# LIFE ON MARS

5A: TOMORROW WORLD'S

ADVANCED ARCHITECTURAL DESIGN (AAD)

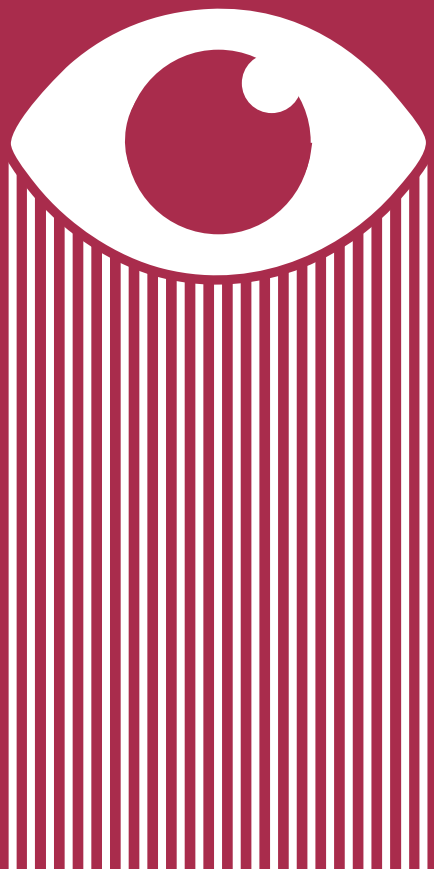
UNIVERSITY OF STRATHCLYDE

2016941142

**NICHOLAS ROBB**

2069

Tomorrow World's



# TOMORROW WORLDS

# 2069

## STUDIO 03
**TOMORROW WORLD'S**

*You see things; and you say 'Why?'*
*But I dream things that never were*
*and I say, 'Why not?'*

**George Bernard Shaw**
PLAYWRIGHT

**UNIT TASK**

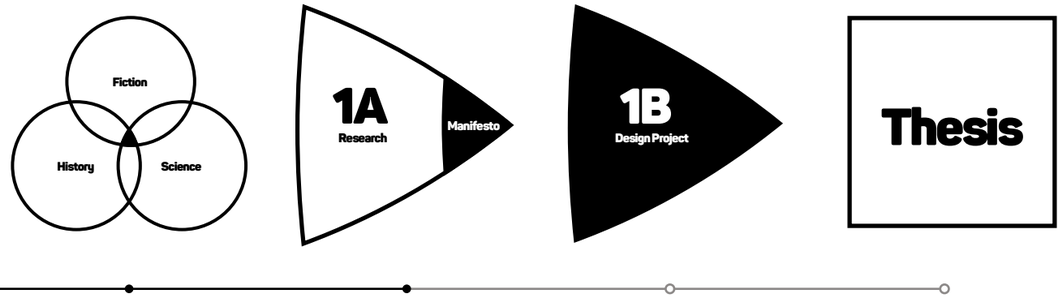
**To make predictions of the long term future condition of the built environment**

**To visually represent said predictions with both conviction and delight**

The intention is not to invite merely the fantastic; the intention is to encourage the invention of 'fantastic realities', to tap into the basic creative impulse and pedigree of the architect: to propose convincing 'visions' of possible realities.

For 5A technological change, invention and subsequent influence are the drivers for this creative process.
The unit shall establish itself into a future context of 2069AD and conduct a series of research exercises,
exploring the individual students chosen field of interest against an associated technological 'thread'.

In 5B, students shall be invited to extend their creative deliberations, develop and then present visualisations of an aspect of 'tomorrow's world'.
Students will be expected to provoke their own imagination, to challenge their own perceptions of the world as we know it, and as it might become.
They will be expected to engage in self-critique and proactive evaluation of their own creative process, to hone and refine visualisation skills and
expand their minds to the possibilities of a world enhanced by the evolutionary and beneficial influence of technology.




# FUTURE HISTORY

**2010**

- Facial Recognition
- Smart Cities
- Maven Probe on Mars
- India's 1st mission to Mars
- Probe lands on comet 67P
- Electric Cars
- Maintream VR
- Biometric Scanning
- 3D Printing
- DNA storage
- Brexit
- Ridesharing
- Drones
- Gene Therapy
- Designer Babies
- Driverless Cars
- Meat Tax
- Cultured Meat Labs
- Hadron Collider expanded
- Railguns
- Japanese mission to Phobos
- Driverless Cars
- Virtual predictive models
- Robotic Assistants
- 3D Projection
- Swarm Robotics
- Virtual Offices
- Fossil Fuel Tax
- First Humans on Mars
- Prosthetic Eyes
- Handheld MRI
- Formation of Space society
- Cybernetic Augmentation
- Space Elevator on Mars
- Cranial Implants
- Animal Restoration
- Memory banks
- Memory sharing
- Fossil Fuel Tax
- National Wage
- Nanobots
- Asteroid Mining
- Arcologies
- Weather bots
- Automated Warfare
- Vertical Farming
- Yottaflop supercomputers
- Global population reaches 9 billion
- Hivemind AI
- HVI Cure
- Humans orbit Mars
- Manned Lunar base
- Quantum Computers
- Permanent human presence on Mars
- Tourist Trips to Moon
- Ectogenysis
- Russian mission to Halley's Comet
- Helium-3 mining on Moon
- Invisibility cloak
- Organic 3D printing
- Robotic Mining of Kuiper Belt
- Brainwave modification
- Tissue Regeneration
- Fusion Power mainstream
- Ozone layer recovers
- World's first Trillionaire
- Automated Housing
- Nanotech clothing
- Global Work Week Reduced
- Hypersonic Vacuum Trains
- Organic AIs
- Flu Virus succesfully replicated virtually
- Super Hurricanes
- Global temperatures rise 2°C
- Virtual telepathy
- Unmanned probe to Chiron
- Carbon Nanotube production
- Robotic exploration of Jovian system
- Transglobal Highway
- Age Treatments
- First signs of Ethnic Blurring on Mars
- Global Population Control
- Voloutary Cybernetic Replacement
- Transhumanist movement gains traction
- New York flood barriers
- Picotechnology
- Martian Space Elevator

**2069**

HTY

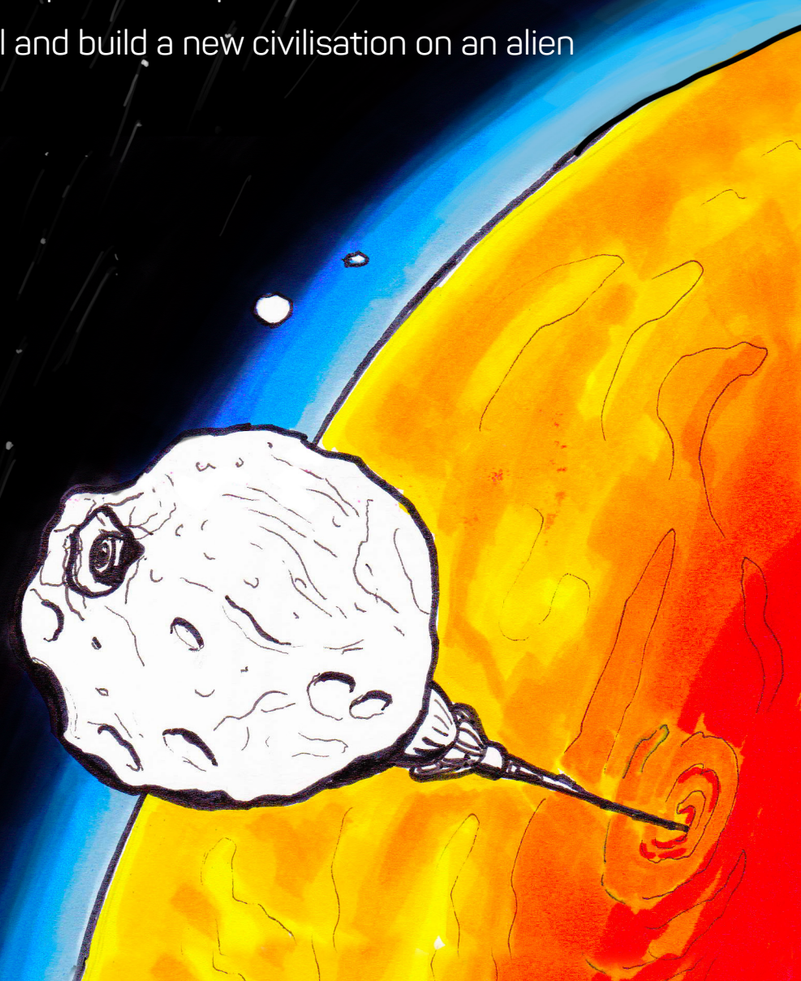
# FALLING INTO HISTORY

We stand at a tipping point in history.
Public interest in space exploration is at its highest since the Apollo missions as private companies and national space agencies compete and cooperate to put the first men and women on Mars.
Even now the world's greatest minds are working to turn this dream into a reality and take humanity across the void of space to stand on alien soil once more.
But when we go to Mars,
we're going to stay.

ENV

# BRAVE NEW WORLD

For years, distant observers on Earth have looked on the Red Planet from afar, predicting intelligent life, advanced civilisations and strange alien structures. Only now that we are here on the surface do we discover the reality is just as strange. Blue sunsets, low  gravity and a harsh climate are a part of daily life on Mars. The challenge and opportunity of this environment requires a unique set of individuals to blaze the trail and build a new civilisation on an alien world.



POP

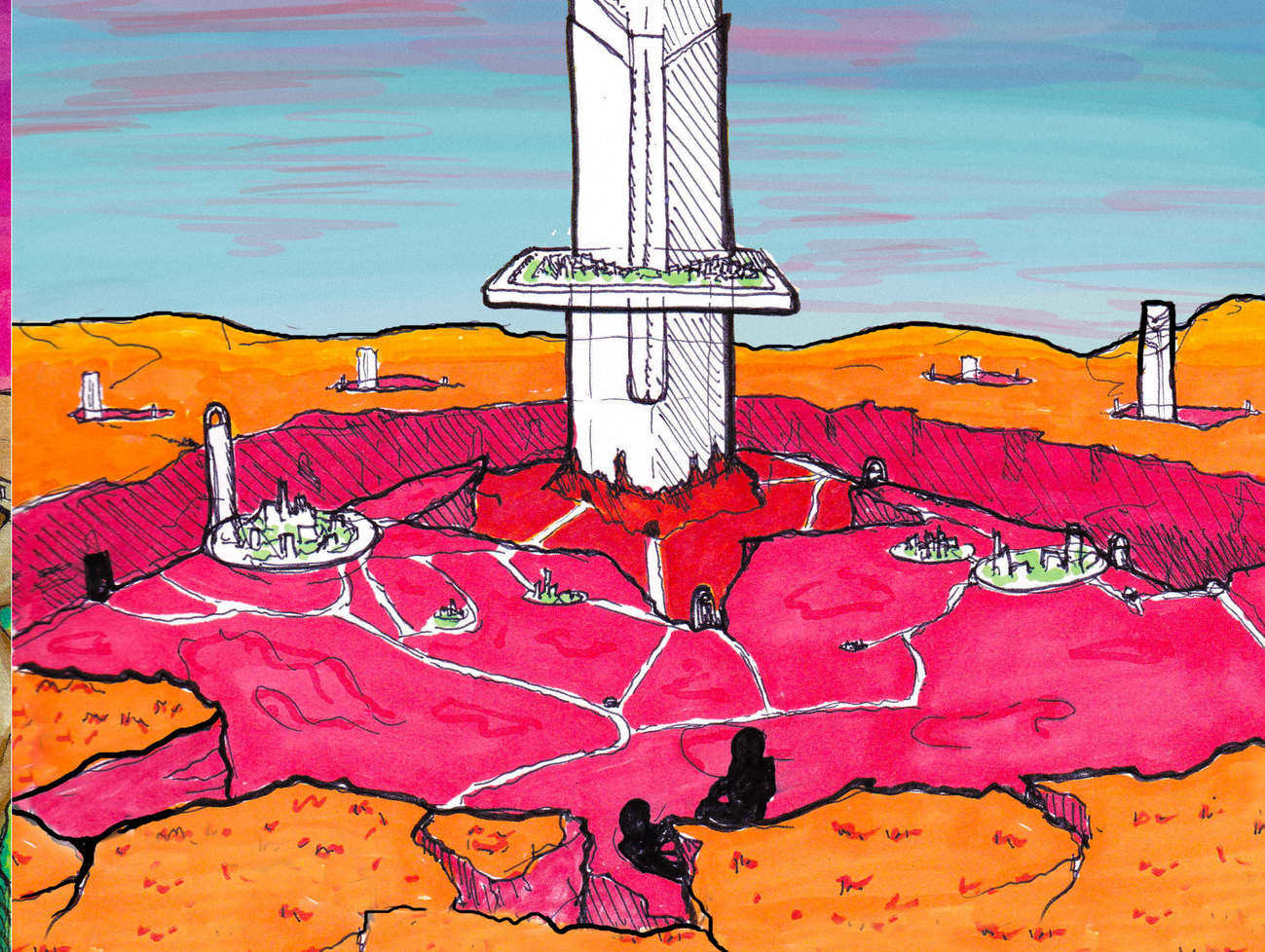
# MARTIAN MELTING POT

Small scale science missions have given way to an intense colonisation effort: men and women from every nation are selling their possessions, travelling across the void of space to begin a new life on Mars. These people are the entrepreneurs, adventurers and pioneers who risk everything to venture out into the unknown.

INF

# LAYING FOUNDATIONS

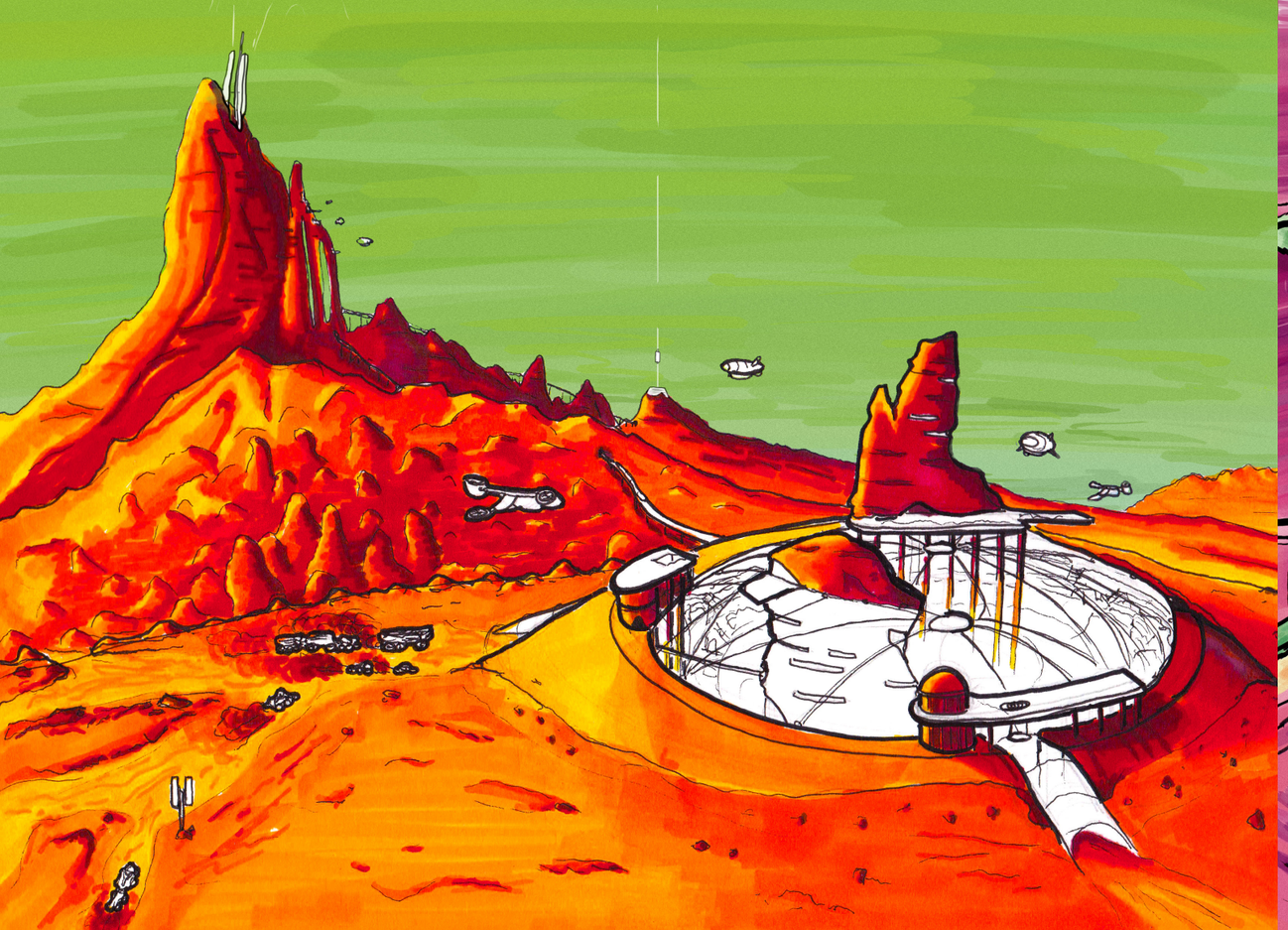
Together they are driven by the united purpose of forging a new land from the wilderness. Traders, missionaries, road builders , engineers, technicians, programmers, surveyors, explorers and scientists work to lay the foundations on which Martian society will stand.



TRS

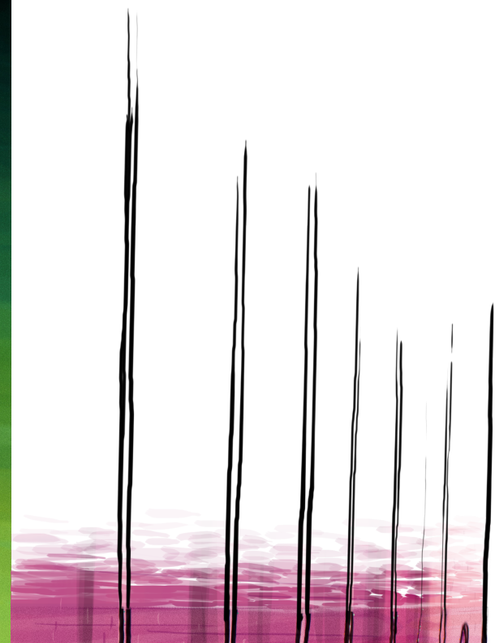
# MOVING THE MARTIANS

New settlements spring to life across the planet, their roots grow rapidly outwards, joining others to form a network of transportation which connects disparate groups of Martians across the vast solitude of the planet.

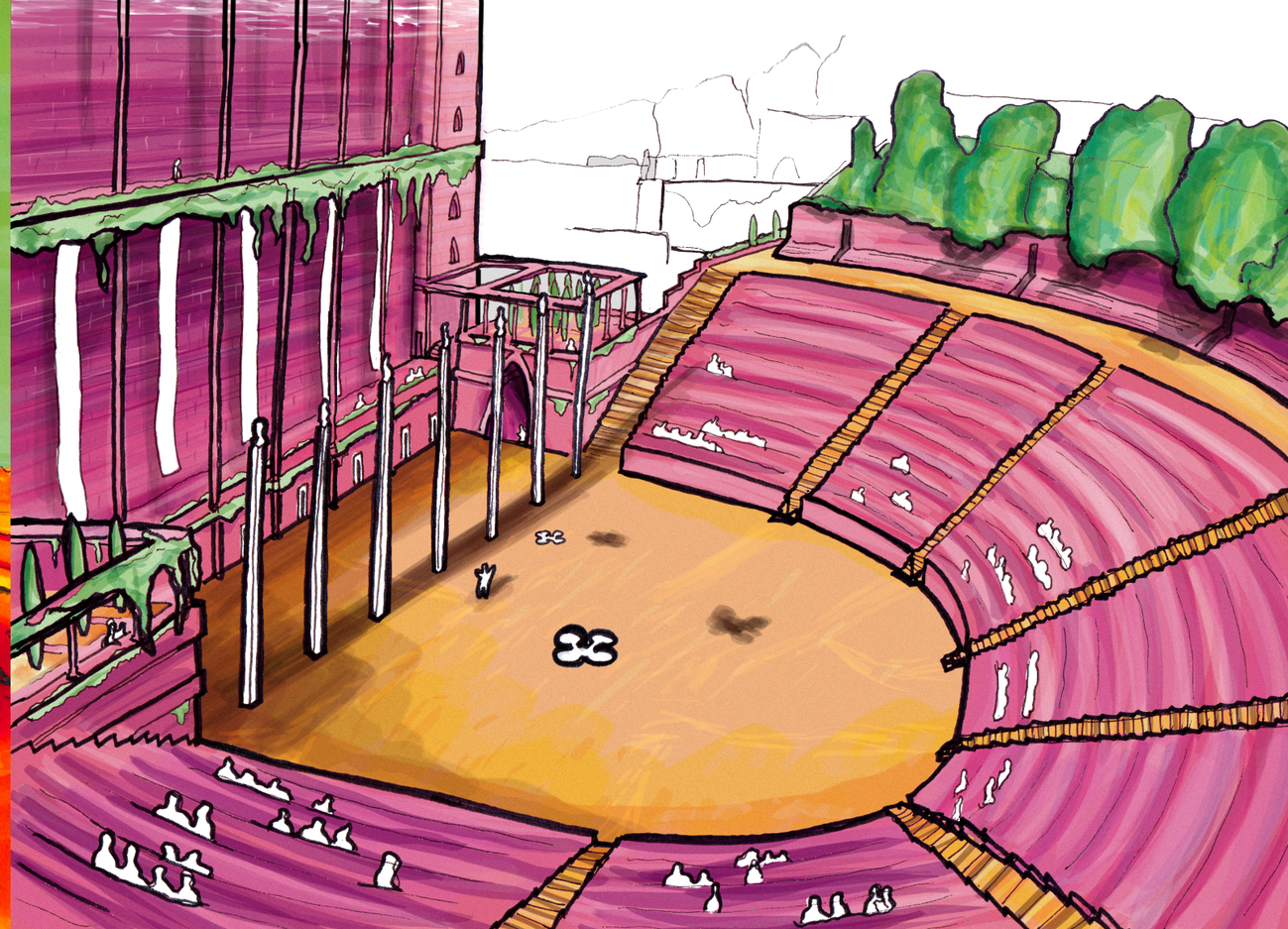


SOC

# NEW WORLD ORDER



From the chaos of this growth comes order: a Martian society emerges with values and customs distinct from those of its originators. The people of Mars no longer identify with the countries of the distant Earth. Mars is their new home, and here they will make their utopia.



CUL

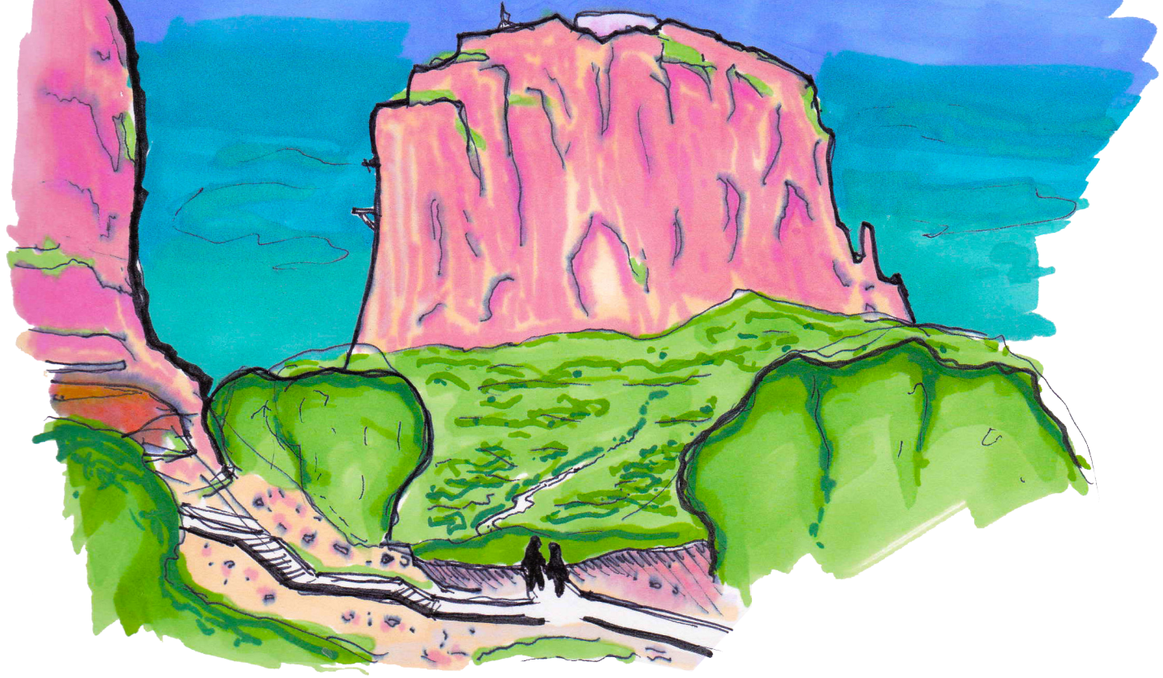
# CULTURAL COLLAGE

Civilization has come to the wilderness and the arts flourish, expressed in new ways through the lens of the Martian environment.

ARC

# NEW WAYS OF LIVING

Architecture is forced to adapt quickly to an influx of settlers with the success of the Martian colonial effort. A new vernacular emerges as a response to unique Martian issues such as radiation, low gravity and thin atmosphere.



**THE YEAR IS 2069**

More than two decades have now passed since the first human explorers set foot on Mars.

The newly completed space elevator atop Olympus Mons and the progression of the ongoing Terraforming has opened the flood gates of colonization and permanent settlements are springing up across the planet to accommodate the incoming settlers.

On Earth Terrans are departing in waves, bound for the red planet from varied backgrounds and for myriad reasons, filled with the promise of the opportunity of a new world and adventure of a new way of life unlike any other.

On Mars the first generation of true Martians are being born into a time of great change; technological advancements and social innovations arrive at a blistering pace, fuelled by adaption to the Martian environment & the work on the Terraforming Project.

The new arrivals mix with the existing population and the emerging Martian generation and the populace thrives on a tide of immigration, commerce and tourism. From this melting pot will grow the seeds of a new society no longer based on Terran values, but on an amalgamation of world cultures, alien environment and Pioneering spirit.

# MANIFESTO

Visualize the form this new Martian society take and how it will adapt to life on Mars.

Suggest how future architects identify and respond to the needs of a Martian Society

# LIFE ON MARS

Life on Mars is a thorough record of investigation into what a future Martian society might look like. What follows is a vision of one possible future based upon a combination of research, projection and postulation. Due to the broad scope and complexity of the issue of life on Mars, a number of subtopics have been identified below. These subjects capture the Martian people and environment, and form a basis for design guidance and constraints for the 5B studio design project.


