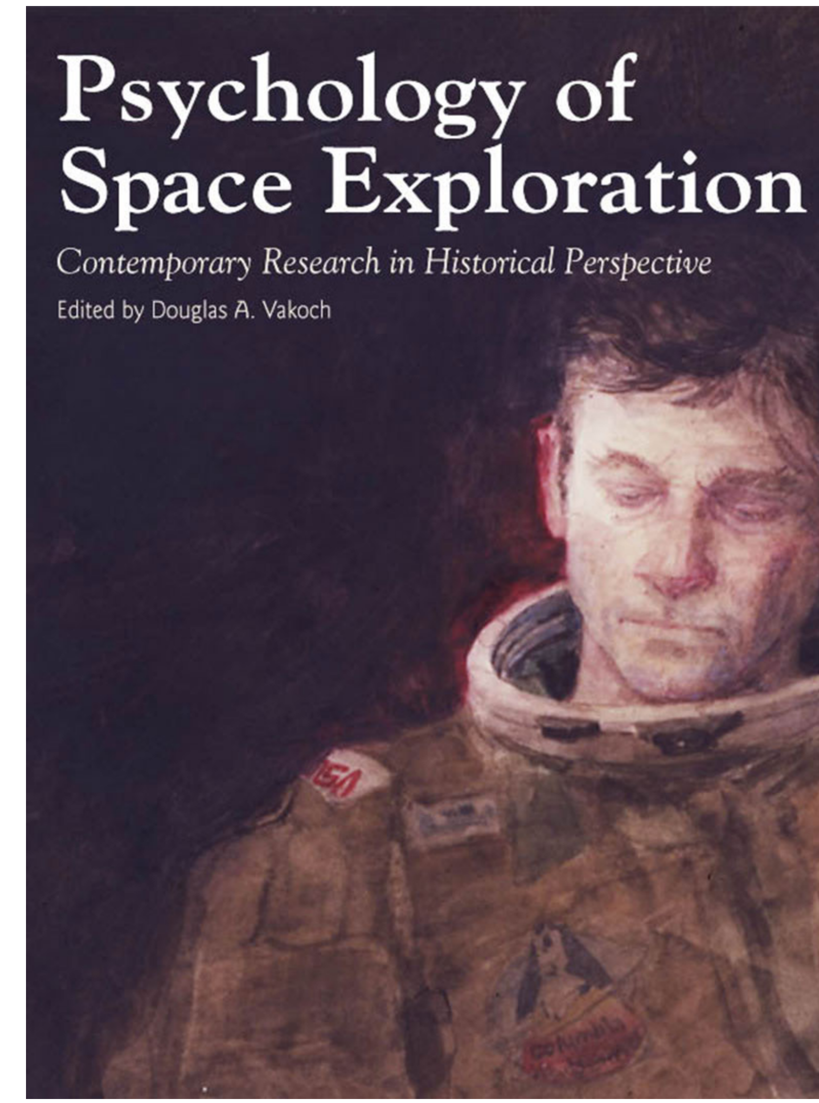
Vaughan Bell

Sun 5 Oct 2014 02.15 EDT

The sight of the entire Earth, visible to the naked eye, has had a profound effect on those who have seen it. Astronaut William McCool described it as "beyond imagination", and many have written how space flight permanently altered how they saw their place in the universe. For mission control, the wonder of space must seem like something of a distraction as they focus on the psychological health of their astronauts working in a high-pressure, high-risk environment, 420km (260 miles) above the Earth's surface. These day-to-day stresses can be equally as life-changing and Nasa consider behavioural and psychiatric conditions to be one of the most significant risks to the integrity of the mission - not least as there is now significant evidence that space travel has mind-altering effects.