HTY — Chapter 01 **FALLING INTO HISTORY** HISTORY

ENV — Chapter 02 **BRAVE NEW WORLD** ENVIRONMENT

POP — Chapter 03 **MARTIAN MELTING POT** PEOPLE

INF — Chapter 04 **LAYING FOUNDATIONS** INFRASTRUCTURE

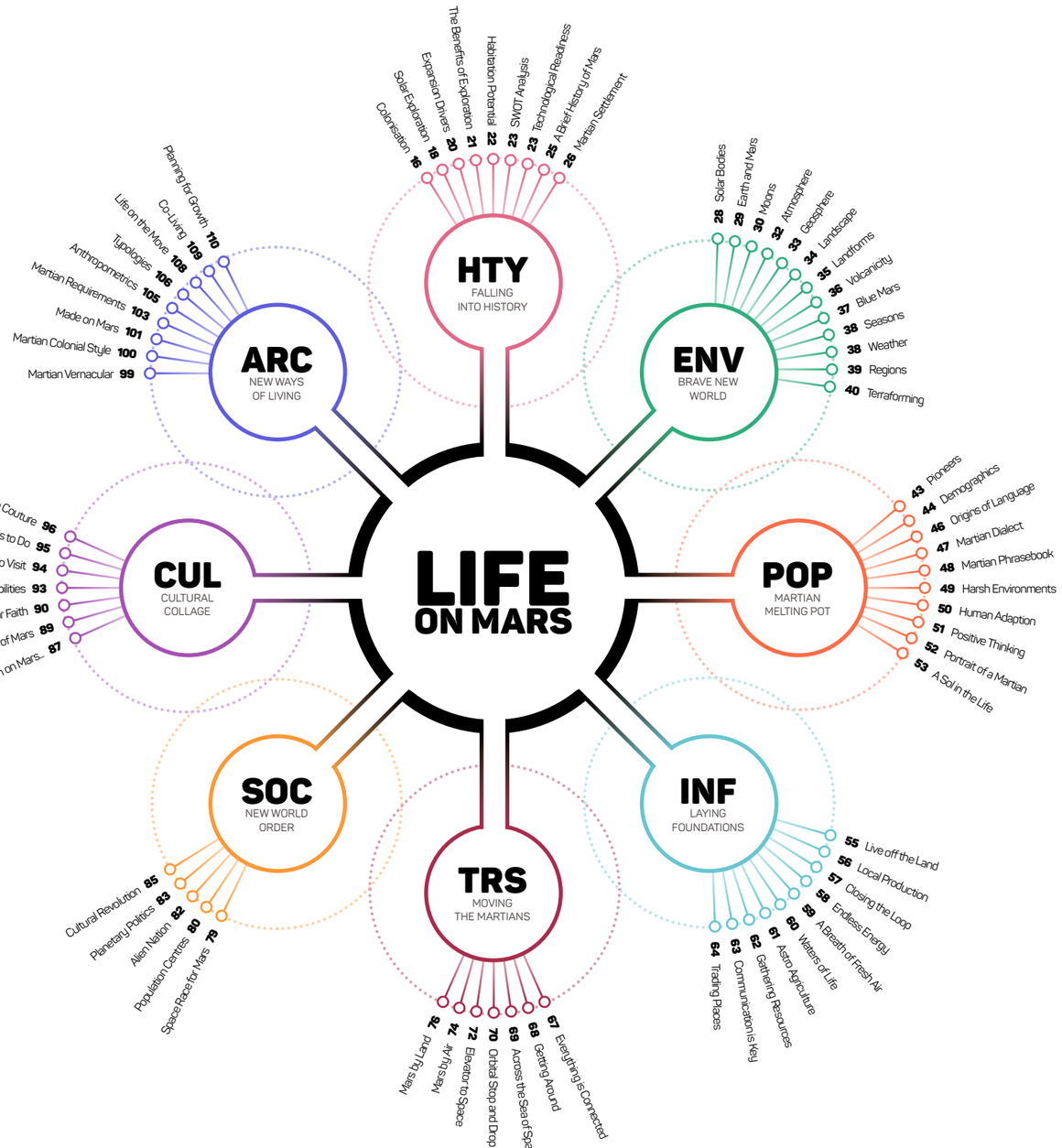
TRS — Chapter 05 **MOVING THE MARTIANS** TRANSPORT

SOC — Chapter 06 **NEW WORLD ORDER** SOCIETY

CUL — Chapter 07 **CULTURAL COLLAGE** CULTURE

ARC — Chapter 08 **NEW WAYS OF LIVING** ARCHITECTURE

# MARTIAN MINDMAP

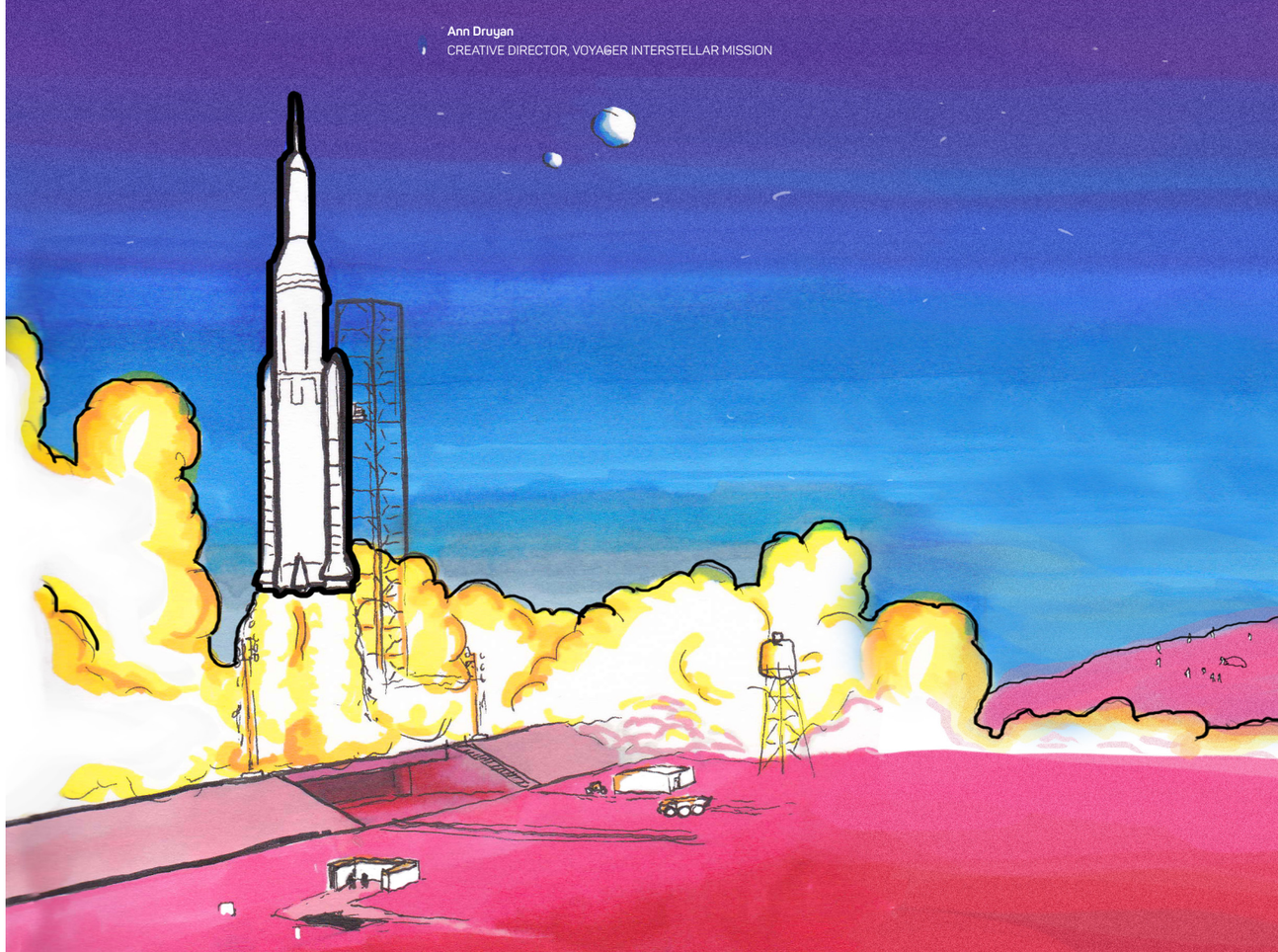



HTY

# FALLING INTO HISTORY

*The first people to stand on the surface of Mars will be experiencing things for our entire species;*
*Things our recent ancestors would never have dreamed possible.*
*It's not science fiction anymore, there are people right this moment planning and working to make this dream a reality.*

**Ann Druyan**
CREATIVE DIRECTOR, VOYAGER INTERSTELLAR MISSION



# 17 COLONISATION

## COLERE
LATIN VERB

to live or dwell in (a place), as a people or animals:

Since the dawn of civilisation mankind has acted upon biological impulse to spread humanity beyond the plains, over the hills, across the sea and beyond.

The diagram below shows the spread of humanity across the surface of the Earth, not in a gradual incline, but in great bursts of parabolic growth.

Just as we always have throughout history, we are now turning our eyes to the next untouched frontier.

## THE NEXT FRONTIER
INTO THE SOLAR SYSTEM

For most of history space has been something enigmatic or philosophical, the subject of mythology or speculation.

Now our grasp finally matches our vision and the solar system will be the next destination for major human expansion.

This colonization drive is set apart from previous efforts typically characterised by violence and exploitation because space, by definition, is devoid of life...

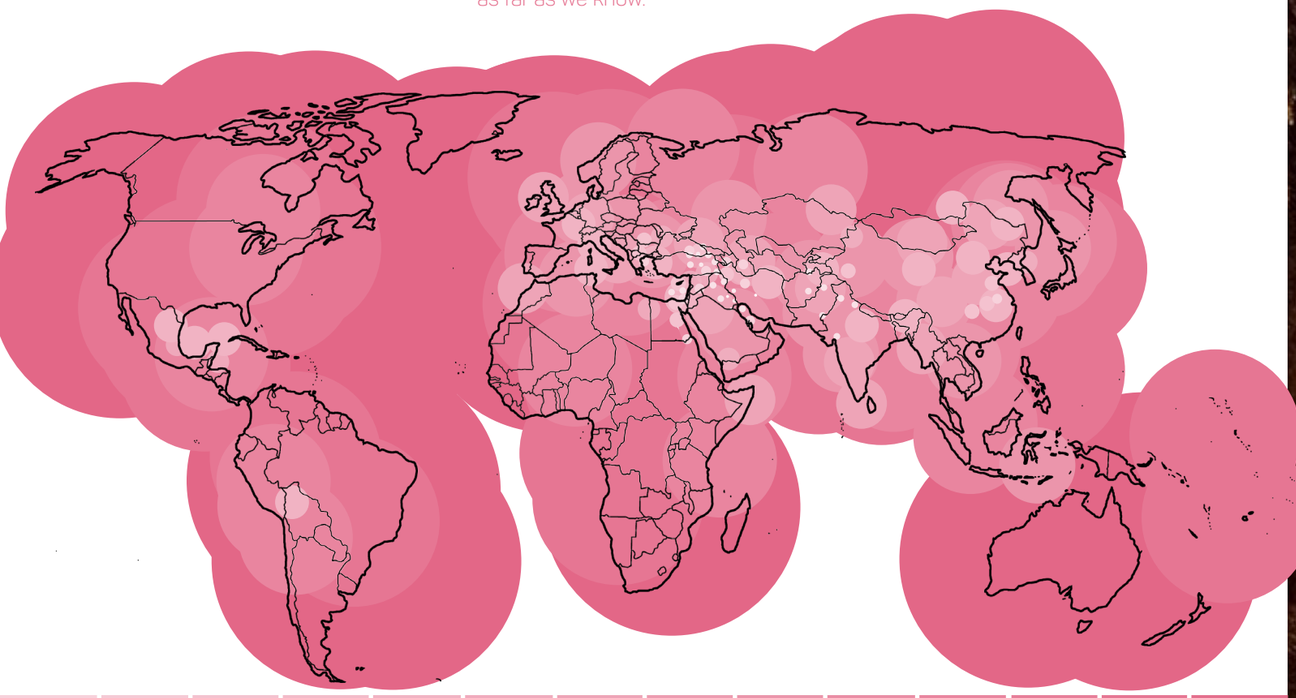
as far as we know.

*How will the future Martians remember our century? They won't remember our names, the recession, the wars. Out of all of history they'll remember the names of the generation that took this amazing step into space.*

**Derek Shannon**
MARS SOCIETY CHAPTER HEAD

FOR MORE INFORMATION SEE

**Pioneers**



**3500 BC** Summerian Civilisation
**3000 BC** Egyptian Dynasty
**2500 BC** Akkadian Empire
**2000 BC** Shang Dynasty
**1500 BC** Turkish Empire
**1000 BC** Chou Dynasty
**500 BC** Persian Empire
**1 AD** Roman Empire
**500 AD** Muslim Conquest
**1000 AD** English Crusades
**1500 AD** Ottoman Uprising
**2000 AD** American Colony, African Landrush, Australian Colony
**2500 AD** Sol Expansion

Kingdom of Israel
Assyrian Empire
Dynasty
Alexander the Great
Indian Golden Age
Viking Expansion
Mongol Invasions
Napoleonic Wars

*We have reached a tipping point in history,*
*Thousands of years from now,*
*whoever we are and whatever we've become,*
*we'll look back at these decades as the time in which*
*we became a mulitplanetary species.*

**Peter Diamandis**
CHAIRMAN, PLANETARY RESOURCES

**Albert Bierstadt**
EMIGRANTS CROSSING THE PLAINS

# 18 SOLAR EXPLORATION

Humans have already begun to push into the frontier of space, and though human exploration is limited to our own orbit and the Moon, we have travelled to the far shores of the solar systems via robots, satellites and cameras in nearly 200 unmanned missions, illustrated on these pages.

**SUN**
**8** missions

**MERCURY**
**2** missions

Messenger

Heading to Mercury, Mariner 10 flew near Venus in 1974, taking images and getting a gravity assist to speed its trip

**VENUS**
**40** missions

2010
2000
1980
1970

Venus flybys

Venus gravity assist (twice)

Earth flyby (twice)

Earth gravity assist

**MOON**
**72** missions

2010
2000
1990
1980
1970
1960

> *When the first humans set foot on Mars the moment will be more significant in terms of technology, philosophy, history & exploration than any that have come before it...*
> *We will no longer be a one-planet species.*
>
> **Stephen Petranek**
> HOW WE'LL LIVE ON MARS

**MARS**
**38** missions

2010
2000
1990
1980
1970

TO OUTER SOLAR SYSTEM

**JUNO:** Launch 8/5/11
**NEW HORIZONS:** Launch 1/19/06
**CASSINI:** Launch 10/15/97
**GALILEO:** Launch 10/18/89

**VOYAGER 1:** Launch 9/5/77
**VOYAGER 2:** Launch 8/20/77
**PIONEER 11:** Launch 4/6/73
**PIONEER 10:** Launch 3/2/72

5W Infographics
COSMIC JOURNEYS

## Space Missions

| SUCCESS | FAILURE | |
|---|---|---|
| | | NASA |
| | | USSR |
| | | Europe |
| | | Japan |
| | | China |
| | | India |

**1961**
I see Earth. it is so beautiful!
YURI GAGARIN

The Soviets were the first to put a human in space, then the first to reach the Moon, crashing Luna 2 into the surface in 1959.

**1969**
That's one small step for a man, one giant leap for mankind
NEIL ARMSTRONG

Russia's success lead to President Kennedy's space programme and culminated in Neil Armstrong's Giant Leap for Mankind.

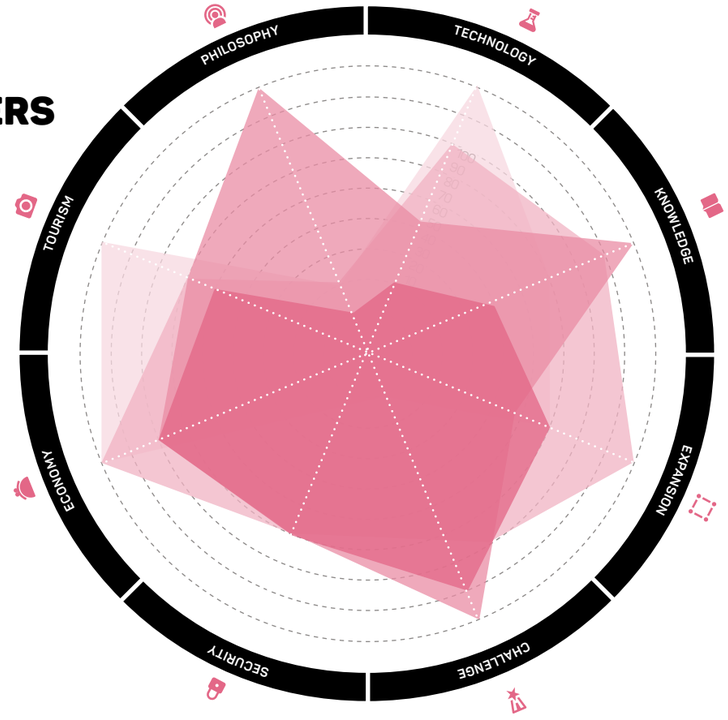
**2035**
—
???

No human has left Low Earth Orbit since 1972. The next great milestone will to be to put mankind on Mars.

Who will be the first to set foot on the Red Planet, and how will the world respond?

# 21 EXPANSION DRIVERS

The drivers of solar exploration vary depending on mission goals but the motivations of each group will have a huge impact on the development and priorities of colonies on Mars, which will eventually develop into political views.




### FACTIONS

- POLITICAL PARTIES
- PUBLIC COMPANIES
- PRIVATE COMPANIES
- NGOS

### MOTIVATORS

**Technology**
Historically, war and colonisation have been catalysts for change and drivers of technological advancement.
New circumstances and environmental pressure force innovation.

**Knowledge**
Whilst war and expansion lead to practical solutions for immediate problems, exploration develops human knowledge of the universe. This knowledge and questioning spirit is less tangible, but vital to the advancement of humanity and science.

**Expansion**
Mars provides an opportunity to fulfil the desire of human expansion into the solar system, acting as a base for further colonisation and for space mining and tourism operations.

**Challenge**
Societies require challenge to grow and stagnate without. Martian colonisation would drive intellectual capital, encourage science and increase perceived political standing, similar to how Kennedy's Lunar program galvanised America in the 1960's.

**Security**
Colonisation of Mars provides protection from natural disasters and collapse of Earth in a distant future, but more immediately provides advances in protection from asteroid collision, radiation damage and extreme weather.

**Economy**
Whilst the economy is initially limited due to the difficulty of export, many private space exploration companies profit from this, and a long term view of ownership and monopoly will encourages private investment.

**Tourism**
As the cost of transportation and the risks reduce space tourism will become exponentially more accessible from wealthy thrillseekers to holiday makers and travellers.

**Philosophy**
Are We Alone? Mars may hold the answer.
If the conditions exist for life but it hasn't arisen by itself, then life is not a natural process and is likely unique to Earth.
If life is found on Mars then statistically it means that life in the universe is so abundant that intelligent alien life is also likely.

# 22 THE BENEFITS OF EXPLORATION

- SEARCH AND RESCUE
- FLOOD MONITORING
- POLLUTION CONTROL
- BIODEGRADABLE MATERIALS
- REFRIGERATOR EFFICIENCY
- FOOD SAFETY
- CORDLESS TOOLS
- SMOKE DETECTORS
- PACEMAKERS
- TEFLON COATED FIBREGLASS
- CAMERA PHONES
- SCRATCH RESISTANT LENSES
- CAT SCANNERS
- MEDICAL ULTRASOUND
- CLEAN ROOM APPAREL
- PRECISION DIALYSIS
- HEART RATE MONITORS
- PHASE CHANGE MATERIALS
- LEDS
- LAND MINE REMOVAL
- FOIL BLANKETS
- WATER PURIFICATION
- EAR THERMOMETER
- HOME INSULATION
- RESCUE CUTTERS
- SATELLITE PHONES
- PLASMA DISPLAY
- PROTECTIVE HELMETS
- VOICE CONTROL
- WIRELESS HEADSET
- MEMORY FOAM
- FREEZE-DRIED FOOD
- BABY FORMULA
- ARTIFICIAL LIMBS
- CHEMICAL DETECTION
- COMPUTER MOUSE
- LAPTOPS
- ANTI-ICE SYSTEMS
- FIRE RESISTANT STEEL
- SOLAR PANELS
- HIGH GRIP TYRES
- ROAD SAFETY
- ...

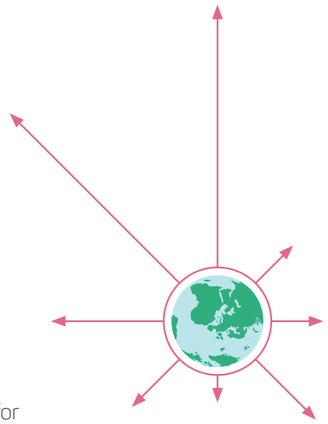
> *By refocusing our space program on Mars, we can restore a sense of wonder and adventure in space exploration. Looking down the road, space exploration and the benefits it yields to science - in medicine and information technology - should not be overlooked.*

**Buzz Aldrin**
NASA SPACE SCIENCE ADMINISTRATOR

Whilst many would argue that space travel is a whimsical fancy, a huge expense that Earth can ill afford given the vast array of problems here at home, the tangible benefits of space exploration are often overlooked. Many of the technologies we use today are directly related to the lunar program and other space exploration related research. These technologies range from medical applications to life saving products and environmental improvements.

What other improvements and technologies might we develop as a result of the complex problem of creating a permanent society on Mars?

# HABITATION POTENTIAL



As a speculative exercise, many scientists have attempted to identify and rate the most attractive solar bodies for habitation using a variety of methods and inputs, scoring planets based on proximity to the goldilocks zone, similarity to Earth, availability of resources, distance from Earth and many other important factors. The chart below combines many of these factors to give an approximate overview of the best potential candidates for colonization.

| | LOCATION | Atmosphere Toxicity | Habitable Area | Weather Extremity | Resource Richness | Distance from Earth | Water Presence | Radiation Exposure | Temperature Range | POTENTIAL |
|---|---|---|---|---|---|---|---|---|---|---|
| Year Length<br>Day Length<br>Surface Temp<br>Earth Similarity Index<br>Gravity relative to Earth<br>Habital Zone Distance | | | | | | | | | | |
| 88 days<br>1,407h 30m<br>167 °C<br>0.438 ESI<br>3.8G<br>-165 | Mercury | 0 | 1 | 1 | 8 | 9 | 6 | 1 | 1 | 3 |
| | | This world is too toxic and hostile to consider, despite rich valuable metals and the presence of polar ice. | | | | | | | | |
| 243 days<br>2,802h<br>464 °C<br>0.817 ESI<br>9.07G<br>-105 | Venus | 4 | 8 | 2 | 5 | 10 | 7 | 1 | 3 | 5 |
| | | Whilst the surface is too hostile, opportunity exists for floating cloud cities in the high atmosphere where winds are less severe | | | | | | | | |
| 687 days<br>24h 40m<br>-63 °C<br>0.658 ESI<br>0.38G<br>+0.43 | Mars | 7 | 10 | 6 | 7 | 10 | 7 | 6 | 7 | 8 |
| | | Although conditions are harsh, Mars is the best candidate for colonisation based on natural resource and similarity to Earth | | | | | | | | |
| 4,333 days<br>9h 56m<br>N/A<br>0.161 ESI<br>2.36G<br>+716 | Jupiter | 1 | 0 | 0 | 8 | 3 | 9 | 0 | 0 | 2 |
| | | Intense radiation largely rules out life on Jupiter, but many of her moons have potential for robotic mining of heavy metals. | | | | | | | | |
| 10,759 days<br>10h 39m<br>N/A<br>0.181 ESI<br>0.92G<br>+15.11 | Saturn | 4 | 0 | 0 | 9 | 2 | 9 | 3 | 0 | 3 |
| | | Saturn is vital for the pending fusion economy with vast reserves of Deuterium, but colonising her moons is more feasible. | | | | | | | | |
| 30,688 days<br>10h 42m<br>N/A<br>0.288 ESI<br>0.90G<br>+32.80 | Uranus | 1 | 0 | 2 | 7 | 1 | 10 | 1 | 0 | 2 |
| | | Mining sites for Helium-3 have been proposed. With a low escape velocity, one of Uranus's natural satellites might serve as a base. | | | | | | | | |
| 60,182 days<br>16h 6m<br>N/A<br>0.284 ESI<br>1.12G<br>+52.68 | Neptune | 1 | 4 | 1 | 9 | 0 | 10 | 1 | 0 | 3 |
| | | Concepts have been proposed for submerged ocean colony pods in air pockets underneath the ice over geothermal sites. | | | | | | | | |
| OTHER | | | | | | | | | | |
| | The Moon<br>Titan<br>Europa<br>Pluto<br>Eris<br>Ceres<br>Ganymede<br>Callisto<br>Asteroids<br>manmade | Many believe the best location for a space colony is not on a planet at all, but on the many other objects that inhabit our solar system: asteroids, moons, dwarf planets or artificial satellites could all provide habitability in space. Smaller bodies could be manipulated to provide artificial gravity through centrifugal force, with sub surface spaces for colonies. | | | | | | | | | 8 |



# SWOT ANALYSIS

**S**

**24hr Day**
required for plants

**Water Presence**
Water can be mined from ice caps and regolith

**Resource Presence**
Many materials needed for manufacturing can be found on Mars

**Public Interest**
Public interest is currently high so political will can be created

**W**

**Environment**
Living on Mars will be very difficult

**Budget**
There are many issues on earth which require money and resources to solve.

**Complication**
The mission is very complex and will require a huge amount of research and development.

**O**

**Fresh Start**
No need to rely on old traditions or protocols, can rethink things from scratch

**Fresh Start**
No need to rely on old traditions or protocols, can rethink things from scratch

**New technology**
Spin off tech and knowledge, as well as intellectual capital as a result of a Mars colony

**International Cooperation**
Will promote cross nation relations, particularly between US and Russia

**Future Exploration**
Creates platform for future space missions and exploration of solar system

**The Life question**
Mars offers an answer to the question: Are We Alone?

**T**

**Cost**
High investment required and may be too high

**Environment**
Harsh environment may cost lives

**Political**
Mars colony will take a long time, whereas political will is short lived between election terms

**Distance**
Mars is so far away that Martians will inevitably become alienated from Earth and eventually crave independence.

# TECHNOLOGICAL READINESS

Technological Readiness Levels were developed by the European Association Research and Technology Organisations (EARTO). They are used by scientists and businesses to estimate how feasible a concept is using current technologies, enabling consistent and uniform discussion of technological maturity across various disciplines in research.

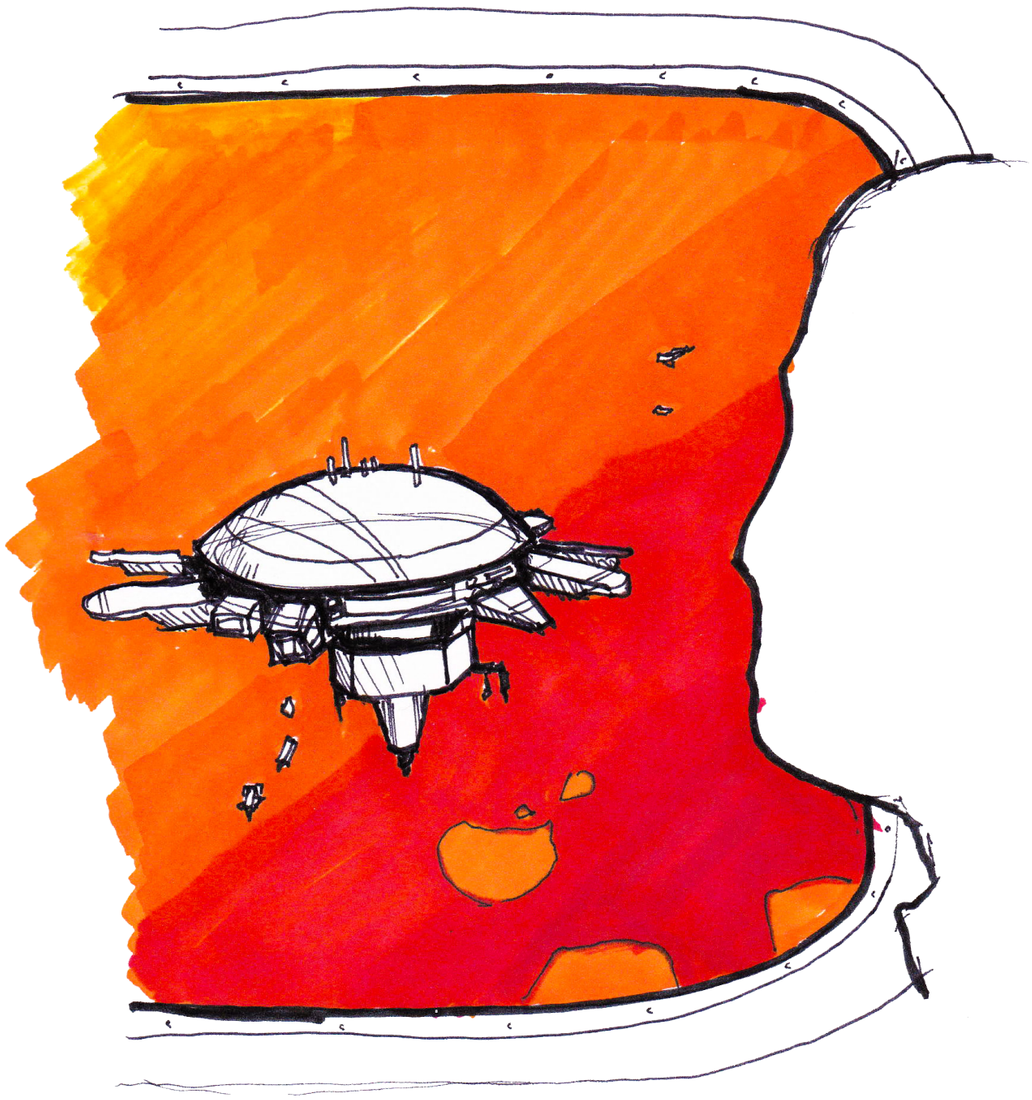
real world
- 09 — Working tech proven through use in an operation environment
- 08 — Working tech proven through tests and demonstations
- 07 — Prototype demonstrated in an operation environment

simulation
- 06 — Prototype demonstrated in a simulated environment
- 05 — Component prototype in a simulated environment

laboratory
- 04 — Component prototype in a laboratory environment
- 03 — Proof of concept tested in a laboratory environment
- 02 — Technology concept developed and formulated
- 01 — Basic research and observation
- 00 — Concept with no testing

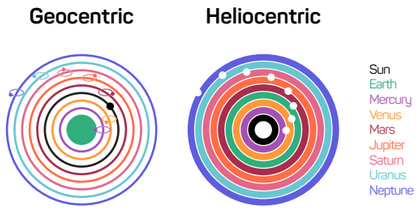
*It's not a vacation.*
*It's saving up & selling all your stuff,*
*like the early American colonies.*
*It's the excitement and novelty*
*of founding a new land.*
*It's an experience that stopped being possible on Earth centuries ago.*

**Elon Musk**
SPACE X



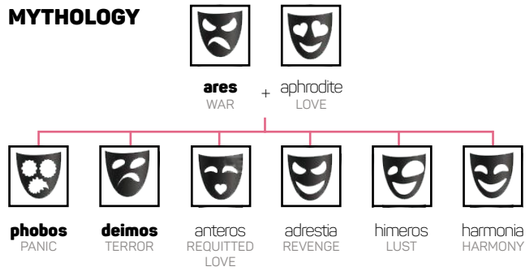
# 26 A BRIEF HISTORY OF MARS

## ASTRONOMY



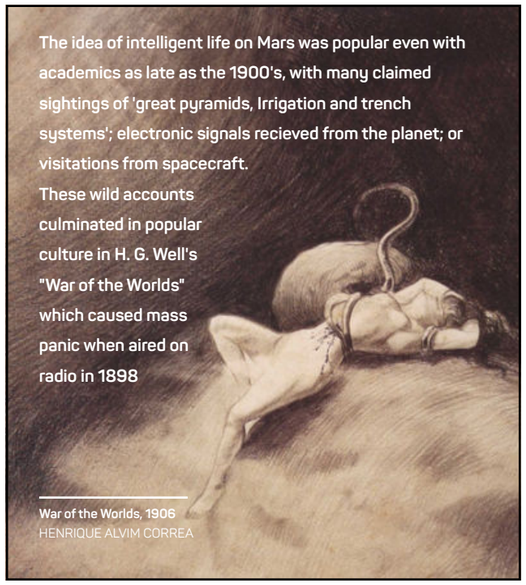

The standard Heliocentric model we use today wasn't accepted until the 1500's. The ancient Greeks used the flawed Geocentric model which considered Earth the centre of the Solar System, despite Mars occasionally seeming to move backwards which was explained by planets having their own "epicycles", or minature orbits.

## MYTHOLOGY




Mars was named for the roman god of war, due to its reddish appearance and connotations of blood, violence and passion. The ancient mythology of the planet has seen a modern revival in fashion, literature and art as Martian culture develops with a strong sense of national pride and identity.

## IN CULTURE



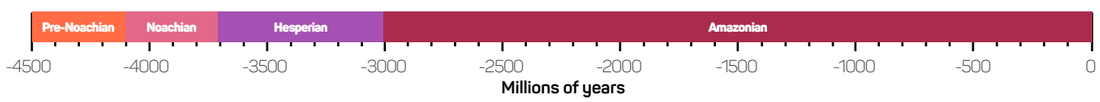

Mars has always been a popular topic for the arts, despite popular fancies of water, canals and intelligent life being dispelled by the Mariner and Viking missions.

> *Another name for Mars is the Red Planet.*
> *If you've ever seen it in the sky when the planet is bright and close to Earth, it appears like a bright red star. In Roman mythology, Mars was the god of war, so think blood.*

**Fraser Cain**
AUTHOR, UNIVERSE TODAY

Typical Martian literature often features rebellion, war and adventure such as H.G. Well's *War of the Worlds* (1898) or C. S. Lewis' Out of the Silent Planet (1938). More recently, as the fiction of a Martian colony becomes reality a number of modern renditions focus more on social or environmental aspects such as *The Martian* (2015) and SyFy's *The Expanse* (2016).

## TIME PERIODS



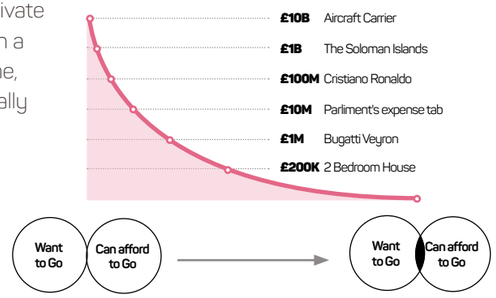
# 27 MARTIAN SETTLEMENT

## SETTLEMENT PLAN

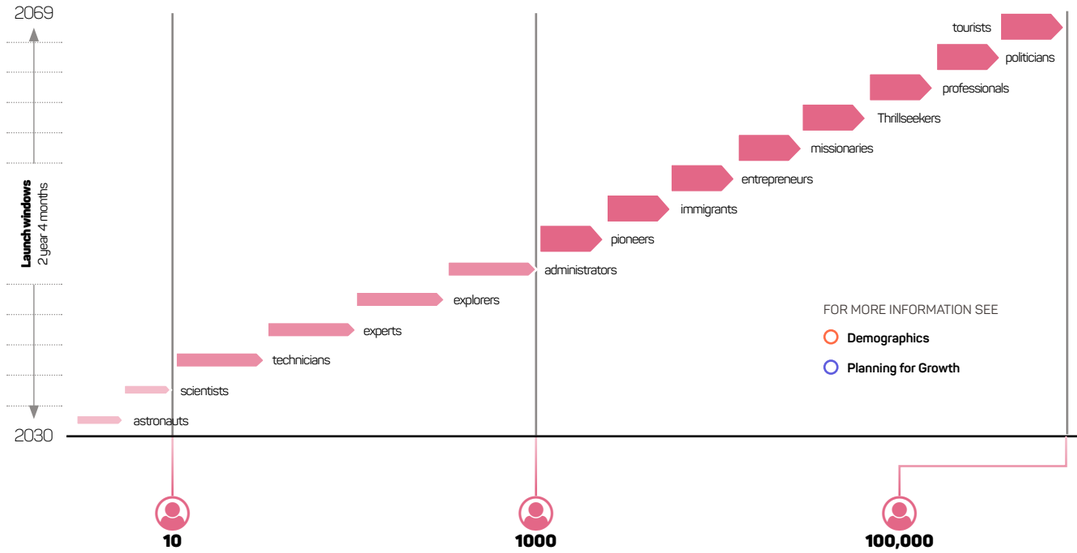
While NASA plans to send astronauts to Mars for science missions, private ventures such as Mars Direct, Mars One and Space X wish to establish a permanent colony on the planet which will grow exponentially with time, develop into a society and attract more settlers, business and eventually tourism.

For the first waves of settlers, moving to Mars will be a monumental decision, requiring lifesavings and sale of all personal possessions to start anew on Mars.

## COST PER PERSON




As the colony progresses economies of scale, technological development and reuse of infrastructure will bring costs down to more manageable levels encouraging further growth and development. As costs fall the nature of the people coming to Mars will change, from nationally funded efforts to more private or personal ventures, with a larger quanitity of people arriving and returning with each trip as infrastructure is improved.




**STAGE 1**
**Exploration**
Establish temporary habitats for short term stay by science team and astronauts

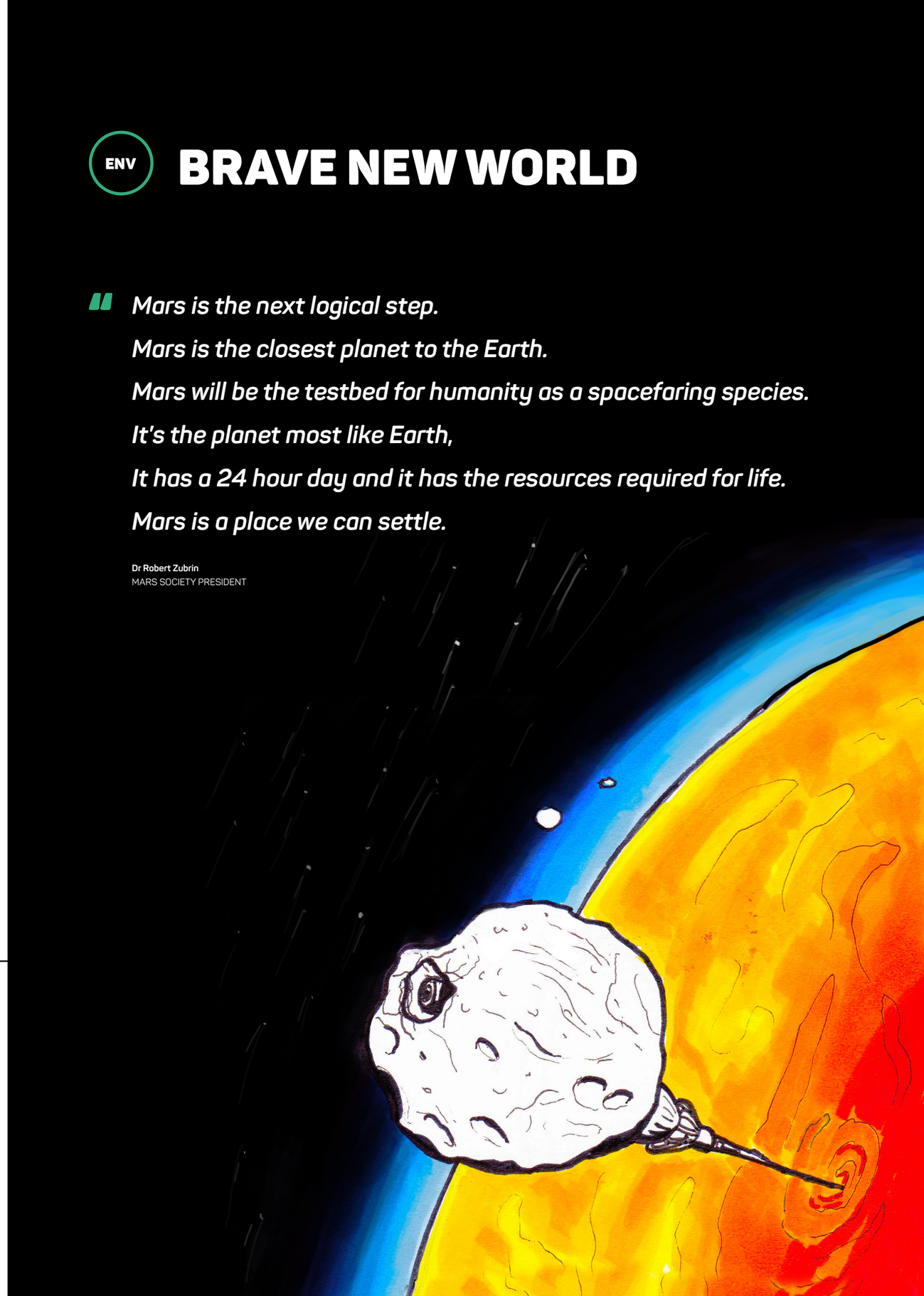
**STAGE 2**
**Colonisation**
Establishment of permanent colonies and infrastructure for growth and expansion

**STAGE 3**
**Formation of Society**
Establish commerce, tourism and industry to sow the seeds of a new Martian culture

# ENV BRAVE NEW WORLD

*"Mars is the next logical step.*
*Mars is the closest planet to the Earth.*
*Mars will be the testbed for humanity as a spacefaring species.*
*It's the planet most like Earth,*
*It has a 24 hour day and it has the resources required for life.*
*Mars is a place we can settle.*

**Dr Robert Zubrin**
MARS SOCIETY PRESIDENT



# 29 SOLAR BODIES

PLANETS

- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn
- uranus
- Neptune
- Planet X

OTHER BODIES

- The Sun
- Comets

ASTEROID GROUPS

- Kuiper Belt
  - "Trojans"
  - "Hildas"
  - "Greeks"
- Main Belt
- Oort Cloud

MOONS

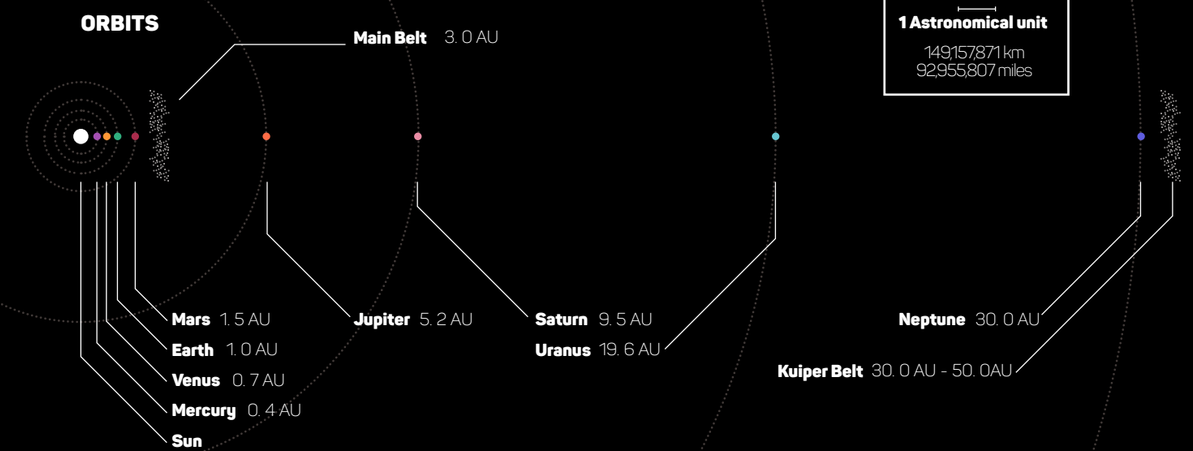
- The Moon
- Deimos
- Phobos
- Ganymede
- Callisto
- Io
- Europa
- Titan
- Enceladus
- Titania
- Overon
- Umbriel
- Ariel
- Triton

DWARF PLANETS

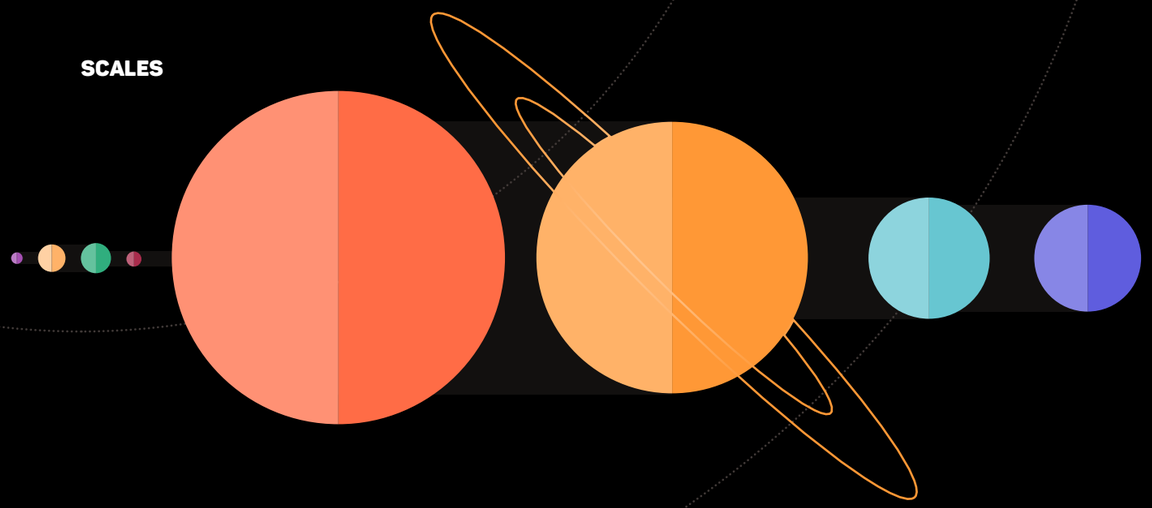
- Pluto
- Ceres
- Eris
- Haumea
- Makemake
- DeeDee

**1 Astronomical unit**
149,157,871 km
92,955,807 miles

## ORBITS

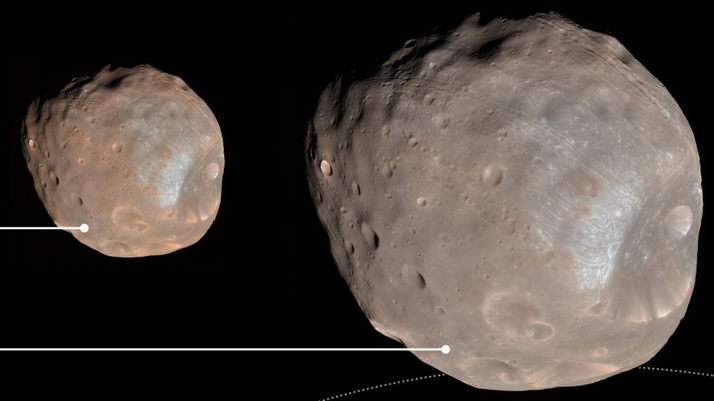



## SCALES



# 30 EARTH AND MARS

# 31 MOONS



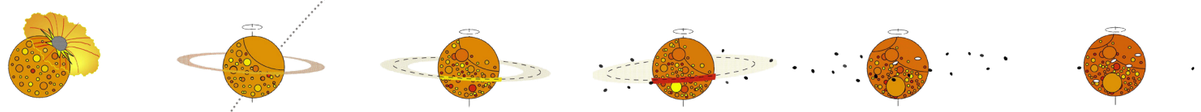
**Deimos**
GOD OF PANIC

**Phobos**
GOD OF TERROR

> *Deimos had just disappeared over the frozen ice wall of Chasma Borealis. Those on the base spent long hours in the purple twilight operating the robotic ice miners.*

**Kim Stanley Robinson**
RED MARS

## ORIGINS



**01** Planetesimal collides with Mars, vaporizing material and associated large impact basin is formed. Angular momentum imparted to the surface gives Mars its final spin rate.
Vaporized material forms an accretionary disk.

**02** Materials dissipate past the Roche limit of Mars (dashed line) and begin to coalesce into small moons.

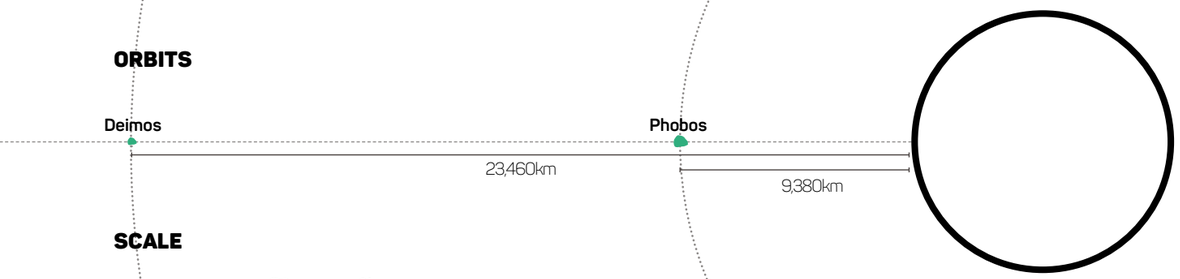
**03** Moons continue to form until accretion disk is exhausted. Only Deimos forms outside synchronous rotation.

**04** Accretion disk completely dissipates. Dozens of small moons are left orbiting Mars. Tidal perturbations cause these moons to fall back towards the Martian surface forming grazing impacts (white ellipses).

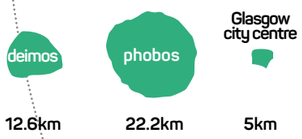
**05** Development of the Tharsis bulge causes the orbital plane to precess.

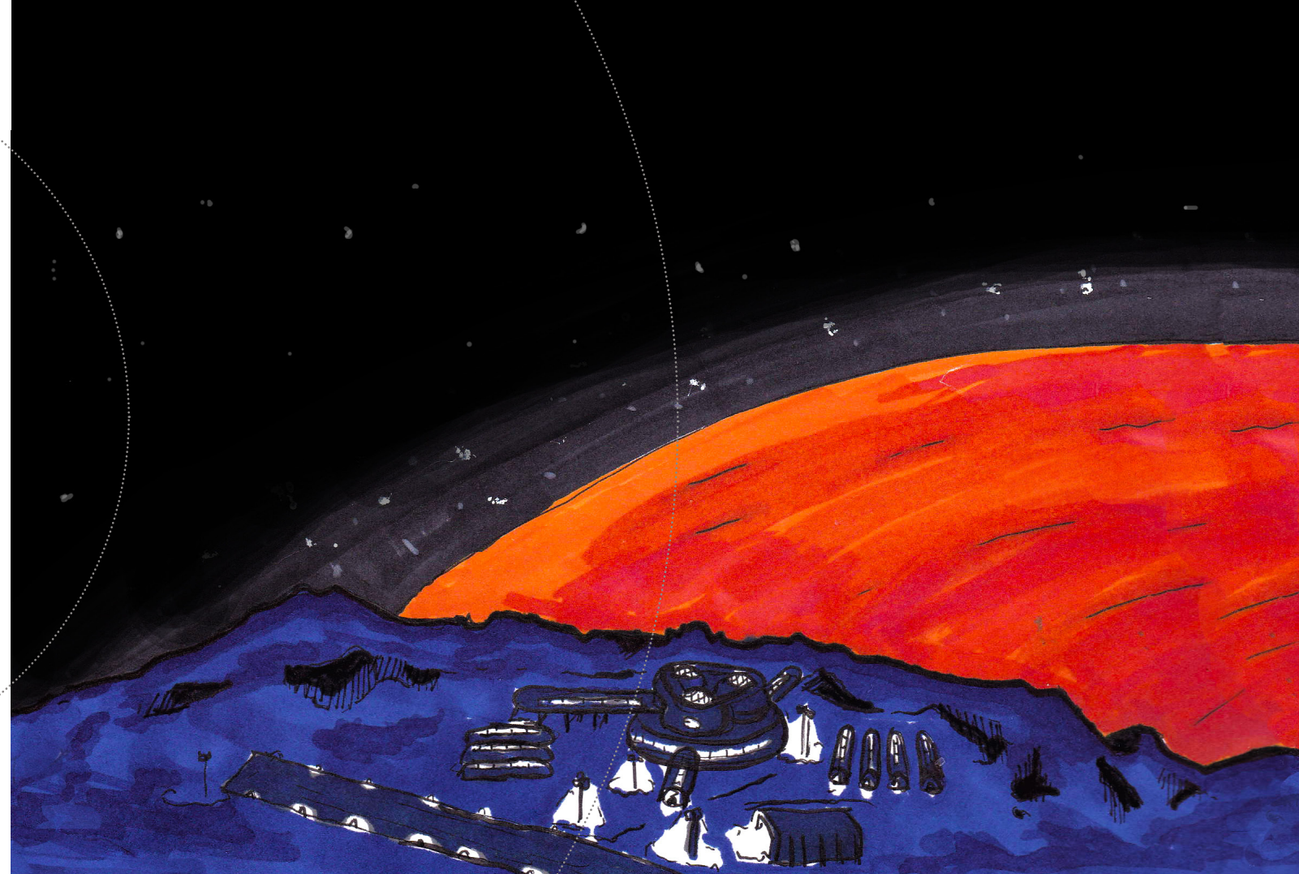
**06** Present Martian system with only Phobos and Deimos in orbit.

## ORBITS



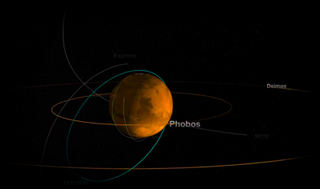

## SCALE



# 33 ATMOSPHERE

GRAPHICS BY NASA

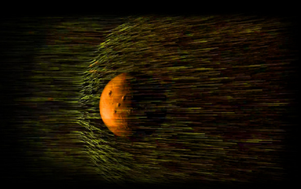



### Maven Probe

Maven probes sent to Mars to study upper atmosphere and gravitational field

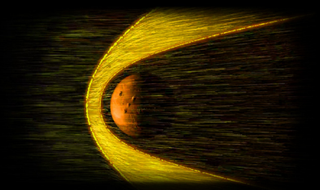
### Gravitational Field

Continual loss of atmosphere identified , resulting in early Mars drying up.