One of the most common experiences are frequent hallucinations that, despite sounding ominous, are probably the least concerning when it comes to in-orbit mental health. In the early

https://www.theguardian.com/science/2014/oct/05/hallucinations-isolation-astronauts-mental-health-space-missions 1/3



Missions

Sky lab 4

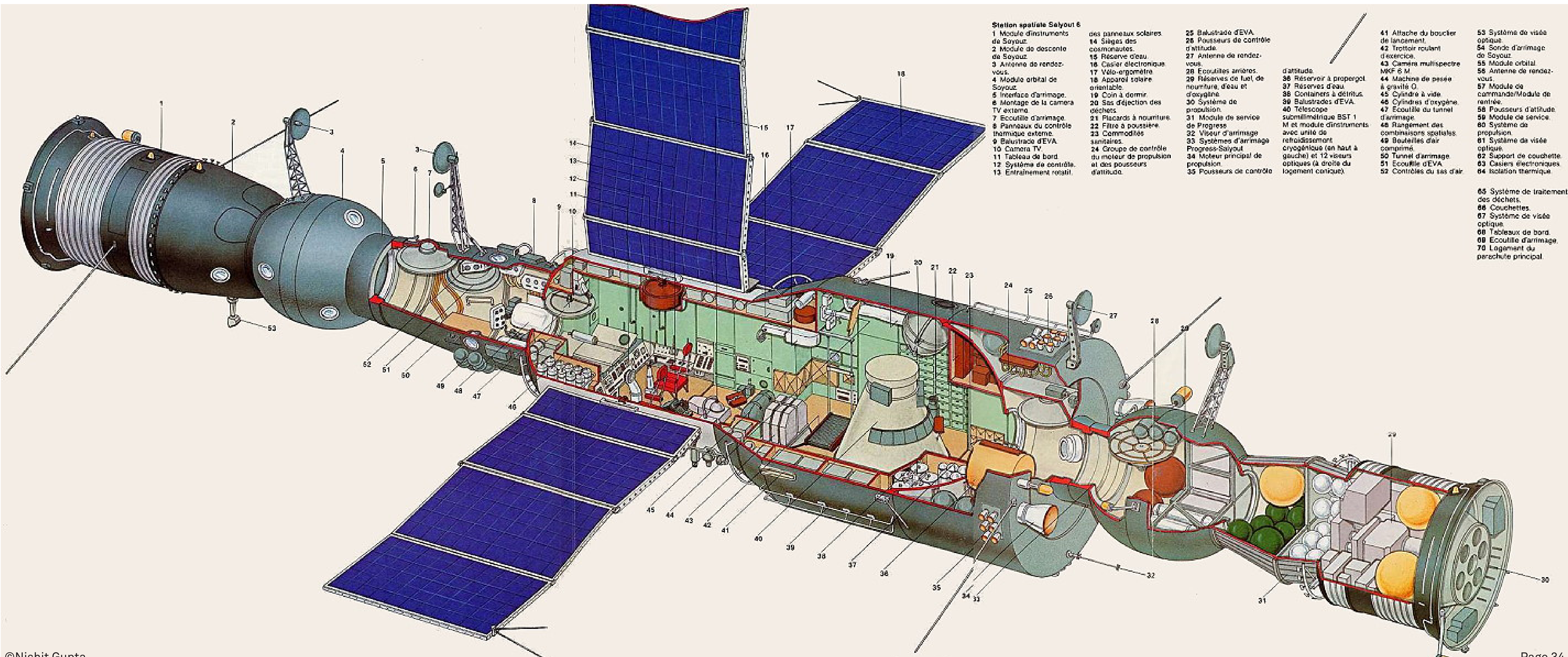
During this mission in 1973, astronauts got stressed out and cut communications with NASA for 24hours.