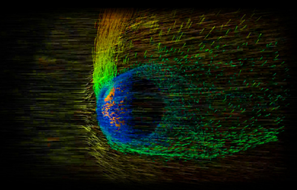
### Solar Wind

Cause thought to be "Solar Wind", a stream of positively charged particles from the Sun called "Solar Wind"



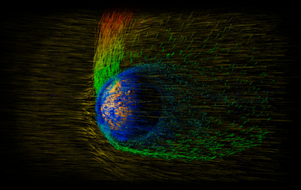
### Bow Shock

Solar wind reacts with upper atmosphere piling up in "Bow Shock"



### Charged Ions

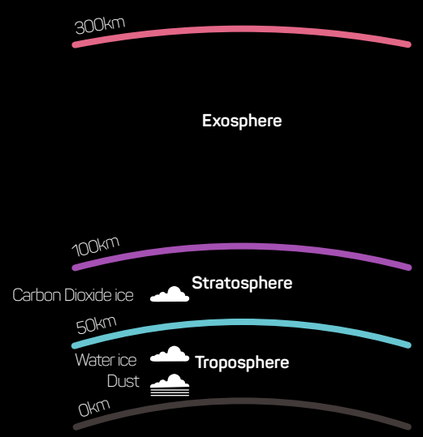
Charged ion particles are pulled by electric field generated by solar wind



### Atmosphere Erosion

Ion particles gather sufficient energy and are swept into space by solar wind

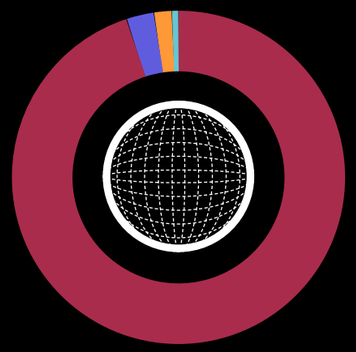
## ATMOSPHERIC LAYERS




The atmosphere of Mars is very thin due to Solar Wind erosion, however it contains many of the building blocks required for life and extraction of Oxygen and other valuable gases from the atmosphere has already been proven as feasible.

| | | |
|---|---|---|
| $CO_2$ | Carbon Dioxide | 95% |
| $N_2$ | Nitrogen | 2.70% |
| Ar | Argon | 2.10% |
| $O_2$ | Oxygen | 0.14% |
| | Other | 0.06% |

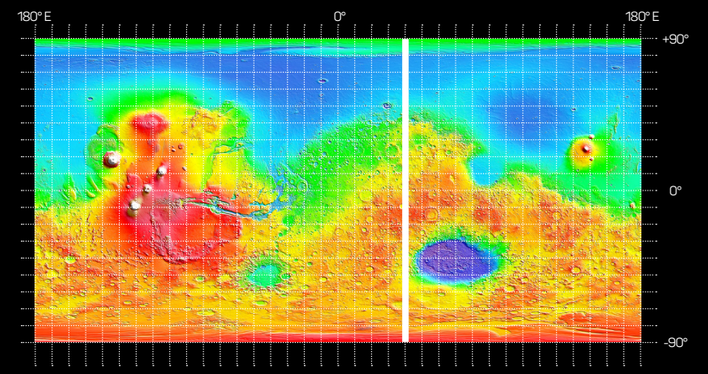
## ATMOSPHERIC COMPOSITION



# 34 GEOSPHERE

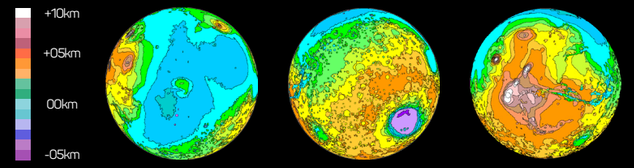
## CRUSTAL THICKNESS

Mars features a striking geological asymmetry, with a noticeable slope from the north polar region to the south. It is speculated that the  northern lowlands might actually be one giant impact basin.

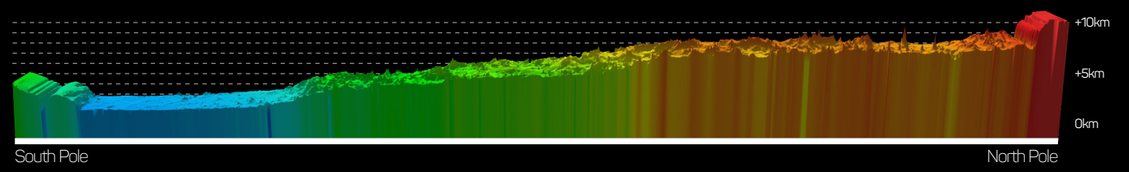



## ELEVATION

These colour coded elevation maps measured by NASA's MOLA show the varied topography of Mars, revealing large, ancient valley networks and outflow channels which once likely held liquid water.

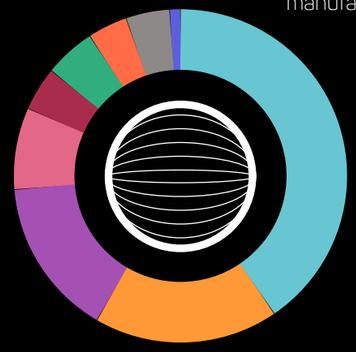



The variety of Martian landscape is striking: northern plains carved by lava flows meet the southern highlands, cragged and pocked by ancient impacts, in stark contrast. The surface of Mars as seen from orbit can be summarized in two different albedos; the plains are flat and pale, covered with Iron rich red oxides and from a distance appear as 'continents'. The rougher terrain of the south appear darker from orbit and were once thought of as 'seas'. They could be seas once more...



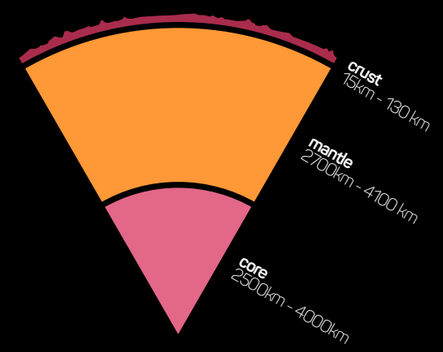

## SURFACE COMPOSITION

The soil and atmosphere of Mars contain many of the main elements crucial to life, as well as many materials used for manufacturing and production.

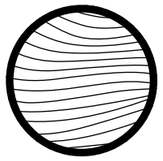


| | | |
|---|---|---|
| $O_2$ | Oxygen | 40 - 45% |
| Si | Silicon | 18 -25% |
| Fe | Iron | 12- 15% |
| K | Potassium | 8% |
| Mg | Magnesium | 3 - 6% |
| Ca | Calcium | 3 - 5% |
| S | Sulphur | 2 - 5% |
| Al | Aluminium | 2 - 5 % |
| Cs | Caesium | 0.1 - 0.5% |

## GEOLOGICAL STRUCTURE



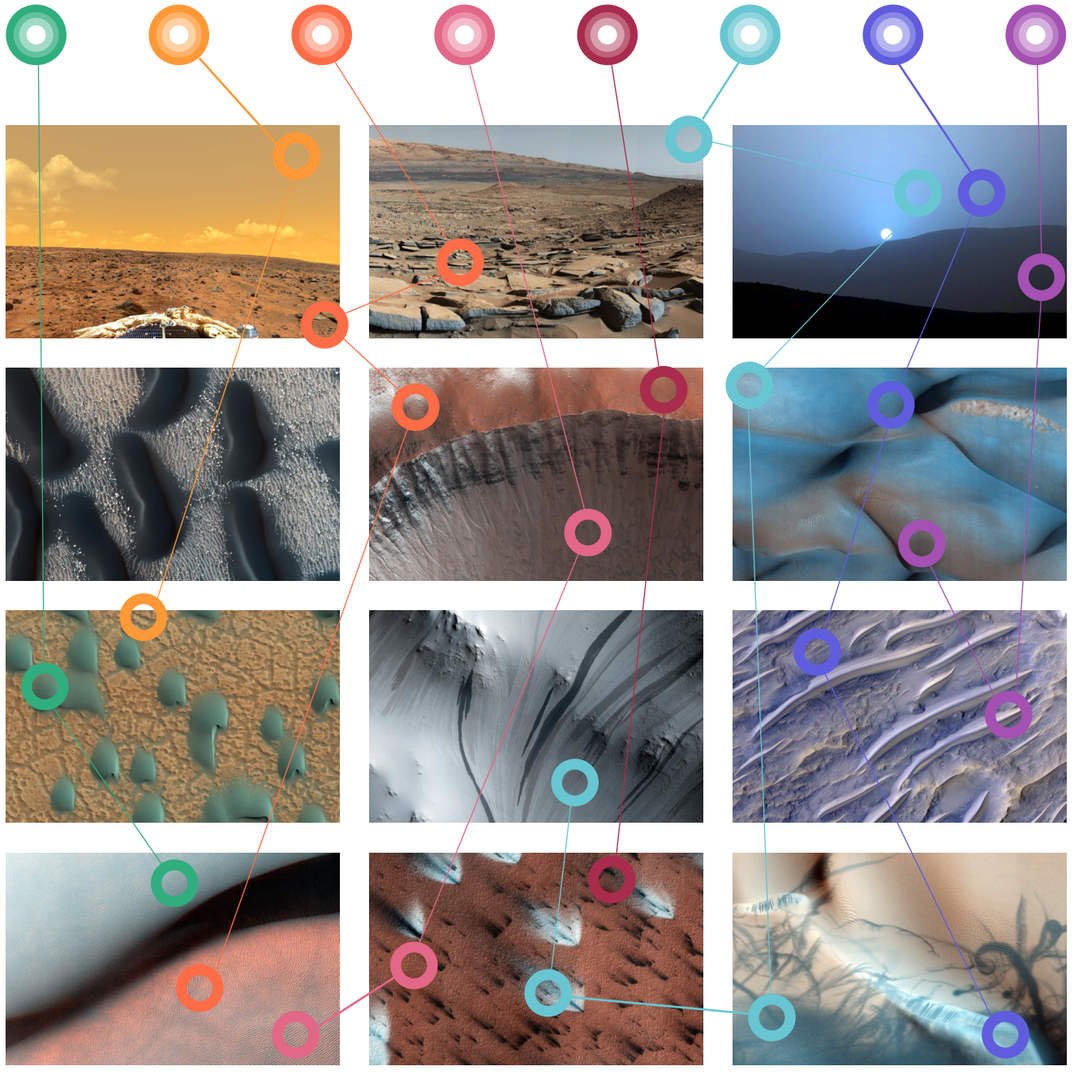
# LANDSCAPE



## COLOUR PALETTE

> *Dawn stained the sky rich berry colours for a few minutes before shifting rapidly through a series of rosy tones to the thick pink and orange of daytime.*

**Kim Stanley Robinson**
RED MARS





# LANDFORMS

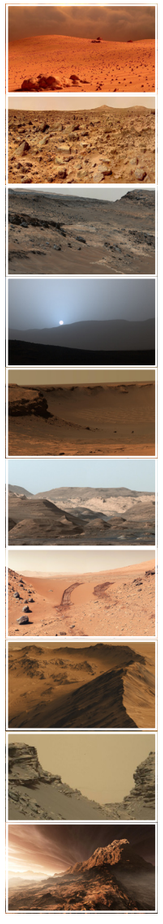
## NOMENCLATURE

The system used to name planetary features discovered on Mars by explorers, satellites or rovers.

| | | |
|---|---|---|
| LARGE CRATERS | — | Deceased scientists who have contributed to the study of Mars |
| SMALL CRATERS | — | Villages of the world with a population of less than 100,000. |
| LARGE VALLES | — | Name for Mars/star in various languages |
| SMALL VALLES | — | Classical or modern names of rivers |

Mars features a highly varied terrain and a brighter colour palette than the browns & beiges that one might expect. Whilst at first glance some of the images look decidedly Earth-like and could be taken on a Terran desert, many features on Mars will feel utterly alien to someone from Earth. The fawn haze of the air, striking blue sunsets, or golden sky all serve to remind that this is a foreign planet.

## MARTIAN LANDSCAPE



**Albedo**
UTOPIA PLANITIA
An albedo feature is a large area on the surface of a planet (or other solar system body) which shows a contrast in brightness or darkness (albedo) with adjacent areas.

**Chaos Terrain**
EOS CHAOS
Chaos terrain (or chaotic terrain) is a planetary surface area where features such as ridges, cracks, and plains appear jumbled and enmeshed with one another

**Terrae**
ARABIA TERRA
Denote extensive areas of land, regions rather than individual surface features. The terrae of Mars are generally uplands, often volcanically formed with rugged, battered terrain.

**Polars**
PLANUM BOREUM
A polar ice cap or polar cap is a high-latitude region of a planet, dwarf planet, or natural satellite that is covered in ice There are no requirements with respect to size or composition.

**Craters**
GALE
A large crater caused by the violent explosion of a volcano that collapses into a depression, or by impact from asteroid.

**Mountains**
OLYMPUS MONS
A mountain is a large landform that stretches above the surrounding land in a limited area, usually in the form of a peak.

**Plains**
ELYSIUM PLANITIA
A plain is a flat area. Plains occur as lowlands along the bottoms of valleys, coastal plains and as plateaus or uplands at high elevations.

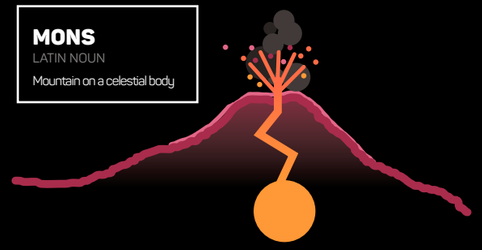
**Ridges**
LYCUS SULCI
A ridge or mountain ridge is a geological feature consisting of a chain of mountains or hills that form a continuous elevated crest for some distance.

**Valleys**
VALLEY MARINERIS
In geology, a valley or dale is a depression that is longer than it is wide.

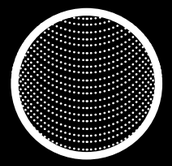
**Volcanoes**
ELYSIUM MONS
A volcano is a rupture in the crust of a planetary-mass object that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface.

# VOLCANICITY

**MONS**
LATIN NOUN
Mountain on a celestial body



## VOLCANOES OF MARS



Mars is home to the largest volcanoes in the Solar System. Originally the dark shapes on the surface stirred thoughts of seas and canals but this was disproved as Mariner 9 sent the first images Mars' immense volcanoes. Convection currents in the core push magma to the surface creating pressure and forcing the crust upwards to create shield volcanoes, or occasionally tearing the crust to form deep valleys such as Valles Marineris.

**Tharsis Bulge** The Tharsis bulge is a dome 4000km across and up to 10km in height - a pedestal for 3 giant shield volcanoes: **Acraeus Mons**, **Pavonis Mons** and **Arsia Mons**, shown below.

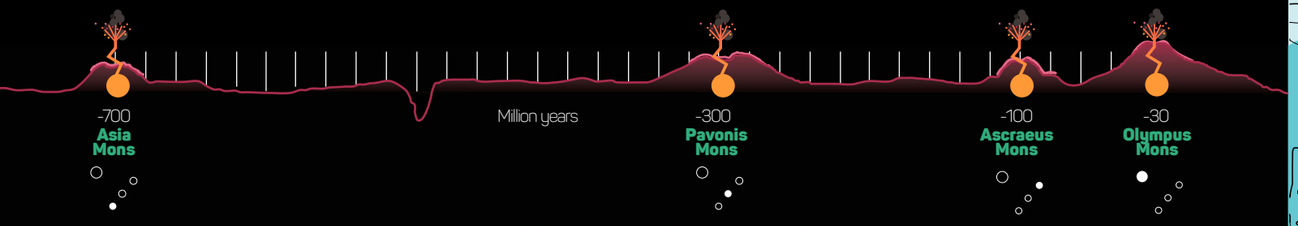
**Elysium Rise** Elysium is a smaller version of Tharsis. **Elysium Mons** has a single caldera and several large 'riverbed' channels to the North West, possibly carved by flowing mud and water released by the heat of an eruption. **Hecates Tholus** is similar in size to Elysium.

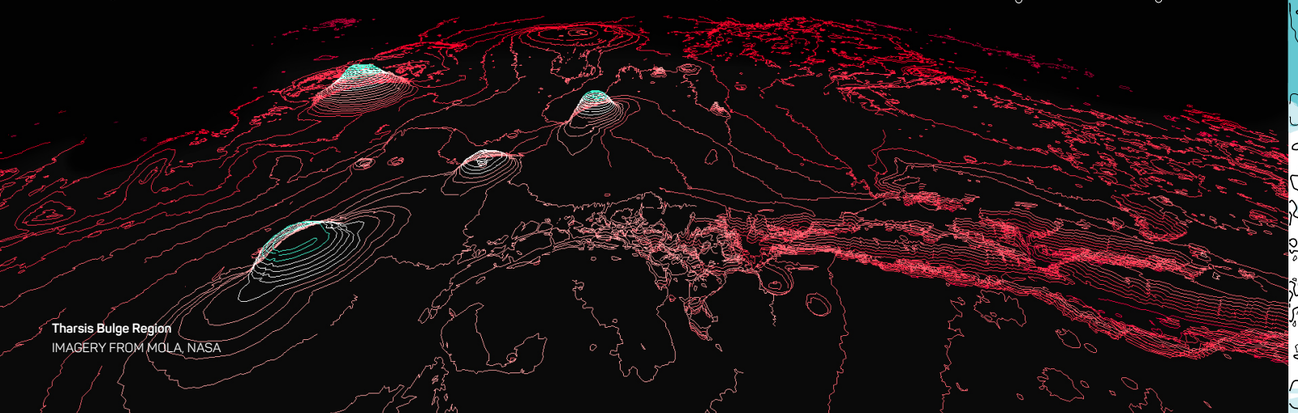
**Olympus Mons** **Olympus Mons** is by far the tallest volcano in the Solar System. It is 27km high and, its average width is 550km. including the basal lava plain, the complex is roughly the size of Spain. The closest volcano on earth is Mouna Loa in Hawaii, if measured from the sea floor it is 9km high and 120km across.

Volcanoes on Mars are up to 100 times larger than on Earth. Whilst on Earth the crust moves and so volcanoes go extinct, Mars has no plate tectonics so the volcanoes stay in one place and keep growing. Therefore huge Volcanoes define the surface of Mars: around 60% of the planet's surface is made up of lava plains and Vallis Marineris is actually a large tear in the planet crust caused by volcanic activity.

FOR MORE INFORMATION SEE
Places to Visit

## ERUPTIONS



**Tharsis Bulge Region**
IMAGERY FROM MOLA, NASA



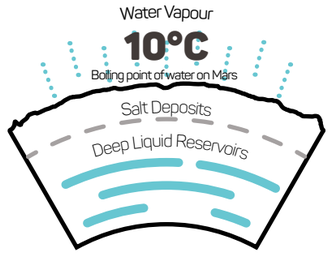
# BLUE MARS

## USEABLE WATER

The waters of life are essential to a colony on Mars. Luckily water can be easily found on Mars. The Martian poles contain up to 5 million km$^3$ of water in their ice caps. Ice also lies in underground reservoirs in warmer locations. The Martian permafrost contains frozen water, and during Summer in warmer equatorial regions the regolith can even support liquid water. These sources are easily found, but will need to be extracted and purified for use by human colonists.

## WET PLANET, DRY PLANET, WET PLANET

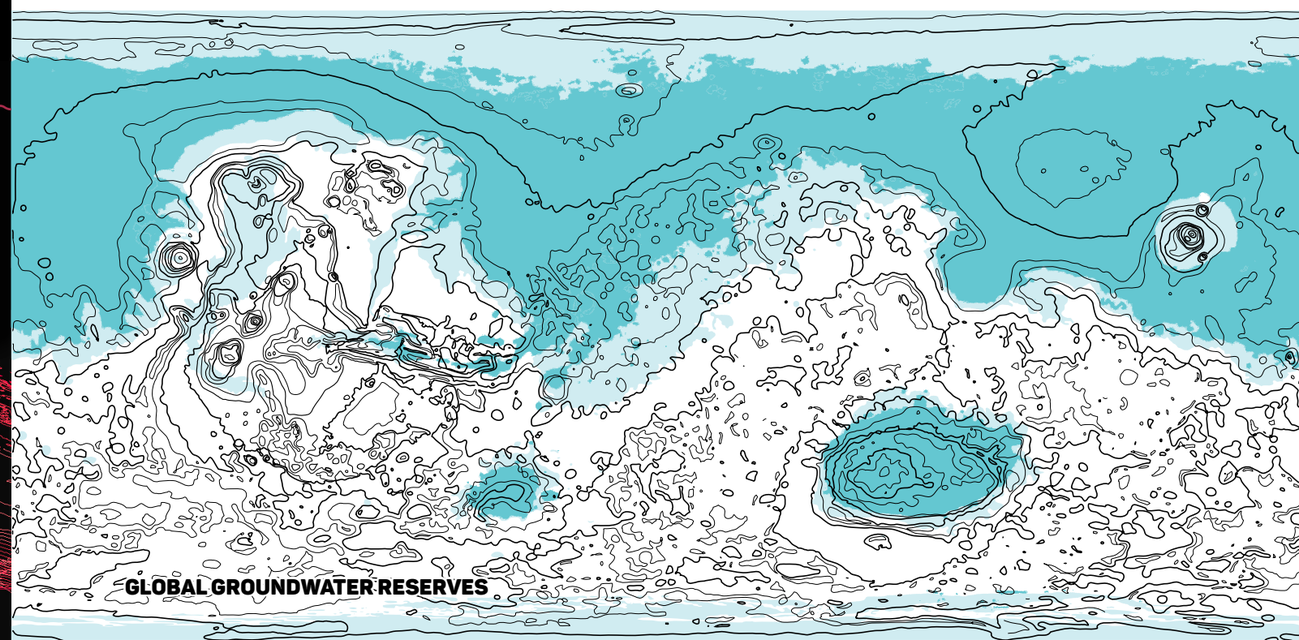
Research suggests intense volcanic activity regularly spewed tons of greenhouse gases into the Martian atmosphere that trapped heat. Each eruption would have kept Mars warm for decades or even centuries until the atmosphere was stripped by solar wind. During this period liquid water would have existed on Mars surface. As the atmospheric pressure becomes thinner the boiling point for water drops until any surface water becomes vapour. There is however liquid water held in deep liquid reservoirs underground, shown in the map below. If the atmospheric pressure could be raised then liquid water might flow on the surface of Mars once more...




FOR MORE INFORMATION SEE
Atmosphere
Terraforming
Waters of Life

> *We have concluded that the rocks here were once soaked in liquid water. We've been able to read the tell-tale clues the water left behind, giving us confidence in that conclusion.*

**Steven Squyres, 2004**
MARS ROVER MISSION, SCIENCE TEAM LEADER



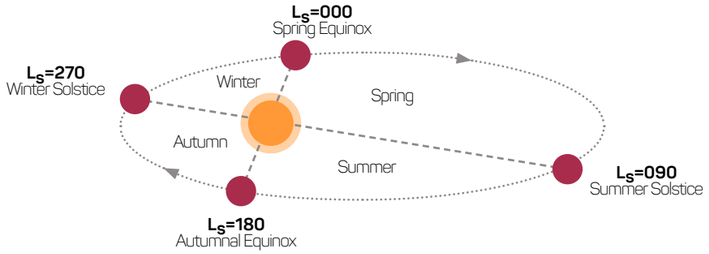
**GLOBAL GROUNDWATER RESERVES**

# 39 SEASONS

Mars has 4 seasons as Earth does because the axis of Mars is tilted with relation to its orbit.

But unlike Earth the seasons have different lengths because of Mars' elliptical orbit.

because of the axial tilt, Mars also has seasons at different times on the North and South Hemisphere.



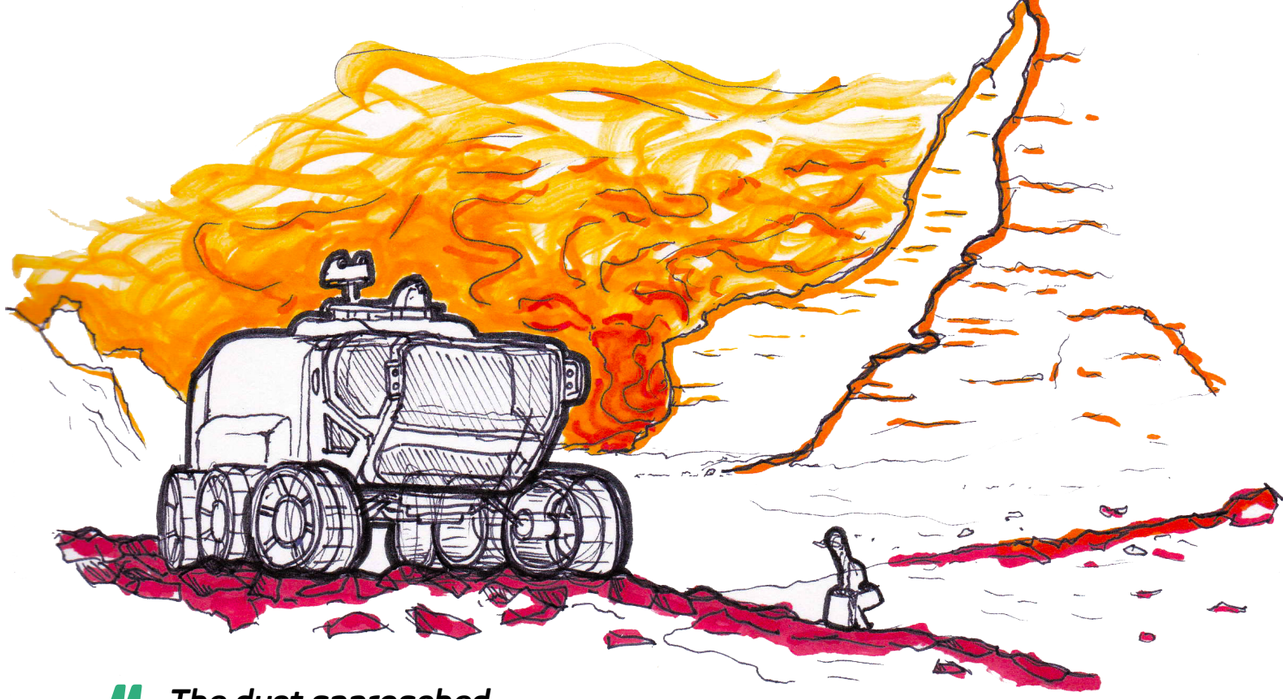


When Mars is close to the Sun, Winters are mild in the Northern Hemisphere...

...and Summers are warm in the Southern Hemisphere

When Mars is farthest from the Sun, Summers are mild in the Northern Hemisphere...

...and Winters are very cold in the Southern Hemisphere

*"The dust approached*
*like a giant breaking wave*
*with bronze filigree foaming up and off of it*
*leaving great curved streamers in the pink sky above.*

**Kim Stanley Robinson**
RED MARS

# WEATHER

### Issues

- Solar Power
- Visibility
- Dust contamination

FOR MORE INFORMATION SEE

**Endless Energy**

### VISIBILITY

The atmosphere of Mars, while thin, is still thick enough to support weather, clouds and winds. The dust on Mars is incredibly fine and wind often carries these fines, reducing visibility and causing a risk to equipment.

It can also cause some spectacular sunsets as the charged ions in the dust react with the atmosphere to create a blue sunset


Blue sunset on Mars

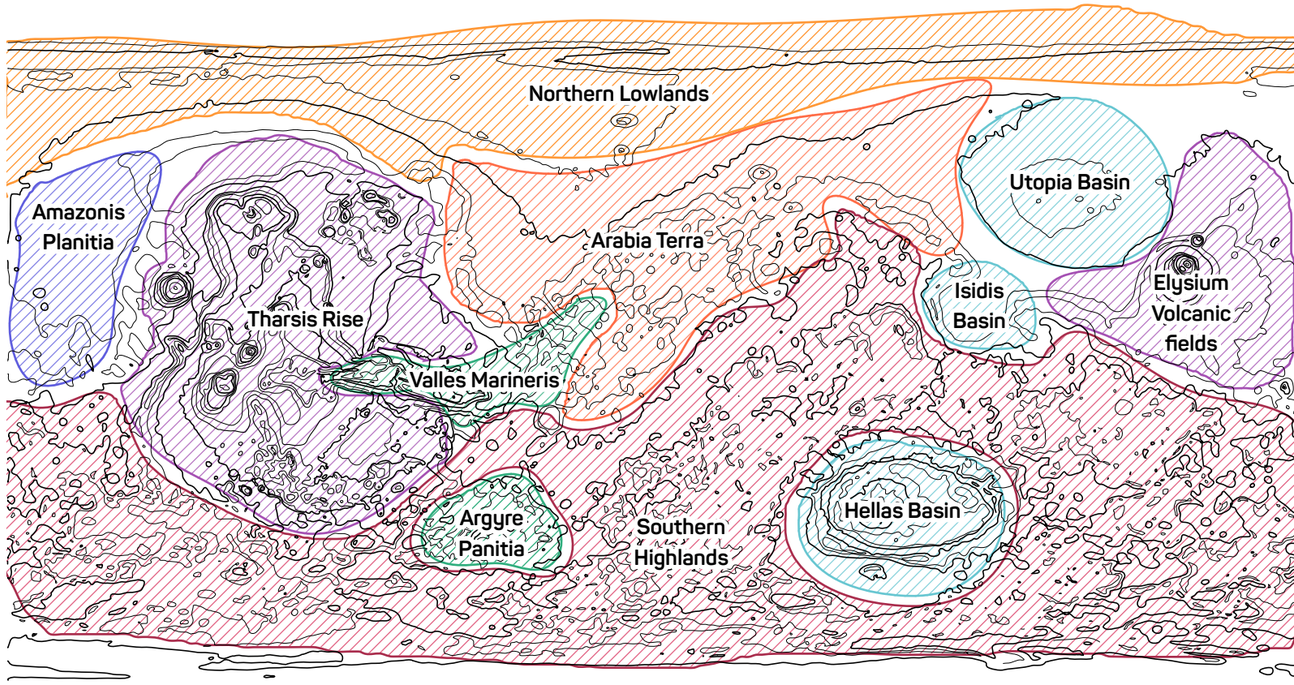
### STORMS

The severity of dust storms on Mars is often exaggerated by science fiction. Even super storms only reach 60mph: then when the sunlight is blocked the air cools and the storm dissipates.
The risk caused by storms to equipment and personnel is minimal, especially since a thinner atmosphere means wind has less pushing effect. However the greater risks are to solar power, and also the dust created is so fine that it can penetrate machinery and even airseals.

*Every five years there are some moderately big dust storms that cover continent-sized areas and last for weeks at a time*

**Michael Smith**
PLANETARY SCIENTIST, GODDARD SPACE CENTRE

# 40 REGIONS



# TERRAFORMING

Terraforming is the name given to process of planetary engineering, the greatest design feat ever undertaken by humanity. The aim of this process is to make a climate on Mars which is more environmentally hospitable to humans, therefore making the colonisation effort more sustainable.

This process would induce an accelerated version of Earth's history. The emergence of life around 3.8 billion years ago transformed Earth from a volcanic lifeless rock into a green planet. Primitive organisms thickened the atmosphere, producing Oxygen and a water cycle until the planet we know today emerged.

## ISSUES

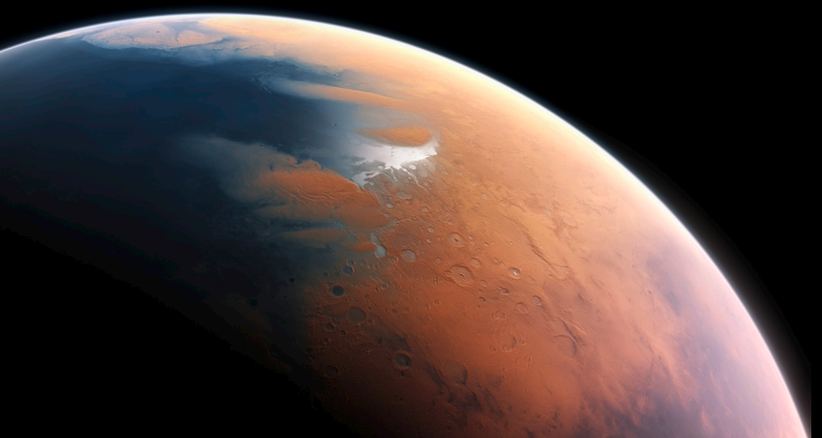
**Ethics**
Some argue that meddling on this scale is unethical on moral grounds, others that it is unscientific as it could destroy native life.

**Investment**
The ongoing cost of the project would be phenomonal and would require the long term view of investment in the availability of an entire new planet.

**Time**
No-one knows for sure how long Terraforming will take but it will likely be generations until Martians can go from suits, to masks, to unprotected.

> *It was once a warm and wet planet and could be again through human effort. Things that would seem utterly fantastical and magical to us will simply be science and technology to future generations.*

**Dr Robert Zubrin**
PRESIDENT OF MARS SOCIETY, AEROSPACE ENGINEER & AUTHOR



FOR MORE INFORMATION SEE
- **Positive Thinking**
- **Planetary Politics**

## 01 RED MARS

PRESSURISED SUITS

GLOBAL WARMING

The first stage of terraforming is to heat the planet using greenhouse gasses. Luckily Terrans have had lots of practice with this on Earth.

One way to do this is melt the Southern polar ice cap .

$CO_2$

This would release a huge amount of $CO_2$ trapped inside dry ice.

F
$NH_3$ $H_2$

The resulting greenhouse gases would help thicken the atmosphere.

A thicker atmosphere traps solar energy and protections from radiation.

## 02 BLUE MARS

REBREATHERS

THE WATER OF LIFE

The second stage is to create water on the surface of Mars to allow for a water cycle and more moderate weather.

A massive orbital mirror will be created to focus sunlight on the permafrost

As ice water melts, surface water would form seas.

Eventually atmospheric pressure will allow for rainfall

Icy asteroids could be redirected to melt in atmosphere, releasing vapour

## 03 GREEN MARS

THERMAL JACKET

PLANTING THE PLANET

The third stage is to create plant life and a living exosystem.

Genetically engineered algae, bacteria and lichen would be developed to withstand the Martian environment

The organisms would create organic soil and release oxyygen

Eventually atmospheric pressure will allow for rainfall and more biodiversity

Icy asteroids could be redirected to melt in atmosphere, releasing vapour

POP

# MARTIAN MELTING POT

*"First come the openers, strong and brave and rather naive. When the rough edges are worn off the new land, businessmen and lawyers come to solve problems of ownership, usually by removing the temptations themselves.*
*And finally comes culture, which is entertainment, relaxation, transport out of the pain of living. And culture can be on any level, and is. The Church and the whorehouse arrived in the Far West simultaneously.*

**John Stienbeck**
EAST OF EDEN

1250

The Venetian Marco Polo is forever linked to the world of exploration. He was the first Westerner to meet Kublai Khan and explored Asia & Europe.

1804

The team of William Clark and Meriwether Lewis, known as the "Corps of Discovery." Their expedition was the first successful trip made all the way across what is now North America.

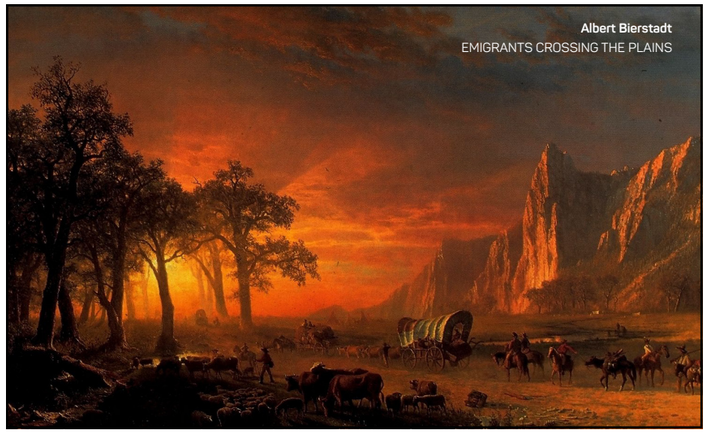
1932

Amelia Earhart was an American aviation pioneer and explorer, famous for flying solo across the Atlantic Ocean before her disappearance during a global circumnavigation attempt

1969

Neil Armstrong holds the distinction of being the first man to walk on the moon. Before becoming an astronaut with NASA, he was a Naval Aviator, officer in the US Navy, and a test pilot.

2039



**Albert Bierstadt**
EMIGRANTS CROSSING THE PLAINS

## 44 PIONEERS

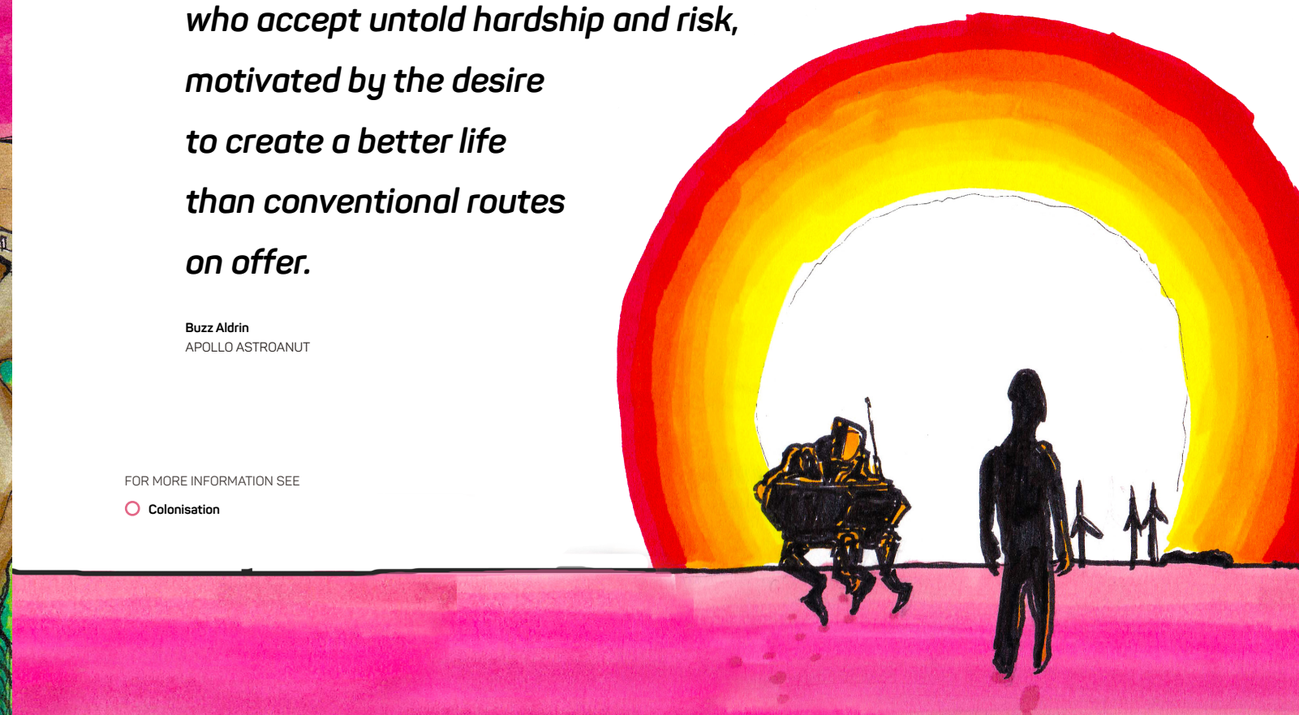
Colonisation on Mars will depend on a select group of hardy individuals who have the drive to explore and settle new lands. The first settlers coming to Mars independently will be of this unique cliche, set on forging a new life in an inhospitable environment through hard work, innovation and determination. Their values and outlook will be passed down to later Martians, and will inform the basis of society.

*"Nations are built by pioneers who accept untold hardship and risk, motivated by the desire to create a better life than conventional routes on offer.*

**Buzz Aldrin**
APOLLO ASTROANUT

FOR MORE INFORMATION SEE

○ **Colonisation**



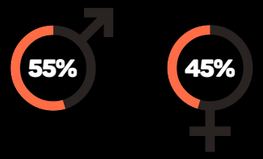
# DEMOGRAPHICS

A total of 200,000 such pioneers replied to Mars One as candidates for a one way mission to Mars. The data below breaks down the demographics of this group, creating a picture of the types of people that would want to go to Mars to colonise, if they were given the opportunity.

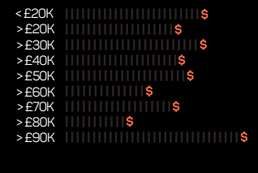
LINCOLN DUKE SHANITA SAULS LARONDA LIANG ANNETTA WHISLER PIPER HUCKLEBERRY MOLLY PAULSON JUDSON GALGANO GUSTAVO BACKER MINTA MCMARTIN CLAY BUENO INELL LOFTIN GWYNETH SCHULTE JEANMARIE CARRANZA GEORGANN BACH GIOVANNA MEAS RALPH STAMEY KORY HOLLEMAN KRISTY SPINELLA BOBETTE SCHOENING NATALYA CARGILL BEVERLEE LETH LOWELL ARNONE DONNIE LANGWORTHY VICKIE HERRINGTON ROSITA RUBIN MARICRUZ FEIST GLYNIS CAREY MARIANO AIKINS DEBBRA FORTUNATO KENIA KEES JACQUELINE YOCHUM JUDIE THORNLEY ERNESTINE LARIN FLORIDA DONER VELVET VANALSTYNE NEVILLE TEASDALE SARI YEAMAN SHEMIKA SHAMBURGER HAILEY GUITIERREZ TAJUANA LAKES AUSHA LEARN SEPTEMBER BRIERLY NONA ADORNO DOUG MCCOY IRENE DIBLASI FOSTER HEARD YEVETTE OURT JEANETTA HEIDT HUGH DOSTIE ELISE KOMAR SERRINA RICHE JAYSON LAMBERT KATHERINA HOMER HIROKO PELLOT HOA MANI LIESELOTTE OVERSON DORTHA GRIDER TRESSIA TROWER CAITLYN SACK KASI CORREA RAINA DANDREA KATHARINE SELLERS GRETTA ACHORN FELICIDAD CAMPUZANO SHAWNEE KETRON CHANELL DAFFRON REBBECA SANTISTEVAN FLORENTINA GILSDORF ILEANA COCA TH SCHUESSLER MAN NAULT PEI MAST SHEILA MADEWELL ELOISE GOVE JIMMY SCHLEIFER VIVIENNE FORT NELDA HOLDSWORTH RENEE SCHWAN JEANE ROSENGARTEN CATHERIN MATTES LOUANNE MAHR DOMINQUE DEFAUL BRINDA WATERBURY LYDA BOGGAN SHEBA EAST CLOTILDE FISCUS SHALINA EASTHAM ARNITA HUDKINS MARCOS REYNA LINO ABERNETHY TAMIE SAIDI BEVERLEE WIREN MACY MCSHERRY JARVIS GOWINS ROSENDA SWARTWOOD RICARDA BLAKEMORE RANDY NAJARRO NATASHIA VINCE CLARETTA PRIME OK CALHOON DENISSE CHILLEMI ALEXANDRIA RUNGE RENATE FITCH CHIQUITA SHOGLUND FERNANDO REDUS DORIE BLANKENBAKER DEANDREA CYBART EMRNA JENNISON BYRON BOELTER ANETTE SALVADOR SILAS ORBISON LANITA FADDIS BELEN MCLAREN APRYL RASHID TRISHA AKINS FRANKIE HAGA LAKIA KAWAMOTO LINN ERB WENDELL ESCAMILLA DERRICK DINZ EDNA PAZOS AUSON MONSEN PALMA RENICK MILAN HATLEY ASHLY MCGREGOR CONRAD LION LISHA GINGRICH TAMA MOOS CAMELIA KINGSBERRY PAULA SHELOR HILDE STALLS RAYMONDE BRAYBOY DANIELLE WORTHINGTON ZORAIDA KRAM ZORA ORDUNO ETHYL BUCZEK

### Respondents

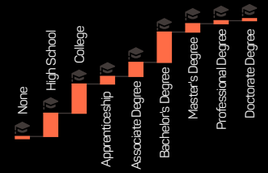

### Gender



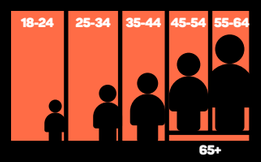

### Income




### Education

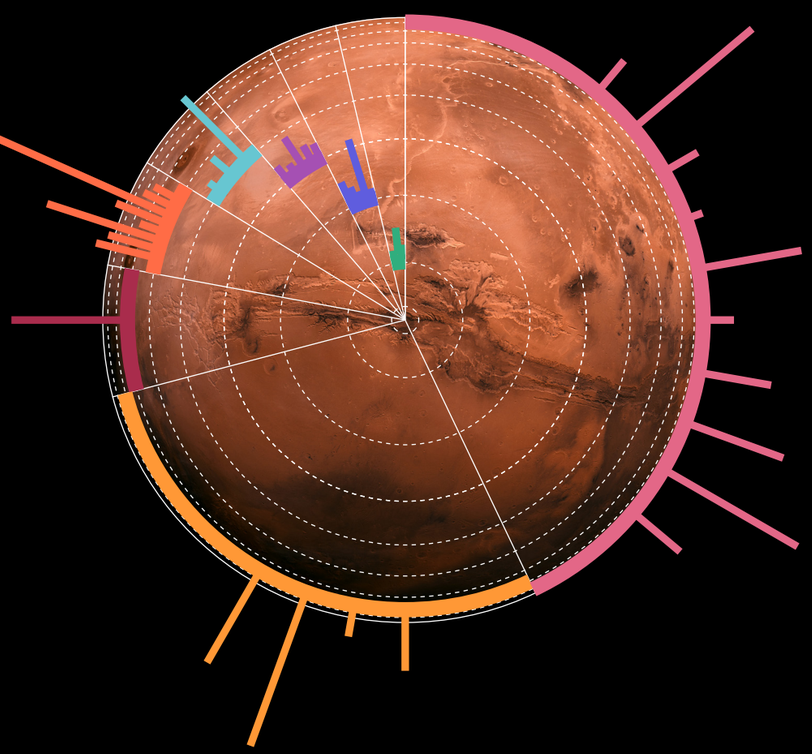



### Age




The gap between those who want to go and those who will be able to go will initally be vast. National and private missions to Mars will have a highly selective application process. Also mission requirements, cost of travel and other barriers will further restrict the range of people who can go to Mars.
As time goes on these barriers will be slowly be lowered or removed, allowing more mainstream emmigration to Mars.

### Nationality



These pioneering spirits will leave from many countries will go to Mars all bringing their own contribution to the Martian culture and social environment. Bias will go to the nations with more advanced space programmes which will therefore have a greater amount of power and therefore influence on the culture of the colony

- CHINA
- HONG KONG
- THAILAND
- JAPAN
- INDIA
- SOUTH KOREA
- VIETNAM
- IRAN
- ABU DHABI
- UNITED ARAB EMIRATES
- CZECH REPUBLIC
- LATVIA
- HUNGARY
- POLAND
- ALBANIA
- BRAZIL
- URAGUAY
- MEXICO
- PEURTO RICO
- ARGENTINA
- SWAZILAND
- UGANDA
- SOUTH AFRICA
- PORTUGAL
- SWEDEN
- SPAIN
- ICELAND
- GREECE
- FINLAND
- FRANCE
- GERMANY
- ITALY
- UNITED KINGDOM
- RUSSIA
- AUSTRALIA
- NEW ZEALAND
- UNITED STATES OF AMERICA
- CANADA

FOR MORE INFORMATION SEE

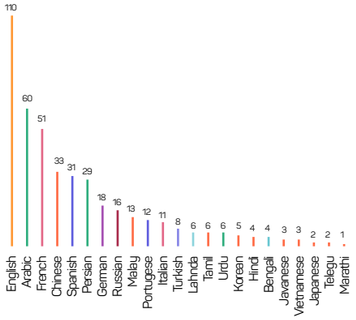
- **Portrait of a Martian**
- **Pioneers**
- **Space for Faith**

**Data based on Mars Generation Survey**
PHILLIPS & COMPANY, SPONSORED BY BOEING

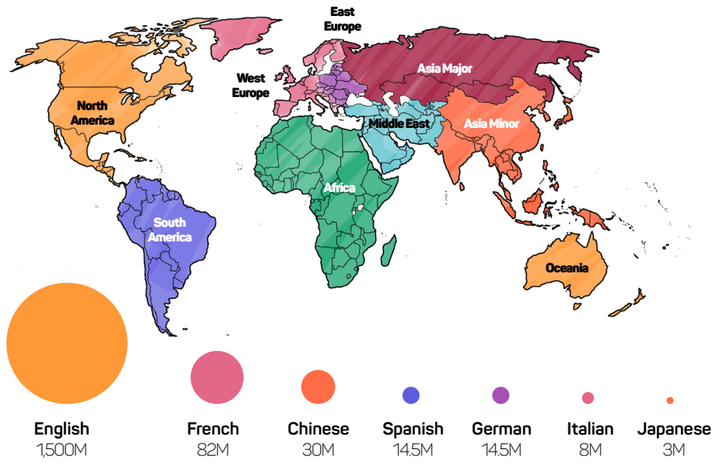
# ORIGINS OF LANGUAGE

Each nation going to Mars will bring their own customs and language. The influence of languages can be deceptive: on Earth the languages spoken by the most amount of people are Chinese dialects, however these languages are spoken in the fewest number of countries. English is the language spoken in the most number of countries, followed by Arabic.

Western languages have spread across the globe due to historical colonialism and imperialism. A similar effect will be seen on Mars as Western companies claim a cultural and influential monopoly through their more advanced space programmes.




**No. of Countries in which language is spoken**




**Languages being learned around Earth**

Languages of the world
THE WASHINGTON POST

A World of Languages
ALBERTO LUCAS LOPÉZ

> *We think in words. So the language we use shapes the way we think as a society*

**Steven Pinker**
COGNITIVE PSYCHOLOGIST & SCIENCE AUTHOR



# MARTIAN DIALECT

## MERGE OF NATIONALITIES

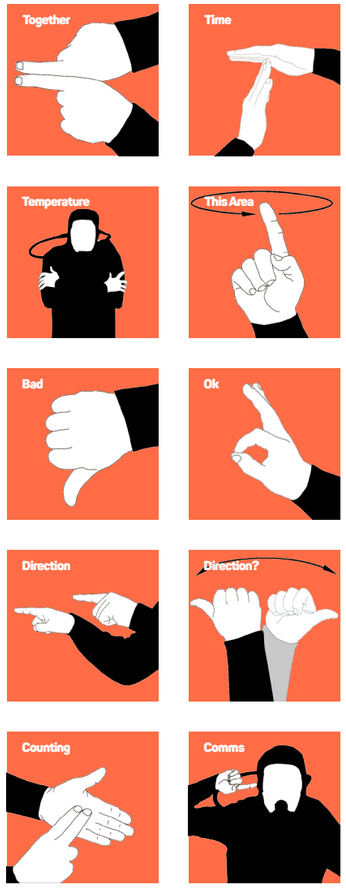
When a large variety of nationalities live in close quarters, languages fuse and evolve in unique ways, until a mixed language evolves which cannot be identified as belonging to any of the original sources. In this way a new Martian dialect might arise, an amalgamation of many Terran languages, yet distinct enough to be something entirely new.

> *Mixed languages are the result of the fusion of two or more identifiable source languages, normally in situations of community bilingualism... furthermore a mixed language may mark the appearance of a new ethnic or cultural group.*

**Dr Felicity Meakins**
PROFESSOR OF HUMANITIES AND SOCIAL SCIENCES


## GESTURES

On EVAs astronauts use hand gestures for variety of tasks from emergencies, instructions and cooperation. These gestures give clarity to communication while wearing an atmosphere suit and would become a part of everyday life for Martians, integrating into colloquial language.