https://fightersweep.com/11880/the-true-story-behind-nasas-1973-skylab-mutiny/

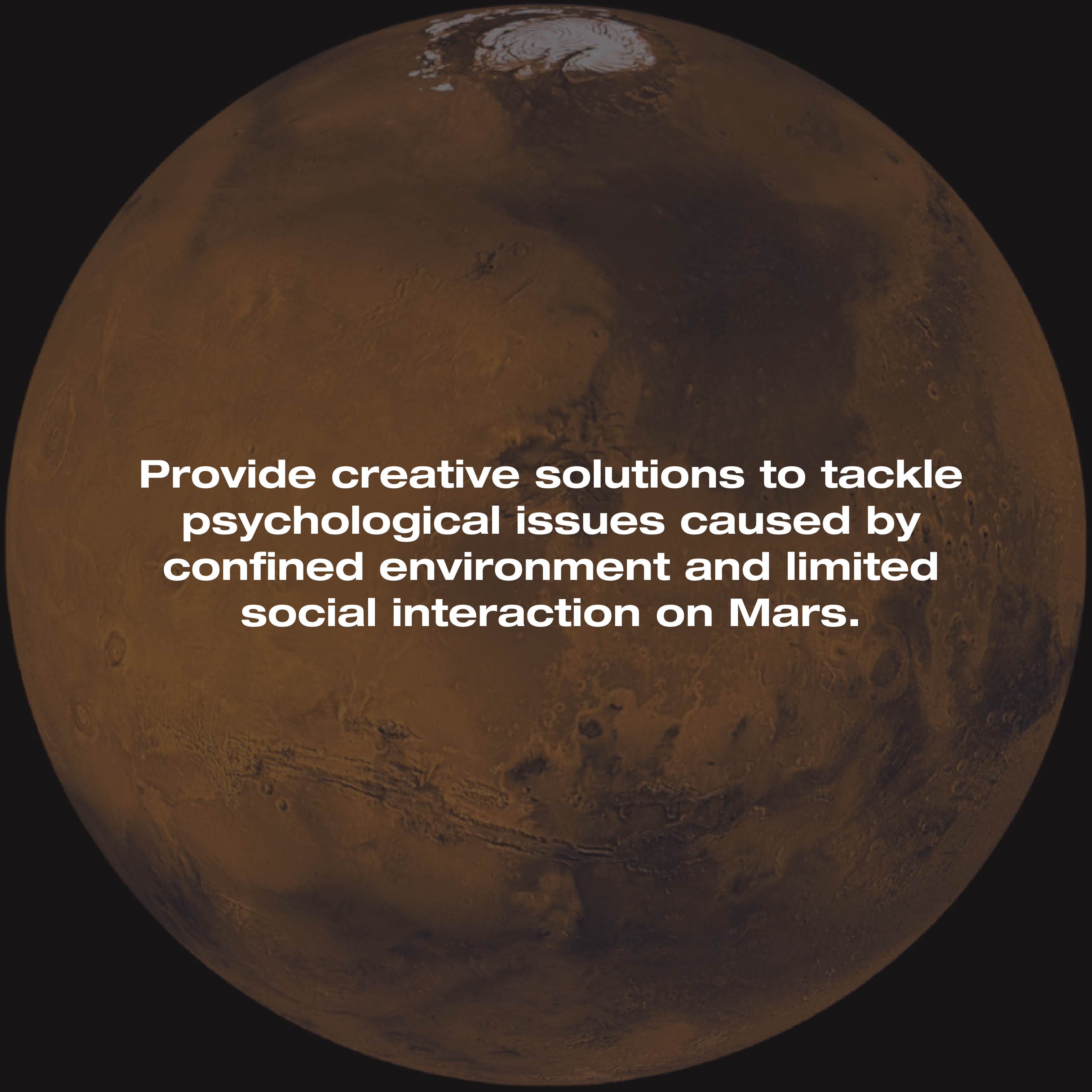
Missions

Salyut 6

During this mission Russian astronauts had a dream about a tooth ache and started obsessing over it. Some astronauts who face anxiety during space flight will semanticize a small problem to be a big one.

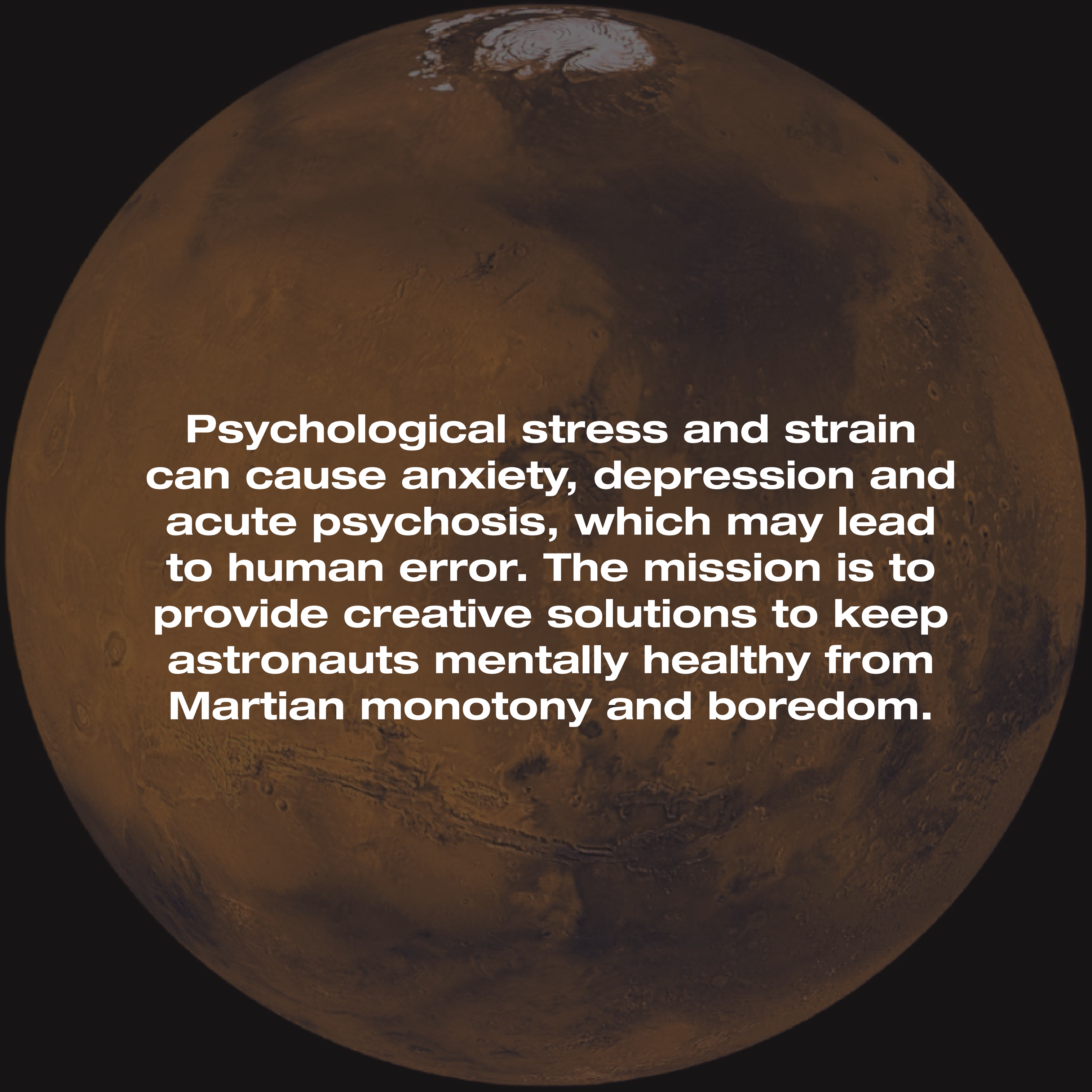


Mission brief



Provide creative solutions to tackle psychological issues caused by confined environment and limited social interaction on Mars.

Value proposition



Psychological stress and strain can cause anxiety, depression and acute psychosis, which may lead to human error. The mission is to provide creative solutions to keep astronauts mentally healthy from Martian monotony and boredom.

Biomechanical advancement

Bionic prosthetics for amputees

Hugh Herr's bionic limb has mechanical - attachment to human body, dynamic - learning from user and electrical - brain and computer interfaces.