# 49 MARTIAN PHRASEBOOK

## Geology

| | |
|---|---|
| Albedo | Geographic area distinguished by amount of reflected light |
| Catena, catenae | Chain of craters |
| Cavus, cavi | Hollows, irregular steep-sided depressions usually in arrays or clusters |
| Chaos | Distinctive area of broken terrain |
| Chasma, chasmata | A deep, elongated, steep-sided depression |
| Colles | Small hills or knobs |
| Crater, craters | A circular depression |
| Dorsum, dorsa | Ridge |
| Fluctus | Flow terrain |
| Fossa, fossae | Long, narrow, shallow depression |
| Labes | Landslide |
| Labyrinthus, labyrinthi | Complex of intersecting valleys |
| Lingula, lingulae | Extension of plateau having rounded lobate or tongue-like boundaries |
| Mensa, mensae | A flat-topped prominence with cliff-like edges |
| Mons, montes | Mountain |
| Patera, paterae | An irregular crater, or a complex one with scalloped edges |
| Planitia, planitiae | Low plain |
| Planum, plana | Plateau or high plain |
| Rupes | Scarp |
| Scopulus, scopuli | Lobate or irregular scarp |
| Sulcus, sulci | Subparallel furrows and ridges |
| Terra, terrae | Extensive land mass |
| Tholus, tholi | Small domical mountain or hill |
| Undae | Dunes |
| Vallis, valles | Valley |
| Vastitas, vastitates | Extensive plain |

## Daily Life

| | |
|---|---|
| Sol | Martian day |
| The slip | The period where the clocks freeze in order to synchronize with Earth time. |
| Common Band | Radio frequency used by all colonists during suited off-tent walks. |
| Gift Economy | Supplementary economic system |

## Architecture

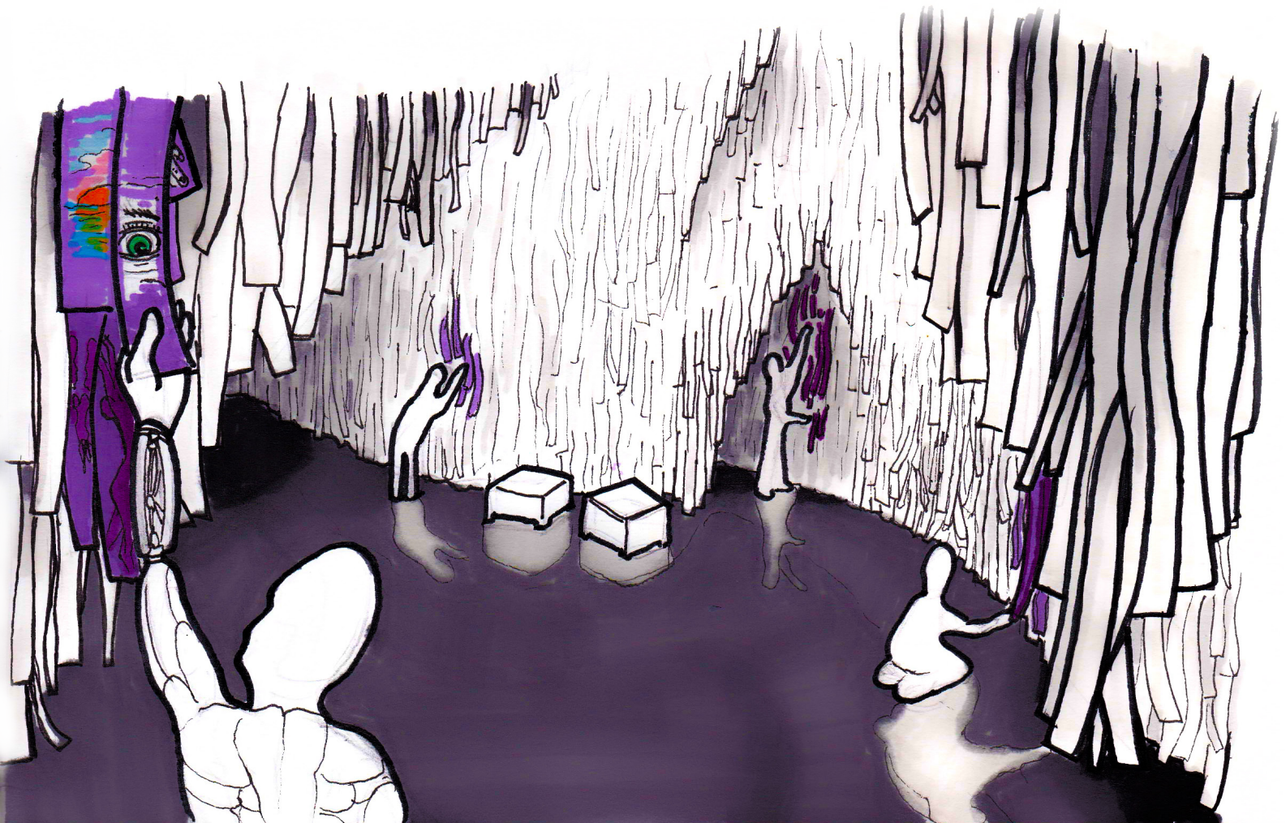
| | |
|---|---|
| MarsJar | Biological Terrarium |

## Mannerisms

| | |
|---|---|
| Shikata ga nai | *(origin: Japanese)* It cannot be Helped |

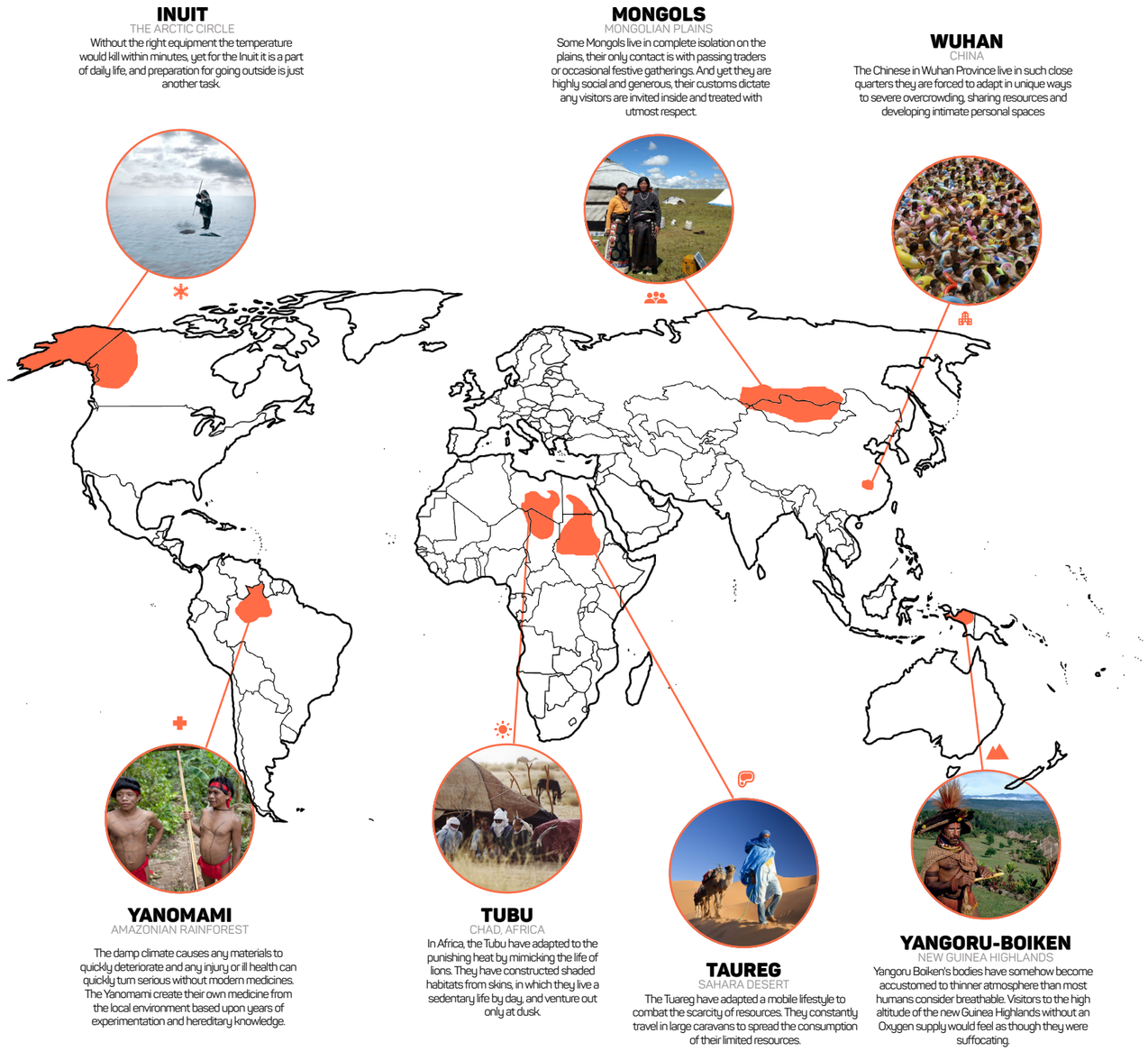
## Cultural

| | |
|---|---|
| Qahiran Mahjaris | Arab Martians |



# 50 LIFE IN HARSH ENVIRONMENTS

The Martian environment is not hospitable, but local knowledge, innovation and technology has allowed humans to adapt, survive and even thrive in extreme environments for thousands of years. Some cultures have adapted to environments that we would consider impossible to live in: thin atmospheres, extreme colds, isolation, overcrowding, lack of resources; Martians face the same problems these cultures have overcome or adapted to.



### INUIT
THE ARCTIC CIRCLE

Without the right equipment the temperature would kill within minutes, yet for the Inuit it is a part of daily life, and preparation for going outside is just another task.

### MONGOLS
MONGOLIAN PLAINS

Some Mongols live in complete isolation on the plains, their only contact is with passing traders or occasional festive gatherings. And yet they are highly social and generous, their customs dictate any visitors are invited inside and treated with utmost respect.

### WUHAN
CHINA

The Chinese in Wuhan Province live in such close quarters they are forced to adapt in unique ways to severe overcrowding, sharing resources and developing intimate personal spaces

### YANOMAMI
AMAZONIAN RAINFOREST

The damp climate causes any materials to quickly deteriorate and any injury or ill health can quickly turn serious without modern medicines. The Yanomami create their own medicine from the local environment based upon years of experimentation and hereditary knowledge.

### TUBU
CHAD, AFRICA

In Africa, the Tubu have adapted to the punishing heat by mimicking the life of lions. They have constructed shaded habitats from skins, in which they live a sedentary life by day, and venture out only at dusk.

### TAUREG
SAHARA DESERT

The Tuareg have adapted a mobile lifestyle to combat the scarcity of resources. They constantly travel in large caravans to spread the consumption of their limited resources.

### YANGORU-BOIKEN
NEW GUINEA HIGHLANDS

Yangoru Boiken's bodies have somehow become accustomed to thinner atmosphere than most humans consider breathable. Visitors to the high altitude of the new Guinea Highlands without an Oxygen supply would feel as though they were suffocating.

# 51 HUMAN ADAPTION

**PHYSIOLOGY**

All of human evolution has prepared the human body for living in Earth gravity and Terran conditions so living on Mars will have a profound impact on human development. Studies based in zero gravity and microgravity have only just begun to tell us the effects that may arise from living in micro-gravity for extended durations.
When facing an adverse environment, there are two possible responses:

### We Alter Environment

Mankind, for right or wrong, has become a master at altering their environment to suit their needs. Through Terraforming Mars may be adapted to conditions more favourable to humans. Genetically modified algae could introduce Oxygen whilst a thicker atmosphere could be generated through greenhouse gases. Water could also be released from frozen sources underground. These effects could be contained within Biodomes at first, before implemntation at a planet-wide scale.

### Environment Alters Us

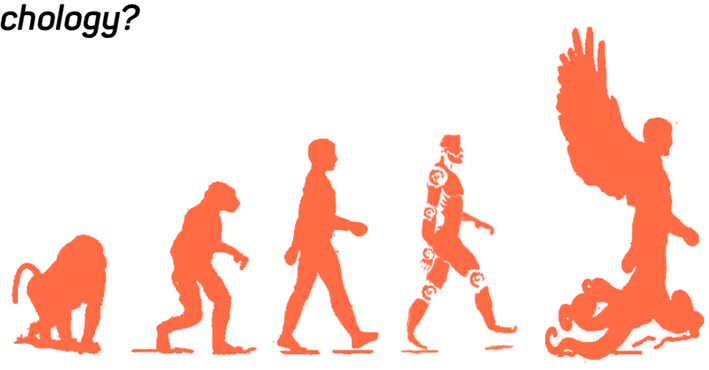
Why adapt the planet when we can adapt ourselves? Whilst ongoing terraforming will take generations, it may be quicker to genetically enhance humans to better withstand low Oxygen levels, extreme temperatures and resist muscle loss, radiation and other negative effects of the Martian environment. In addition, passive cybernetic implants, or active prosthesis controlled directly by the brain could enhance or augment human strength, endurance and durability.

> ***We have never before had the opportunity to observe the long term effects of microgravity on the human body. Who knows what effect it will have on anatomy, physiology and psychology?***

**NASA Office of Inspector General**
HEALTH HAZARDS REPORT

FOR MORE INFORMATION SEE

- **Terraforming**
- **Portrait of a Martian**
- **Planetary Politics**



# 52 POSITIVE THINKING

Mars would be taxing not just physically but also psychologically.

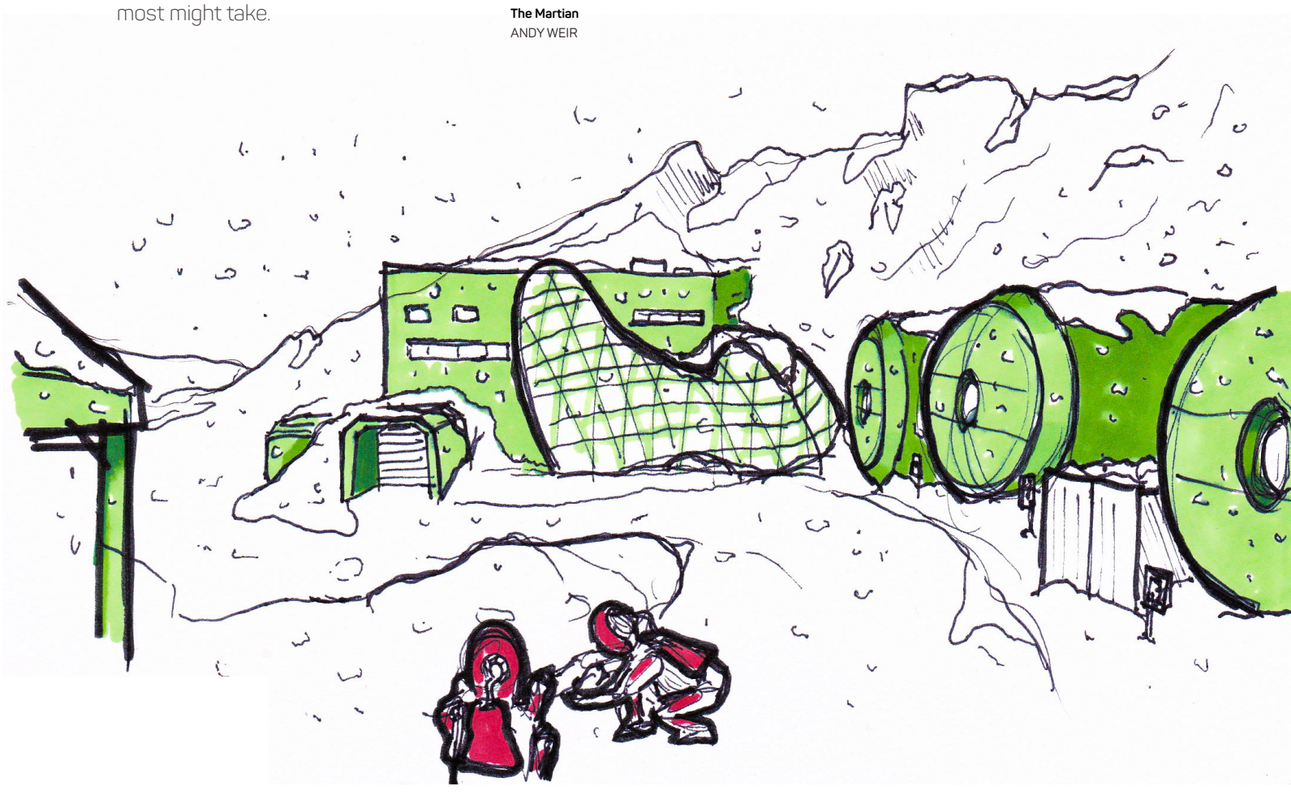
The hardships of living on an alien planet, the complete isolation from the homeplanet, the harsh landscape and lack of escape route could all detrimentally affect the first settlers.

Nevertheless the first colonists to Mars would be hand selected from a huge pool for a unique psychological outlook: an ability to resist stress, to accept unusual conditions, a drive to succeed and the temperament to work well with others.

This unique set of characteristics and traits would enable them to look at things differently, to rethink old problems and approach a Martian society with a different outlook than most might take.

> ***The first to go to Mars were unique individuals***
> ***Picked by hand from a pool of millions.***
>
> ***Brilliant enough to stand out,***
> ***Normal enough to get along.***
>
> ***Old enough to have wisdom,***
> ***Young enough to withstand rigours of work.***
>
> ***Driven to excel***
> ***Relaxed enough to socialize.***
>
> ***Crazy enough to leave earth forever***
> ***Sane enough to mask it as scientific curiosity.***

**The Martian**
ANDY WEIR



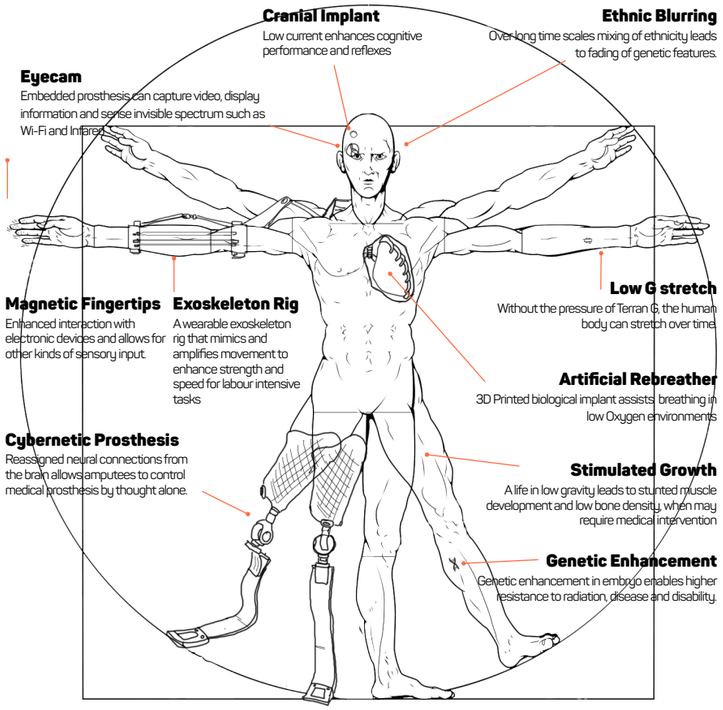
# PORTRAIT OF A MARTIAN

## HOMO CAELESTA

There are a number of adaptions which would change the human body and mind in a number of ways.
At some point a combination of environmental, anatomical and physiological changes will reach a point where debate will be needed about whether humans on Mars are even the same species as those from Earth.

FOR MORE INFORMATION SEE

- Space Couture
- Demographics




## TRANSHUMANISM

The hard life of the extreme environment on Mars, combined with technological advancement and innovation makes Mars the ideal test bed for many transhuman movements which have already manifested on Earth in the early 21st century

> *Transhumanism literally means "Beyond Human". It's using science and technology to radically change and improve the human species and experience*

**Zoltan Istvan Gyurko**
FUTURISM JOURNALIST



# A SOL IN THE LIFE

LS=90. 2069
TOUCHDOWN DAY

**0600** Today is the annual anniversary of the first human boots on Mars. You wake to a blue Martian sunrise and rise to go to the heads for the toilet. Human waste is used to fertilize the co'ops food supply.

**0700** Drop by the MarsJars to see that your human waste isn't being wasted. Others are already up and about, chatting as they tend to the crops, clean or work on repairs. You prepare a light meal of soya, rice and mushrooms and set the vats to cultivate meat for dinner later, afterwards serving breakfast in the communal area and eating with three or four others, discussing the celebration plans for Touchdown Day.

**0800** You check in to medical bay for routine med-check and anti radiation dose. The AutoDoc gives you the all clear.

**0900** Head to the airlock and pull on elasticated pressure suit and helmet. Your palm pc registers your proximity to one of the co'ops rovers and your virtual assistant projects all relevant information. You book it out as 'in use' with a gesture and head out to visit the icemines.

**1000** After clearing the rougher terrain and reaching the flat dusty lowlands the rover's AI offers to drive, so you head aft and pull up your palm pc to set the 3D printer to producing spares for the iceminers.

**1100** Pass some time chatting to nearby caravan of surveyors on common band who bring news from Valles Marineris and chatter excitedly in mixed Japanese and French.

**1200** The robotic iceminers need their dust filters replaced and the spares have finished printing so you slip into the rover's exoskeleton, and perform triple checks to Oxygen, fuel and battery before heading outside.

**1400** During the repairs the microscopic Martian dust has clogged the vent on the pneumatic drill. It burns through your glove before you notice it but the elastic layers of your pressure suit quickly shrink to cover the gap. Nevertheless you sustain a pressure burn and sever bruising to your hand. You will need to revisit the medical bay upon return but in the meantime you finish the repairs using a spare pressure suit, cursing the time wasted returning to the rover to resuit.

**1800** When you return from the repairs, the Rover's comm have a long distance relay message waiting. One of the women from the co'op has finally managed to conceive and has departed immediately for the Geostation atop the space elevator. The Terran gravity there will be better for the baby. You draft a quick message conveying your joy, apologising for not being there to bid farewell.

**1900** The rover heads towards home and you use your palm pc to organise a few trades. You exchange surplus water from the iceminers for some precious metals plus some luxury goods from a nearby commune of Geologists. Your purchase some new AI algorithms from the web which you hope will improve the efficiency of the robotic iceminers.

**2100** On the way home you stop by the reflection temple and sit a while appreciating your own distorted image in the perfectly reflective surface, silhouetted against the Martian sunset. The stillness of the air and the vast emptiness of the Martian landscape here is profound.

**2200** Touchdown Day celebrations have already begun in earnest in the communal area when you return so you settle in to watch a low gravity dance with fellow members of the settlement. As the night goes on dancers become more drunk and the choreographed performance disintegrates into socialising.

**2400** As the Martian timeslip approaches activity winds down so you slip away, remembering to brush your teeth. The waste water goes to recyclers for filtration and reuse.

**- - - -** The clocks freeze and the timeslip begins as all of Mars waits in limbo to adjust to accommodate for Earth's 24 hour clock. As is your habit, you use the 40 minutes to do some casual reading in the cubby before bed.

**0000** The clocks click back into life so you put your book down and head to an empty cot and climb inside, sealing it behind you for privacy while you sleep.

> *It might be helpful to realize, that very probably the parents of the first native born Martians are alive today.*

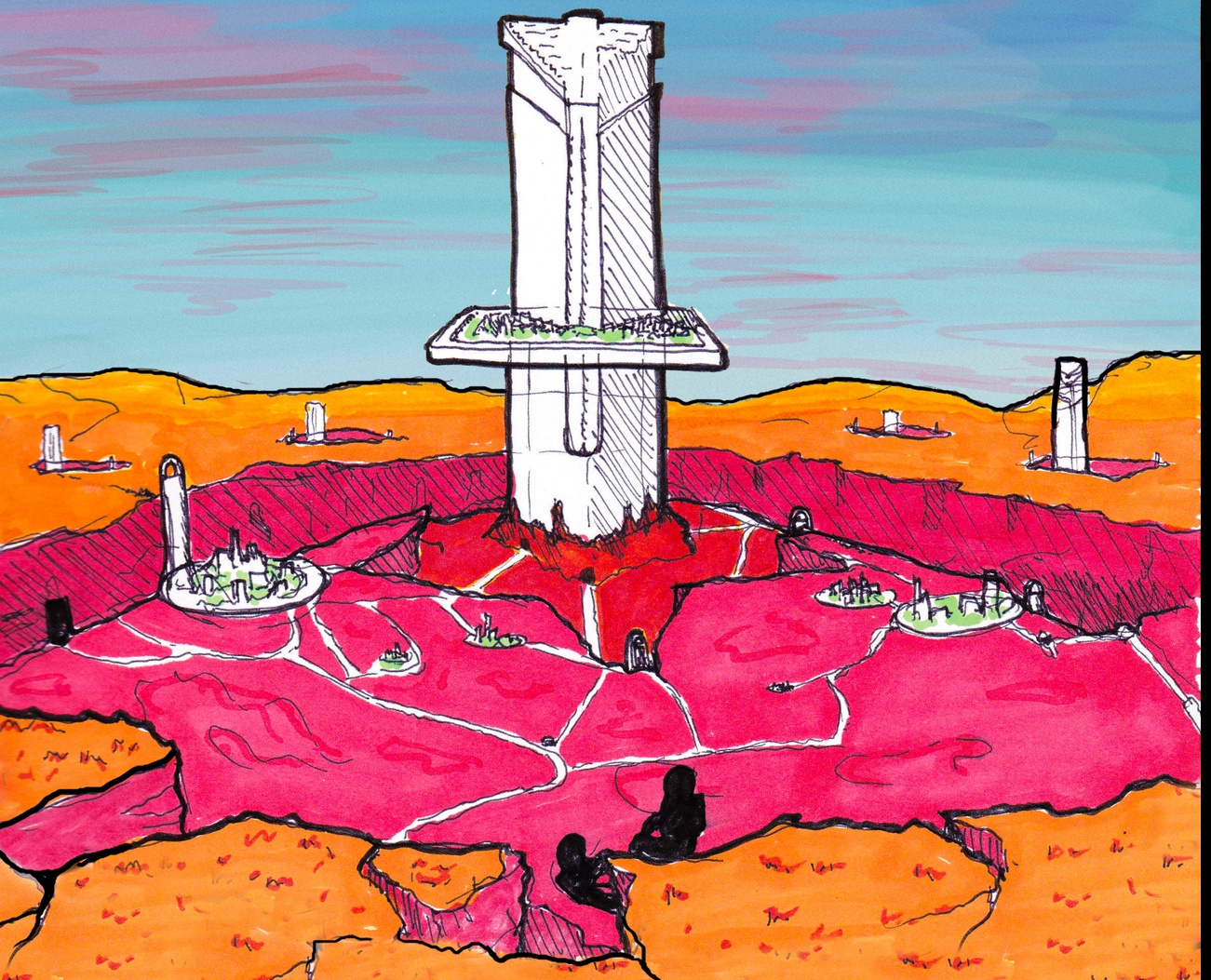
**Harrison 'Jack' Schmidt**
APOLLO 17 MOONWALKER

INF

# LAYING FOUNDATIONS

*The form a society assumes as it evolves over time owes more to large-scale works of civil engineering - what we now call infrastructure - than almost any other factor save topography.*

**Martin Filler, Up in the Park**
ARCHITECTURE CRITIC



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## LIVE OFF THE LAND

In Situ Resource Utilization is the key technique which will allow colonisation on Mars to become sustainable. ISRU means collecting, processing and using materials found on Mars, rather than relying on resupply from Earth.
All of the materials necessary for life support: propellants, construction and energy are present in the soil and atmosphere already.

The Martian soil contains many elements and resources which can be mined and refined into manufacturing materials. This avoids costly transportation costs and makes a Martian settlement feasible over the long term.