https://www.youtube.com/watch?v=CDsNZJTWw0w

Pressure exoskeleton

Ekso Vest

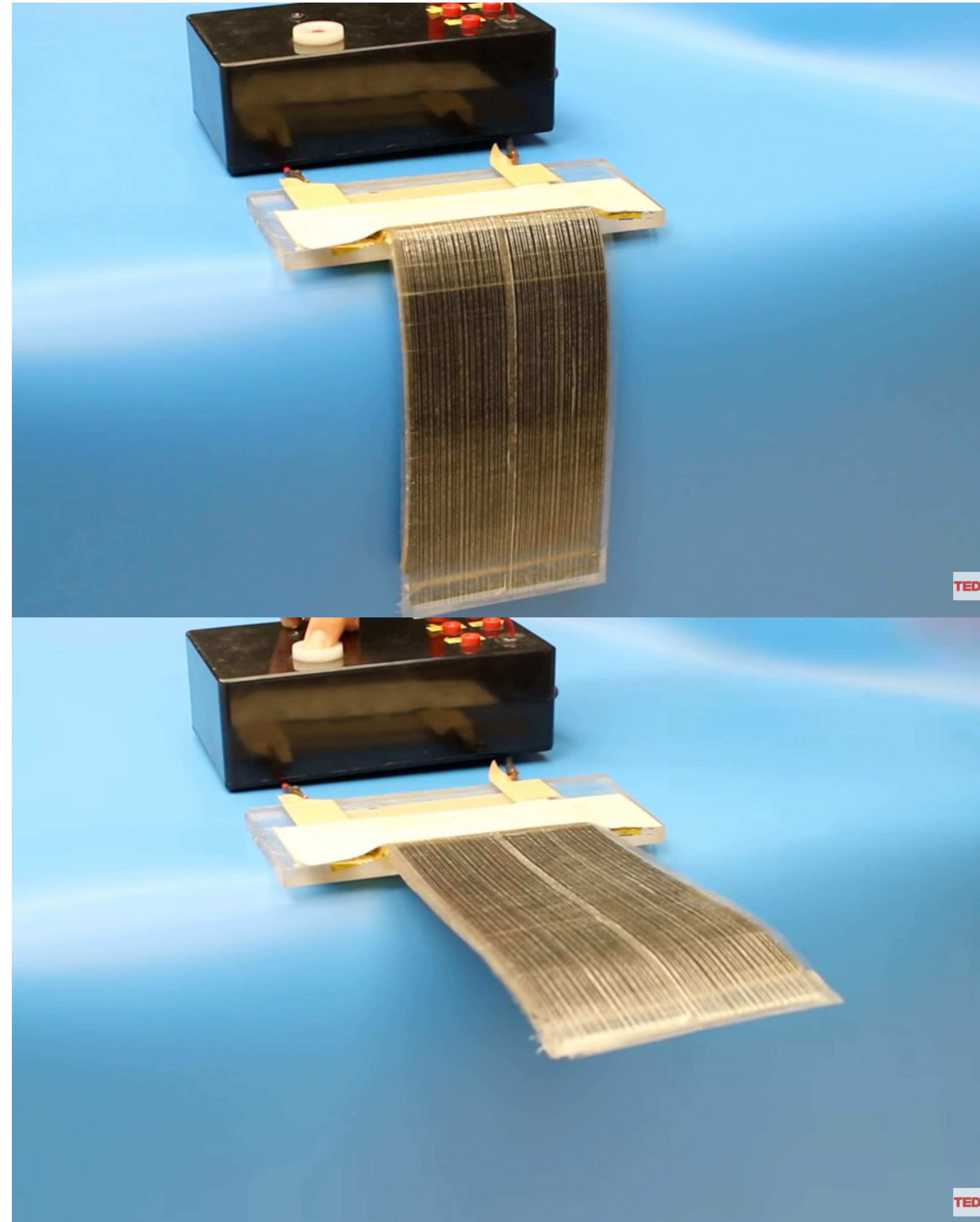
The Ekso Vest is an exoskeliton the works by shifting pressure from user's arms and shoulders to their legs.
The goal is to make everyday tasks easier. It is not about super human strength.

https://www.youtube.com/watch?v=lWmFEoDjUc4

Artificial muscles

SRI International

No voltage = floppy fabric
With Voltage = stiff



Pneumatic systems

Using air pressure

In a pneumatic electronic hybrid, electric components simply control the flow of air pressure, removing the burden of weight and kinetic actuation from electric to pneumatic power. The result is a lightweight low idle-power system with high-power kinetic impact.

http://www.cwwang.com/2008/04/08/soft-pneumatic-exoskeleton/

Suit inside a suit

Dava Newman suit

In order to survive in the vacuum of space, human bodies require pressure. EMUs solve this problem by creating a pressurized vessel, sort of like a mini airplane cabin. By contrast, the BioSuit employs semi-rigid ribs traced across the body to provide mechanical counterpressure while letting the wearer retain a full range of movement.

https://appel.nasa.gov/2012/01/11/building-the-future-spacesuit/

https://www.wired.com/2014/01/how-a-text-book-from-1882-will-help-nasa-go-to-mars/

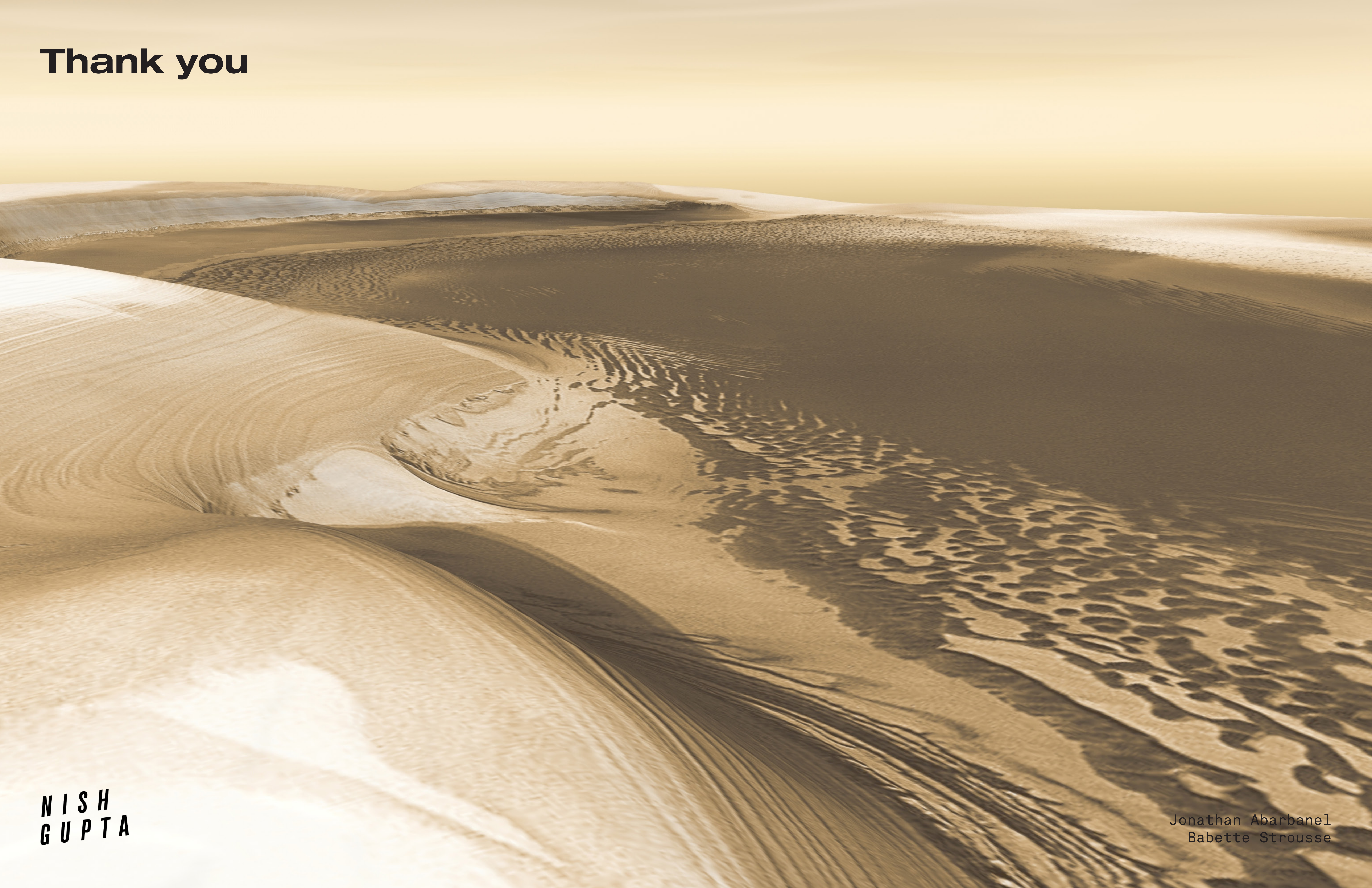
https://www.youtube.com/watch?v=lZvP_URAjmM

Robotics 2019

Doston Dynamics

https://www.youtube.com/
watch?v=wXxrmussq4E

Thank you



NISH
GUPTA

Jonathan Abarbanel
Babette Strousse