FOR MORE INFORMATION SEE

- Geology
- Closing the Loop
- Building Blocks

| | | |
|---|---|---|
| $O_2$ | **Oxygen** | Breathing, Water Synthesis, Propellant |
| Si | **Silicon** | Computer chips |
| Fe | **Iron** | Manufacturing and construction |
| K | **Potassium** | Organic compounds, Fertilizer |
| Mg | **Calcium** | Lime cement |
| Ca | **Magnesium** | Lightweight bars for construction |
| S | **Sulphur** | Chemical processing, Plastics |
| Al | **Aluminium** | Manufacturing and construction |
| Cs | **Cesium** | Semiconductors and Photocells |

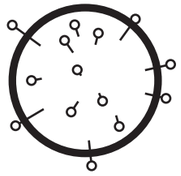
> *ISRU will enable the affordable establishment of extraterrestrial exploration and operation by minimizing the materials carried from Earth.*

**NASA Ames Research Centre**

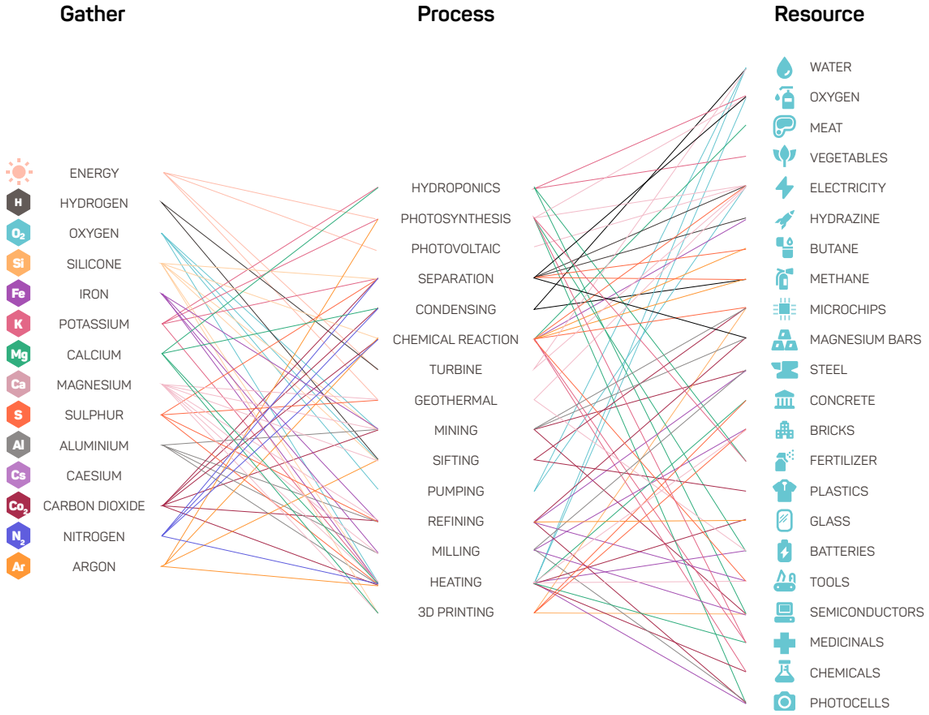
*We decided to do Mars the way Lewis and Clark did America.*
*Use the local resources, travel light, live off the land.*

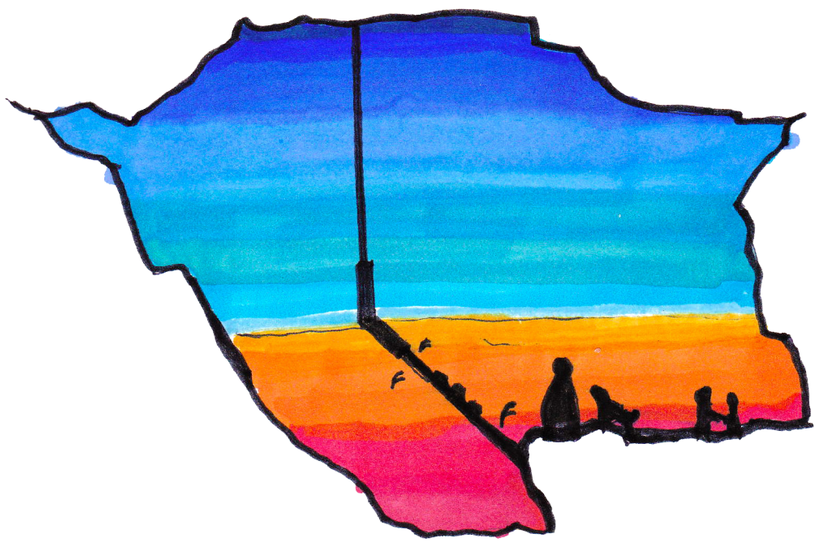
**Dr Robert Zubrin**
MARS SOCIETY PRESIDENT

# LOCAL PRODUCTION



Raw resources can be gathered by refining the regolith, sifting the atmosphere and combining  or separating compounds to make others. Using a variety of processing techniques these raw resources can then be combined into tools, resources and sustenance.

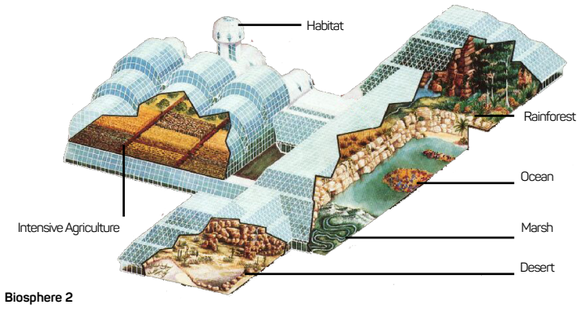




# CLOSING THE LOOP

## CLOSED ECOLOGICAL SYSTEMS



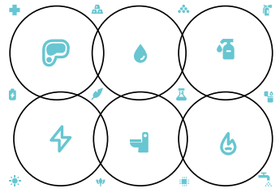

**Biosphere 2**

Once these resources have been produced they must be used efficiently. Resources will be rare enough and processing costly and resupply from Earth will be prohibitively expensive so the Martian ecosystem must be completely independent as far as is humanly possible. This means that enough that not only must resources be used efficiently, but any waste must also be recycled and reused.

Programmes on Earth such as Biosphere 2 have attempted to simulate closed loop systems, where any waste products produced by one process, biological or mechanical must be used by at least one other process. In this way 'waste products' such as carbon dioxide, faeces and urine will be converted into Oxygen, food, and water.

> *Everything is connected*
> *Everything has to go somewhere*
> *Nature knows Best*
> *No such thing as a Free Lunch*

**Barry Commoner**
CLOSING THE CIRCLE



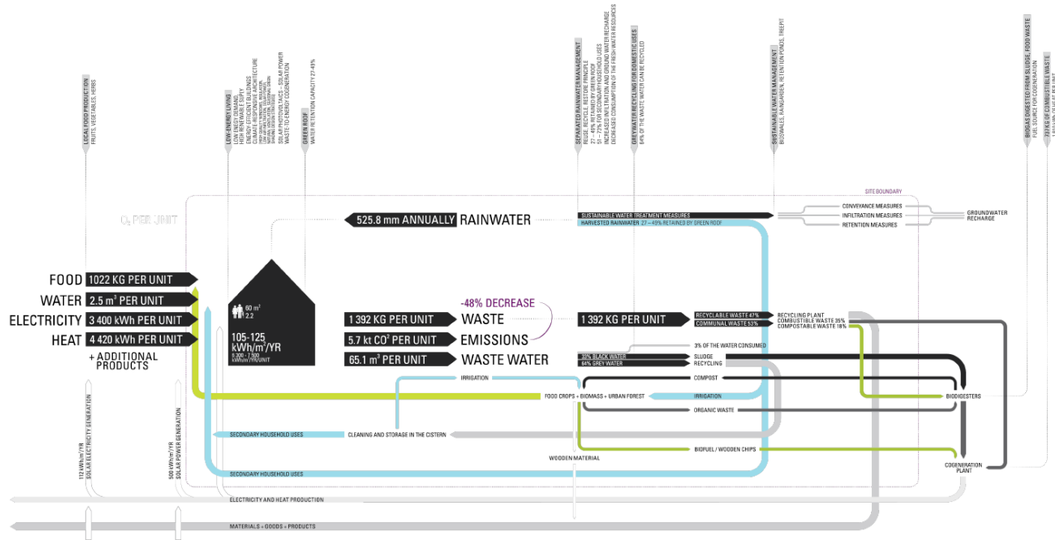
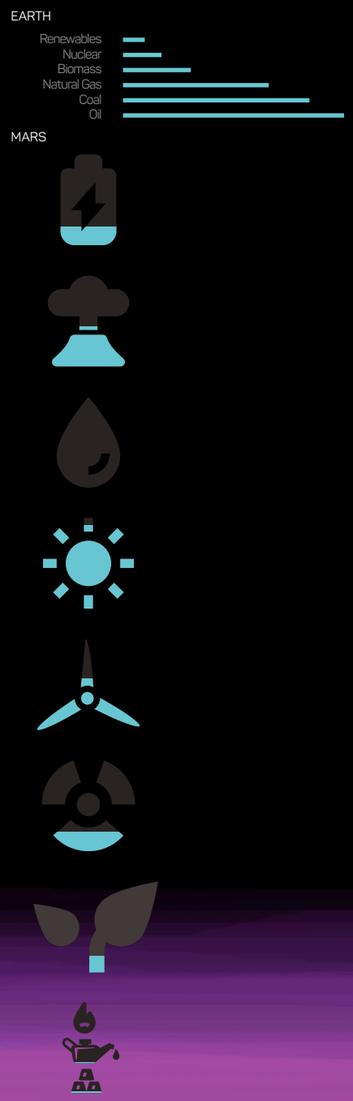



**Diagram of a Closed Loop System by Katelina Vondrova**
THESIS- THE URBAN ECOSYSTEM AS FOUNDATION OF BROWNFIELD TRANSFORMATION

# 59 ENDLESS ENERGY




## PRODUCTION

The energy grid on Mars is will look very different to the global energy grid on Earth which relies on fossil fuels as opposed to renewables. On Mars this will not be an option.

### Piezoelectric

Energy can be generated from applied mechanical stresses such as wind pressing on the outer skin of a habitat, or subtle vibrations through the ground.

### Geothermal

Geothermal heat from Mars' crust can be used to create electricity via steam turbines. This would provide a large source of steady energy.

### Hydro

Until Terraforming has created a Martian atmosphere this form of energy is unapplicable on Mars

### Solar

Solar power is the most efficient way to gather free energy on Mars. In tandem with wind generation this will provide the bulk of energy on Mars.

### Wind

Static and floating wind turbines also have great potential for energy generation on Mars, and act as a backup during dust storms or cloudy days.

### Nuclear fission

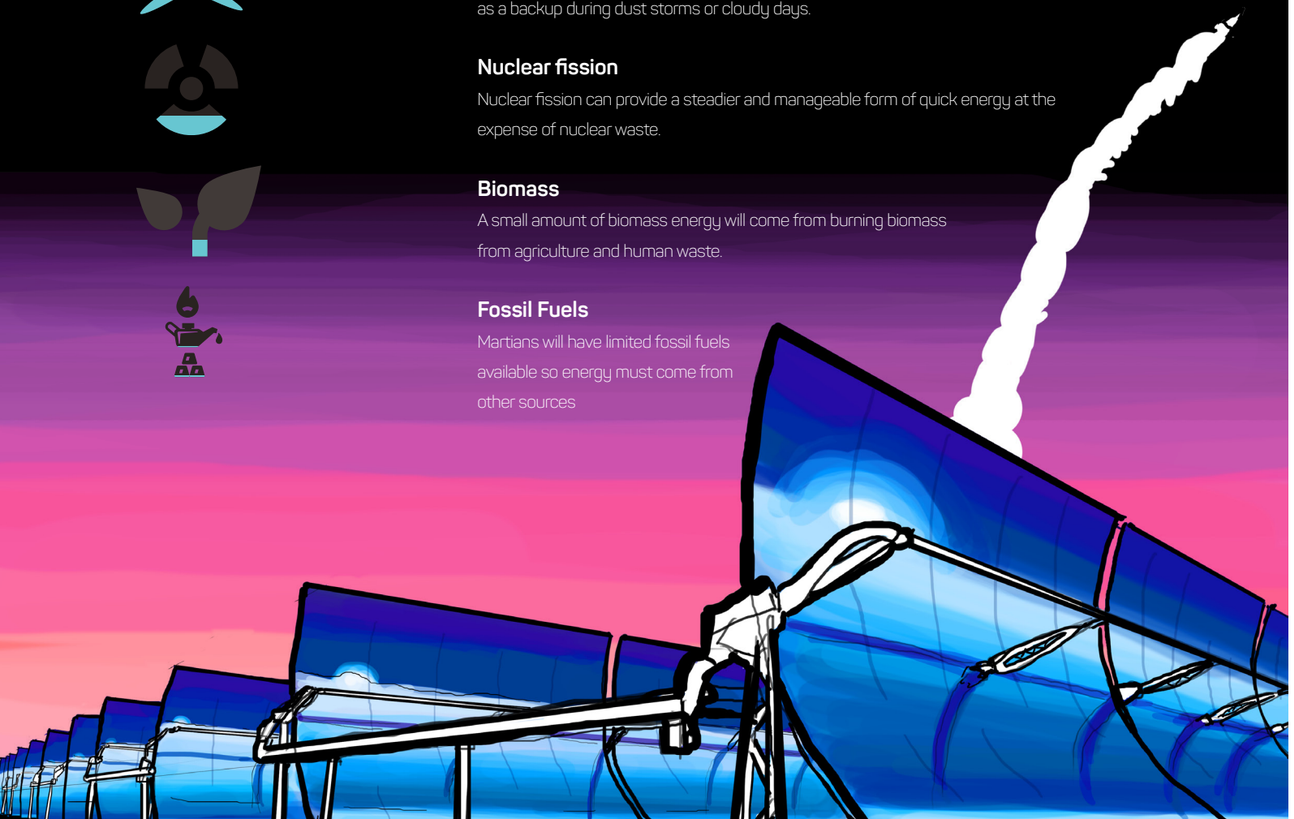
Nuclear fission can provide a steadier and manageable form of quick energy at the expense of nuclear waste.

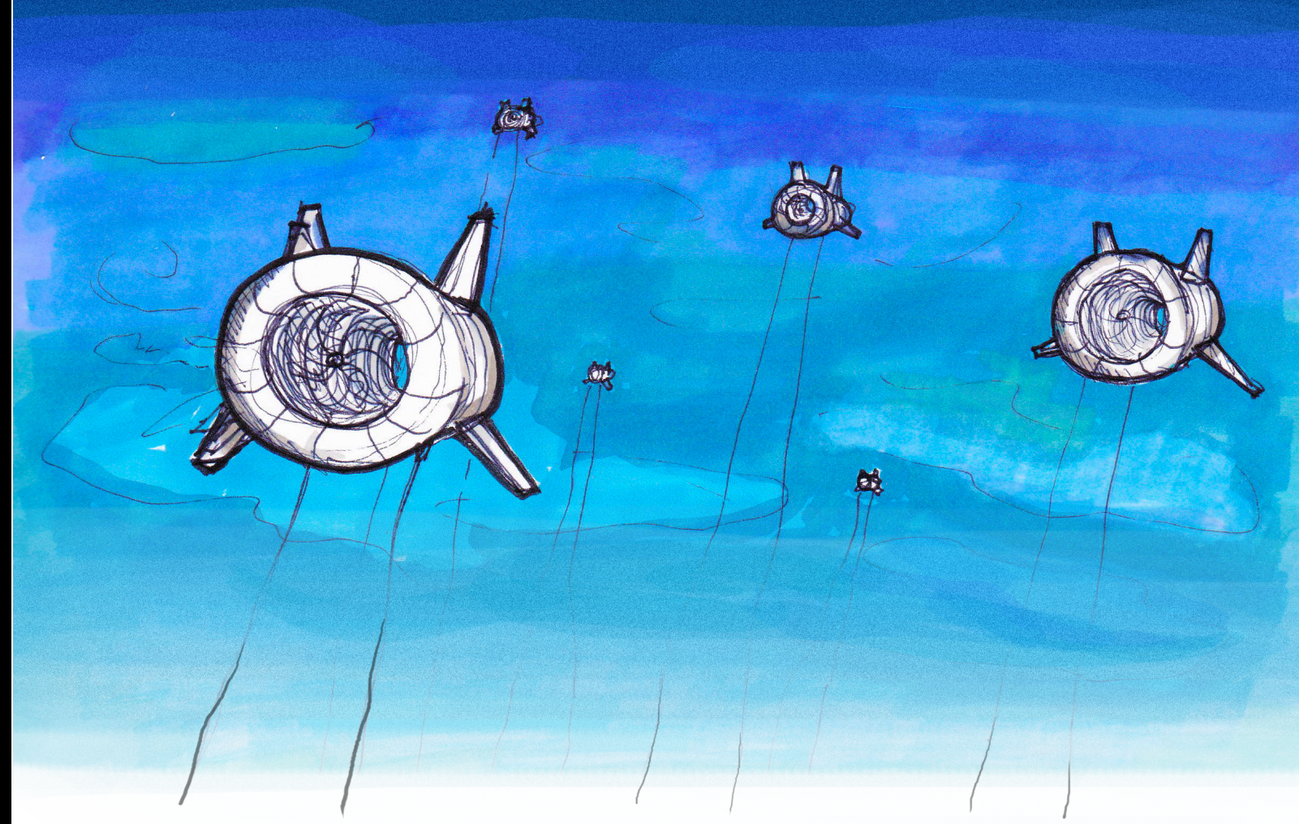
### Biomass

A small amount of biomass energy will come from burning biomass from agriculture and human waste.

### Fossil Fuels

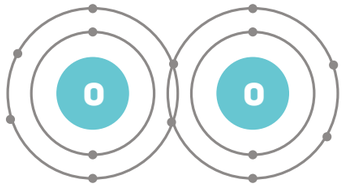
Martians will have limited fossil fuels available so energy must come from other sources





# 60 A BREATH OF FRESH AIR

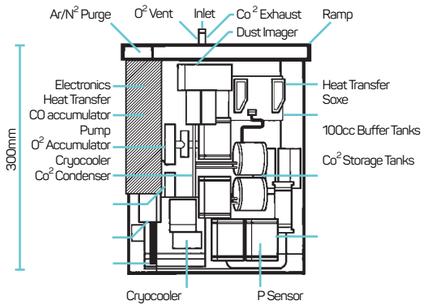
**550L** consumption per day propellant

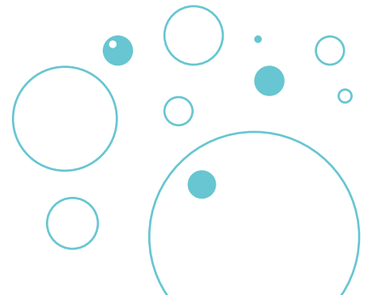




## Moxie

Scaled from a 2010 NASA prototype, the **Mars Oxygen In-situ Resources Utilisation Experiment** uses ceramic fuel cells to convert carbon monoxide to Oxygen and carbon monoxide, filtering Oxygen and other useful gases from the Martian atmosphere.



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# WATER OF LIFE

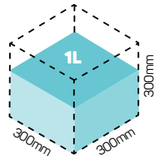
**2L** consumption per day

Crops, Sanitation, Waste etc

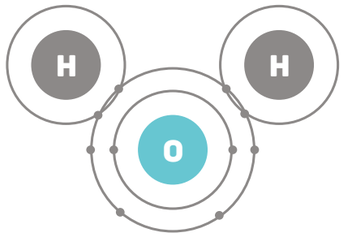
It will be decades before the Terraforming Project creates liquid water on Mars so until then water is a precious commodity which must be extracted, purified and religiously recycled.

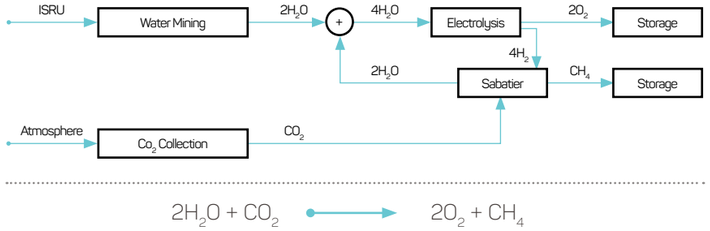
Water is essential for consumption, sanitation and agriculture, as well as many manufacturing processes. The process below shows how water can be gathered on Mars from the polar caps, from the regolith and from the atmosphere.

5 Million $km^3$ of Polar Ice




Frozen water contained within the Martian regolith

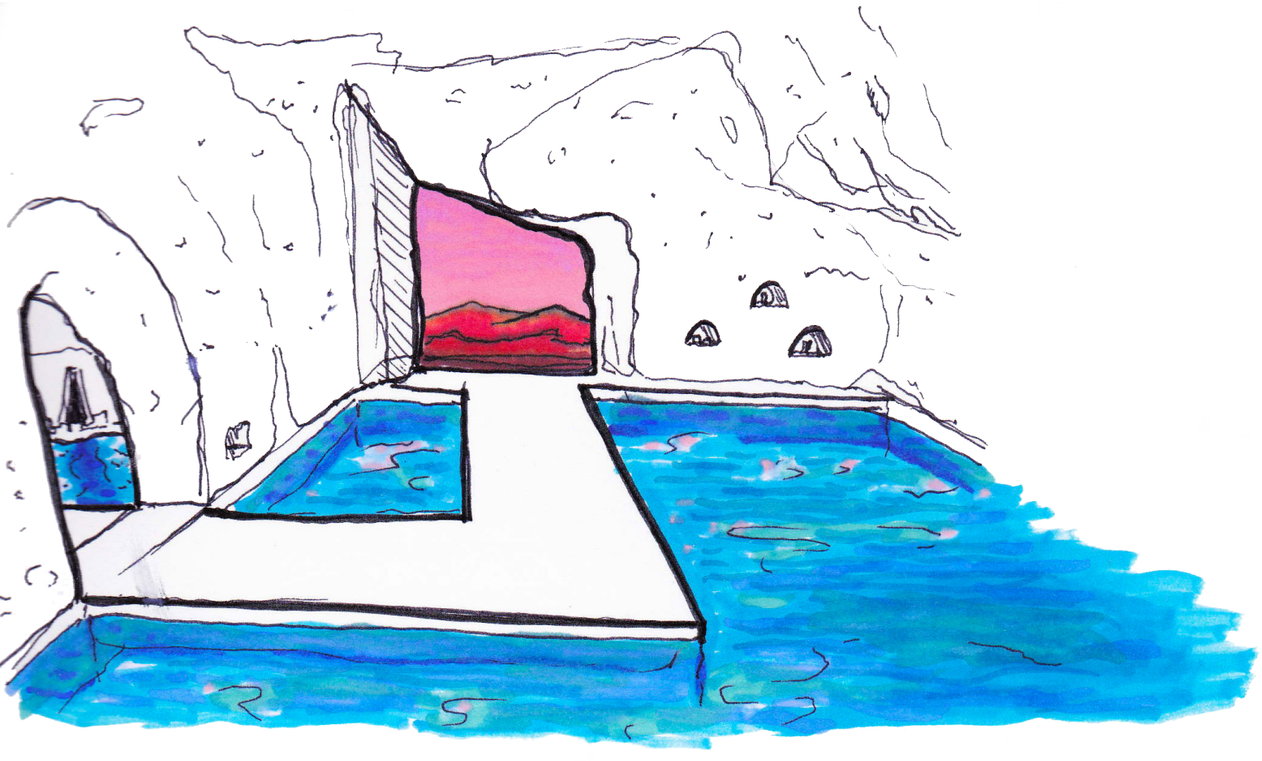



$2H_2O + CO_2 \longrightarrow 2O_2 + CH_4$

FOR MORE INFORMATION SEE

- Blue Mars
- Terraforming



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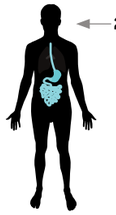
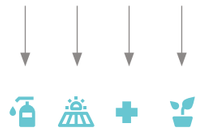
# ASTRO AGRICULTURE



**2,250 kCal** consumption per day

Biofuel, seeds, medicine, fertilizer

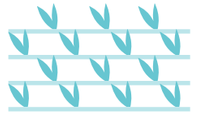


High density methods of farming have changed the face of agriculture. Planting in soil is the least effective way to produce food on Mars and the need for large swathes of land for livestock are no longer needed. Food wastage is near zero as food is produced on-site and as needed with minimal storage or transportation.

Cultured vat meat

Aqua & Aeroponics

Vertical Farming

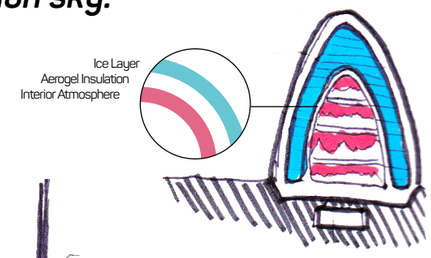


BioRegeneration

Printed Meals

> ***"The ghostly ice exterior of the vertical farms glowed with activity like some alien monument in the long dusk under the lemon sky."***

**Kim Stanley Robinson**
RED MARS



# 63 GATHERING RESOURCES

### ROBOTIC REFINERIES

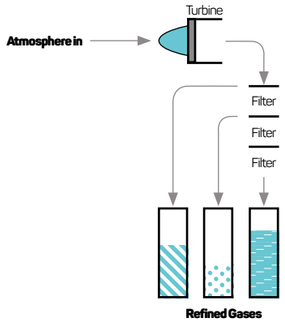
Robotic miners can sift Martian dirt, refining water, Hydrogen and Oxygen from the regolith. These can then be used for propellant, 3D printing, consumption and construction.

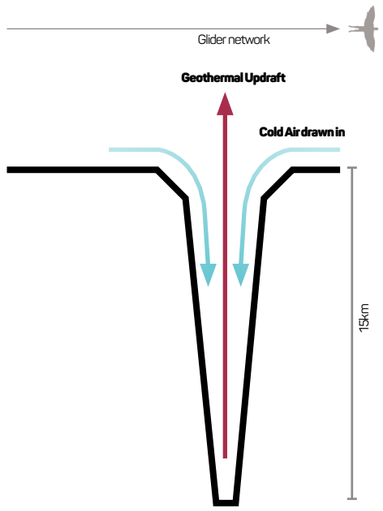
### AIRSIFTERS

Air miners use large turbines to collect and filter the Martian air into component gases, storing and rendering them into more useful chemicals.

### MOHOLES

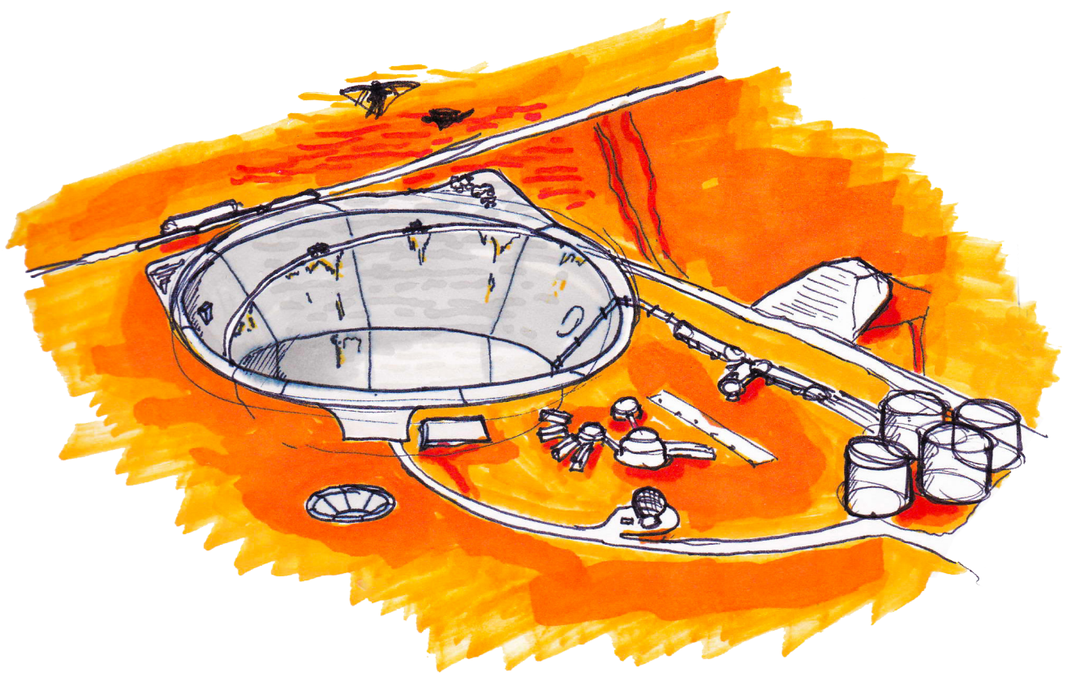
Robot Miners dig vast shafts into the Martian crust to release geothermal heat into the atmosphere. The materials from the mine are processed and used and the resulting shaft can be inhabited. The thermal uprising from a network of moholes can also be use by the transport network for glider routes.



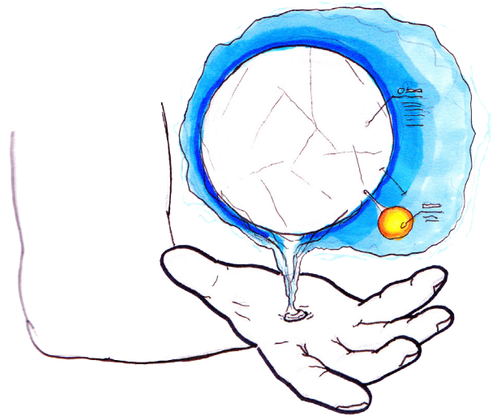




FOR MORE INFORMATION SEE

- Terraforming
- Mars By Air
- Local Production
- Building Blocks

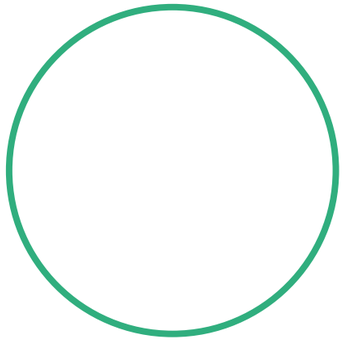


# 64 COMMUNICATION IS KEY



Communication across Mars works just as on Earth via local radio masts or global satellite arrays. But due to disruption and time lag live phone calls to Earth would be impossible. Instead communication would occur via texts, voice and video messages.

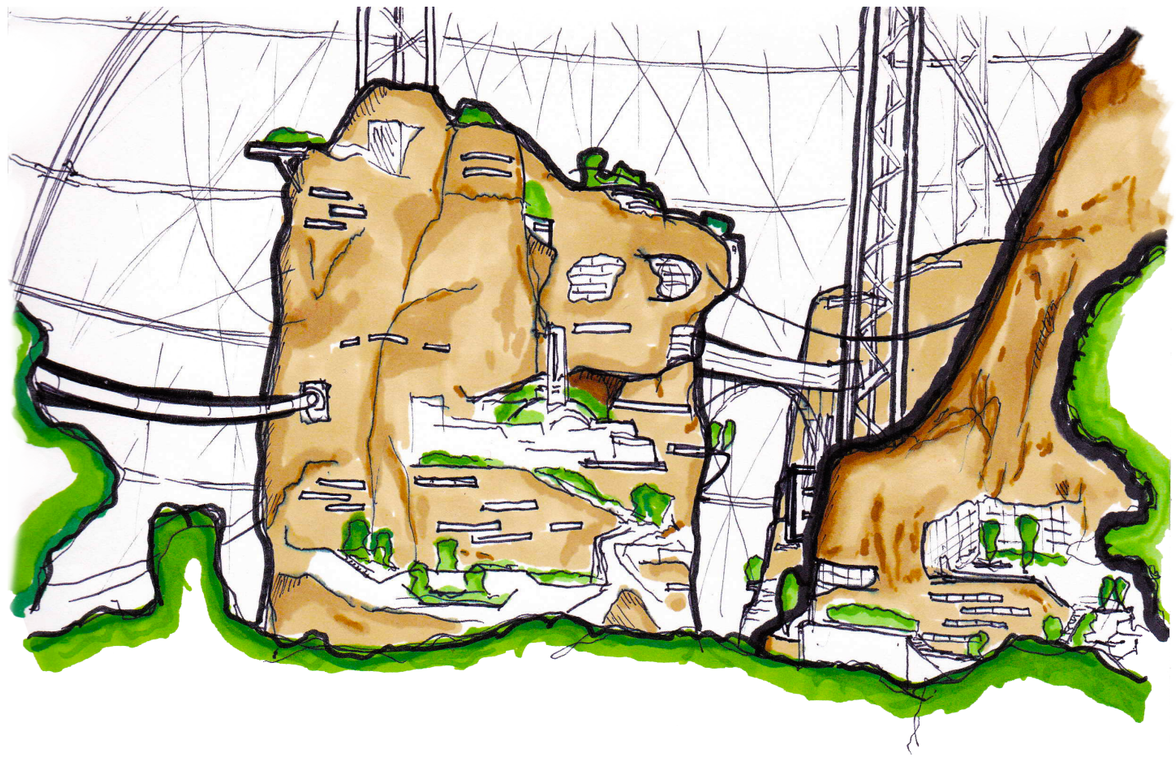
### LOST IN TRANSLATION



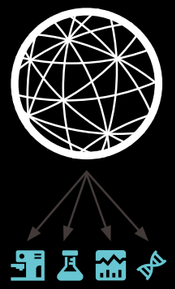
Aside from the distance and timelag, greater barriers to interplanetary communications exist via the culture gap. Simple phrases can often be misinterpreted across various languages, to the point where skilled translators are needed at every political discussion.


FOR MORE INFORMATION SEE

- Alien Nation



# 65 TRADING PLACES



Trade forces people to move from one place to another.  As they move they spread new ideas and cultural practices with everyone they meet, and absorb new ways of living themselves. On Mars trade will be an essential part of life, as a community can produce goods based on local resources, exchanging them for others that they cannot. On a planetary scale Mars' chief export will not be physical goods, due to the expense of transportation, but rather digital goods such as technology and virtual designs in the form of patents. The harsh environment  and high technical knowledge of the colonists makes Mars a pressure cooker for invention, leading to development of vital technologies such as energy efficiency, materials design, genetic engineering, AI and food production.

## BARTER ECONOMIES

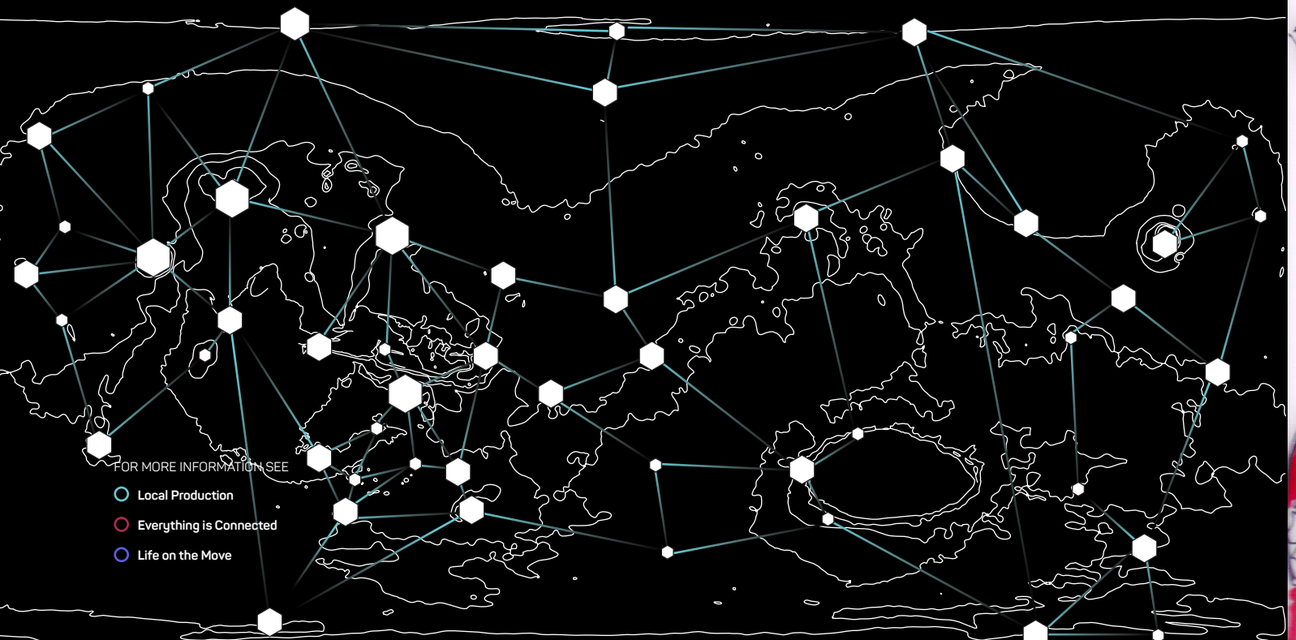
The first social groups on Mars were based upon mission structure from the national or private space missions. This social structure has evolved into a Martian culture where essential and day to day resources belong to, and are shared within a social group and currency is used only for luxury items.

Where Terran economies are based on global markets, Mars focuses on smaller self sustaining communities which produce at a local scale and on demand to avoid unnecessary storage and transportation infrastructure. These communities trade surplus amongst themselves through barter systems for resources they are unable to produce themselves.

> *Before Europe was united legally it was economy and culture that united all the countries of Europe. Arts, literature, music and religion  spread through traders*

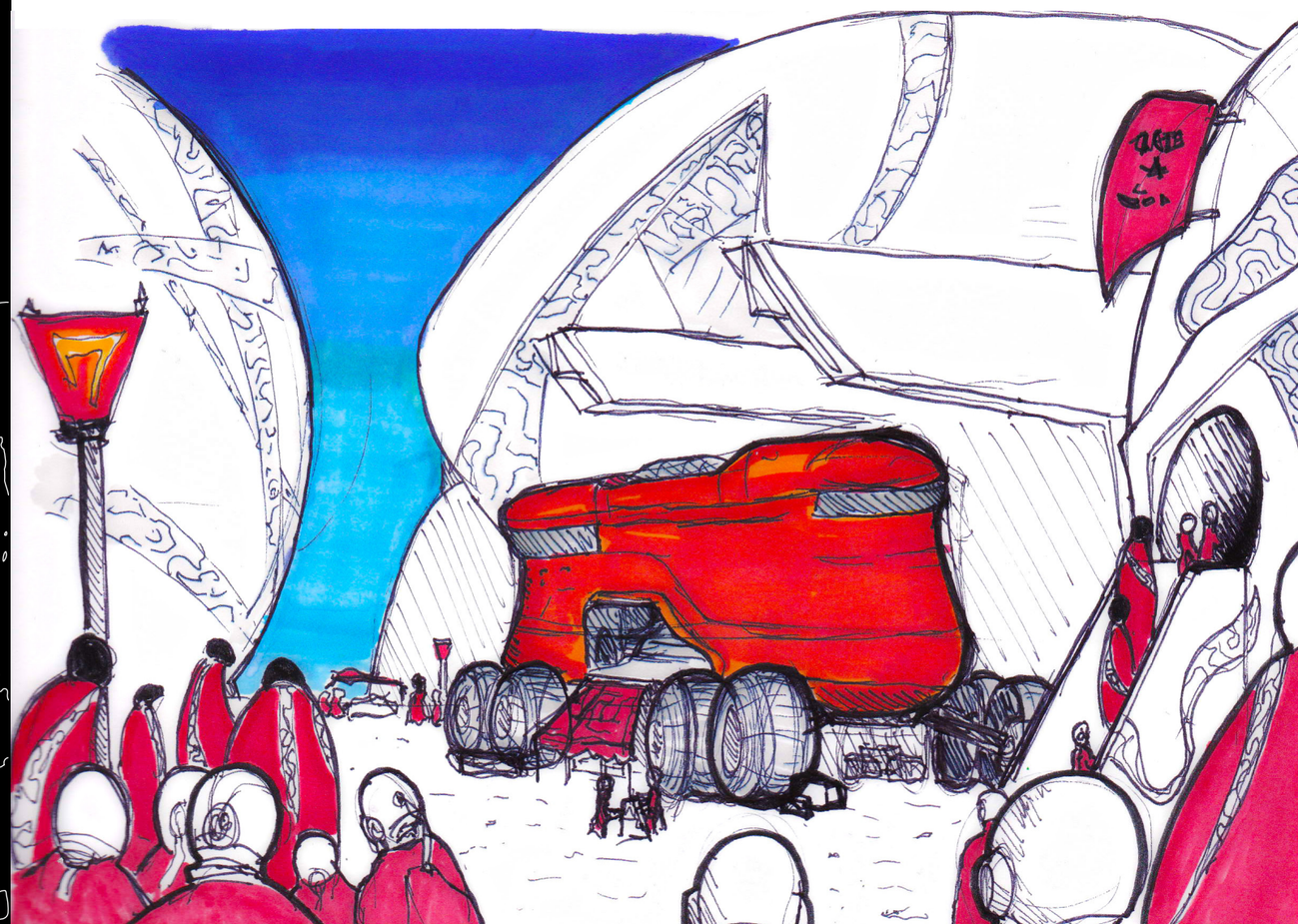
**Dario Fo**
POLITICAL CAMPAIGNER, PLAYWRIGHT

The Martian map will be in part defined by trade, as the quantity or quality of resources which a community has to trade will influence how and where Martians travel to conduct their trade. Outskirt settlements with valuable or high quality goods might attract more visitors than a core settlement with access to common or inferior raw materials.




> ***The Swiss' love of country seemed to be expressed by making a certain kind of life: rational, just, prosperous, scientific. They would work for that life anywhere, because to them it was the life that mattered, not a flag or a creed or a set of words, nor even that small rocky patch of land they owned on Earth. The Swiss road-building crew back there was Martian already, having brought the life and left the baggage behind.***

**Kim Stanley Robinson**
RED MARS

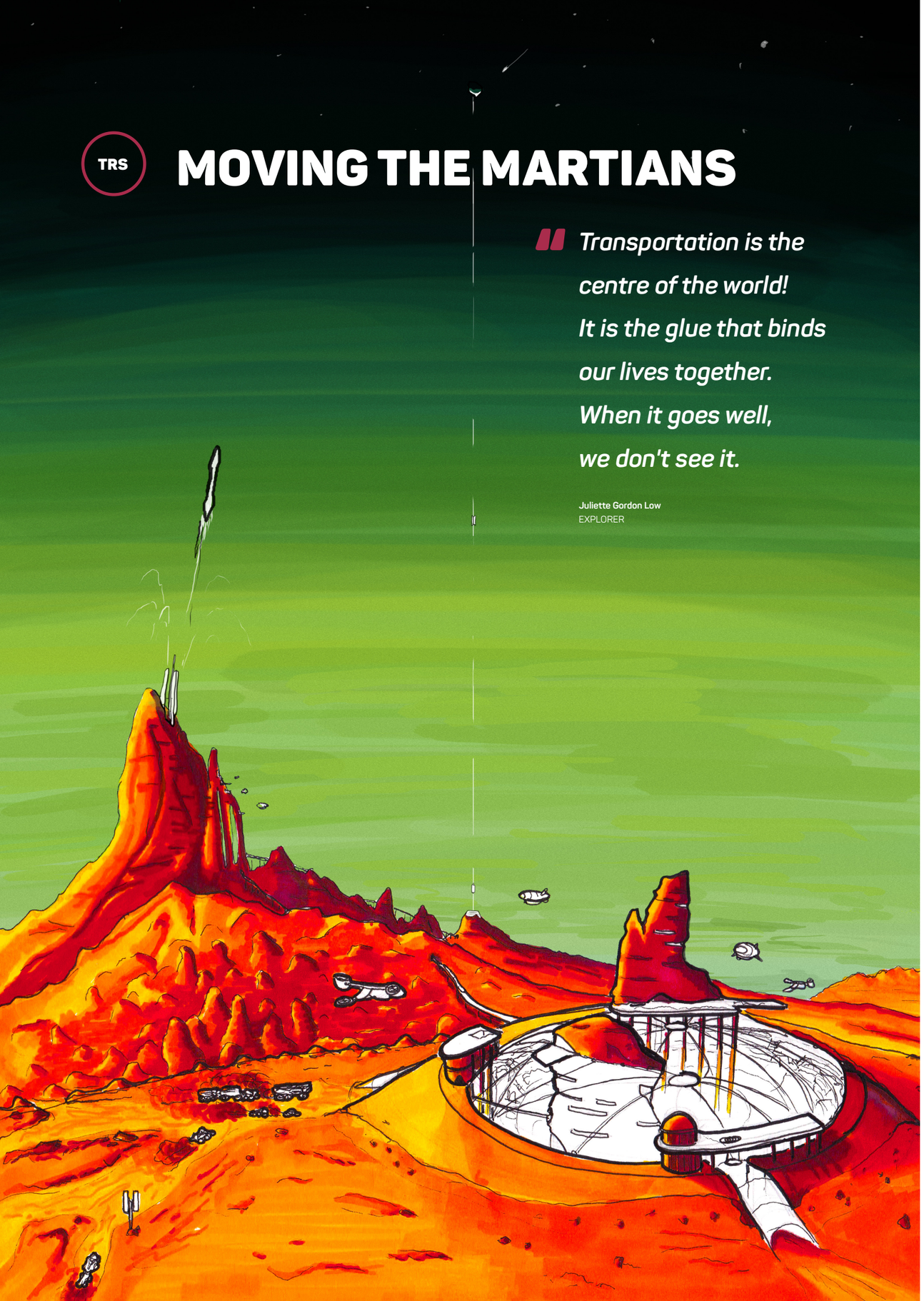


TRS

# MOVING THE MARTIANS

*"Transportation is the centre of the world! It is the glue that binds our lives together. When it goes well, we don't see it.*

**Juliette Gordon Low**
EXPLORER



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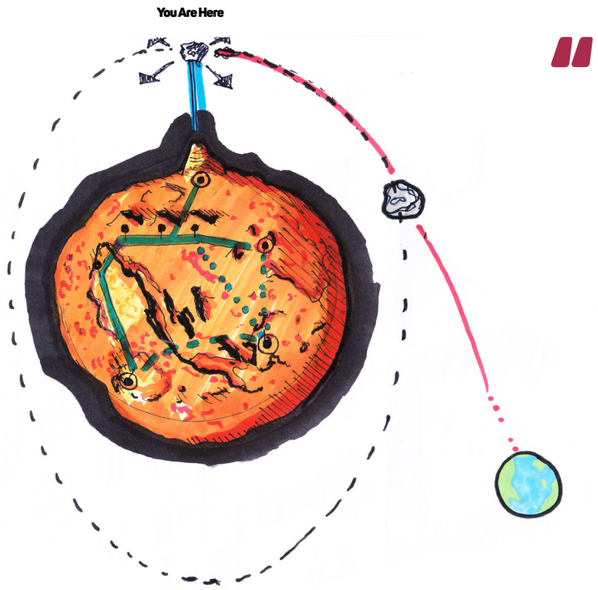
## EVERYTHING IS CONNECTED

*Measured in time of transport and communication, the whole round globe is now smaller than a small European country was a hundred years ago.*

**Sir Boyd Orr**
NOBEL PRIZE WINNER

Trade between communities will create the transport infrastructure on Mars and a networked system of transit will grow organically based on the natural movements of the population.

Transport, as seen in past colonisation efforts, can be taken as a symbol of the progress of civilisation. Just as with the railroads in the colonisation of America, transportation brought civilisation and culture to wilderness, and made the country a smaller place. People equate distance as time. and as the time taken to travel decreases, Mars will become a more accessible for civilisation.


*"Transport and communications will bring the world into closer relations so that the youth of the world should have standards and ideals in common.*

**Juliette Gordon Low**
EXPLORER

# 69 GETTING AROUND

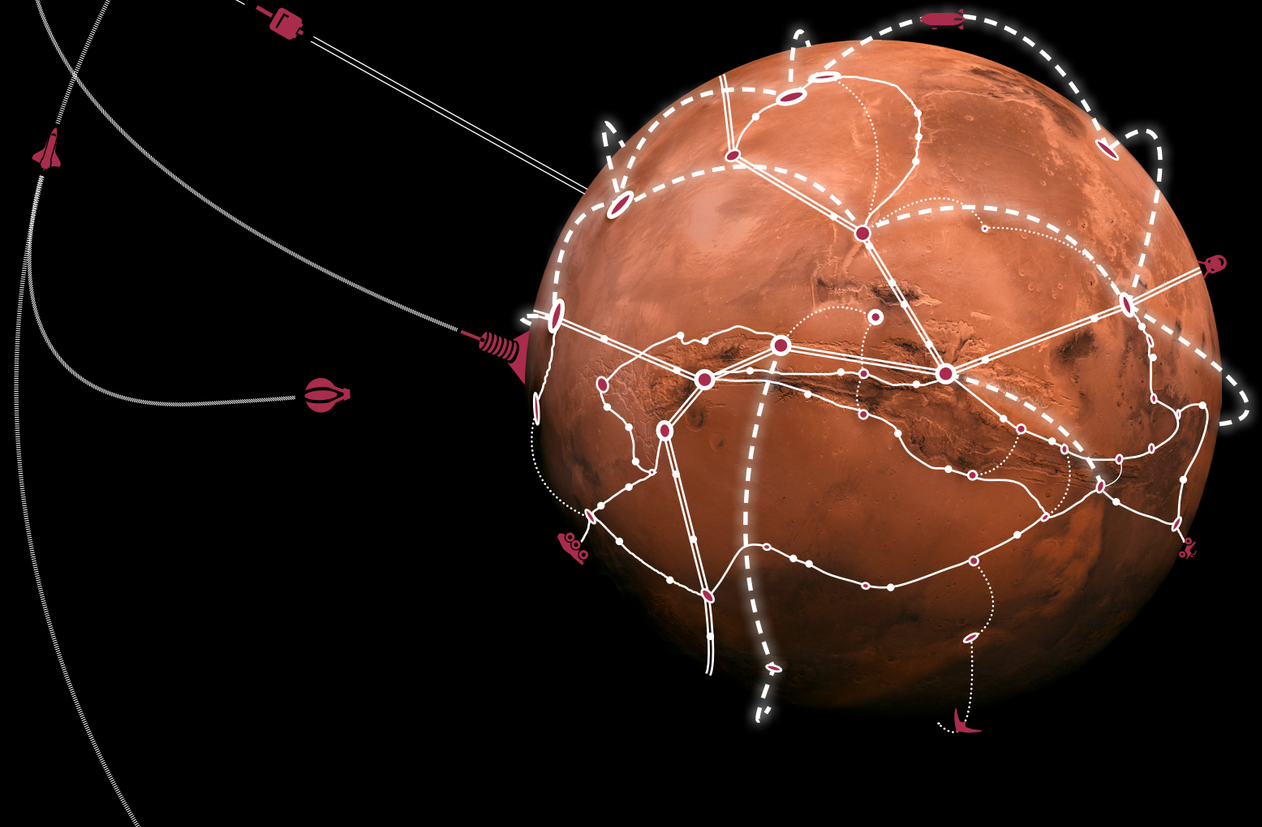
| | Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|---|
| SPACE SHUTTLE | ●●●●● | ●● | ● | ● | ●●●●● | ●●●●● |
| ORBITAL TRANSFER | ●●●●● | ●● | ●● | ●●● | ●●●●● | ●●●●● |
| SPACE ELEVATOR | ●● | ●●●● | ●●●●● | ● | ●●●● | ●●●● |
| DIRIGIBLE | ●●● | ●●● | ●●●● | ●● | ●● | ●●● |
| LAVARAIL | ● | ●●●●● | ●●● | ●●● | ●● | ●●● |
| ROVER | ● | ● | ● | ● | ● | ●● |
| BIKE | ●● | ● | ● | ●● | ● | ● |
| CITYBUG | ● | ● | ● | ● | ● | ● |
| GLIDER | ●●●● | ● | ● | ●● | ● | ●● |

**WELCOME TRAVELLER!**

You are about to embark on the greatest journey on Earth (or not!)

We hope you have packed well, as the first and longest leg by far on the journey to Mars is across the seas of space by space shuttle. At least you don't need to worry about Scurvy anymore!

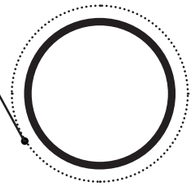
6 months later you will be greeted at the Space Elevator Geostation to great fanfair, with a fantastic view of Mars from orbit. There will be plenty of time to enjoy the view: the luxury space elevator cars will take 5 days to reach the surface descending at a gentle 150mph until they reach the base station atop the famed Olympus Mons. From here you can ride the Hyperloop through underground lava tubes to any of the major Martian settlements, or check out a rover to see some of the local sights. If you have a bit more time why not book a room on a dirigible and visit some far flung parts of Mars? For those in a rush, reserve a glider and stretch your wings!



# 70 ACROSS THE SEAS OF SPACE

**Space Shuttle**

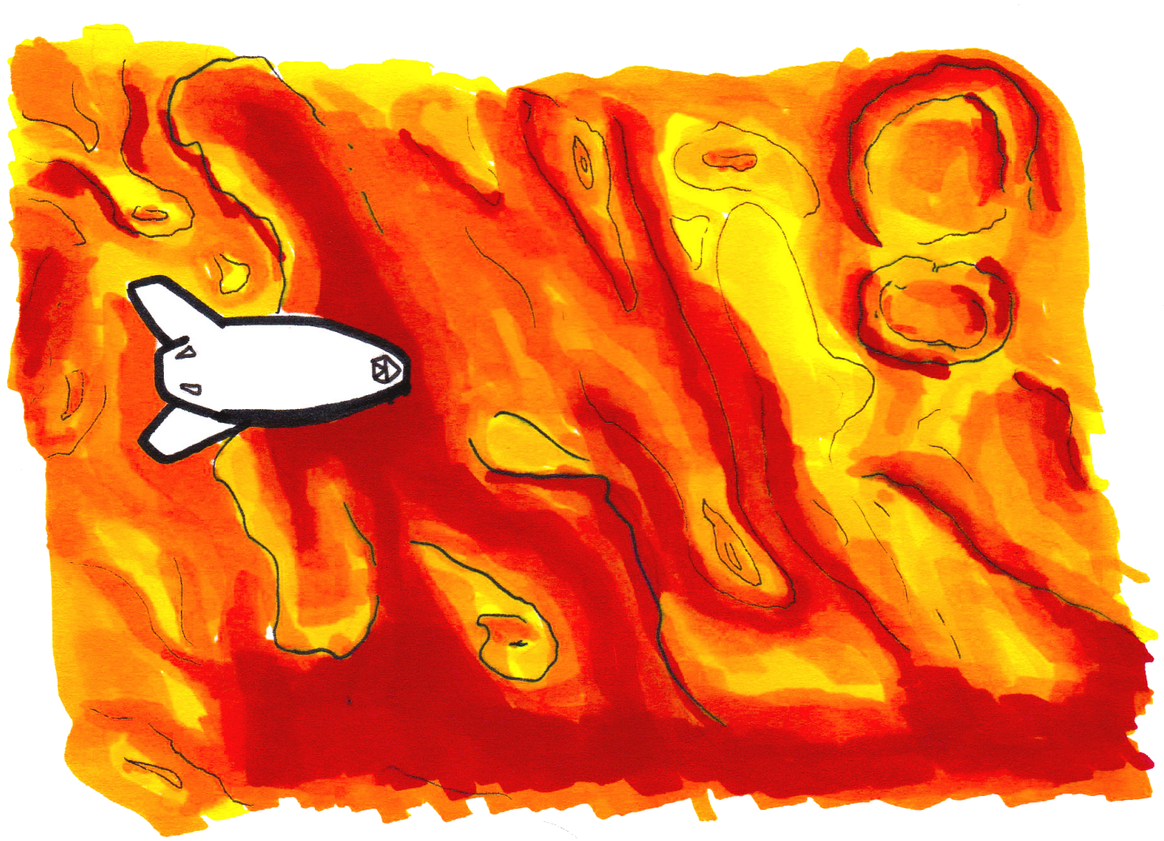
| | Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|---|
| | ●●●●● | ●● | ● | ● | ●●●●● | ●●●●● |



The journey to Mars is long and tedious, in cramped conditions. This leg of the journey is akin to an Atlantic passage sea voyage of the 1600s in terms of duration if not quite discomfort. Unfortunately this is unavoidable for the foreseeable future. As infrastructure improves the trip will become somewhat more comfortable as spaceships are adapted for civilian use. Reusable rockets and in orbit refuelling will allow for more spacious crafts, however private companies may want to monetize this space with more passengers as opposed to improving comfort.

> ***It was obvious that we could never colonise Mars without reusability, any more than America would have been colonised if they had to burn the ships after every trip.***

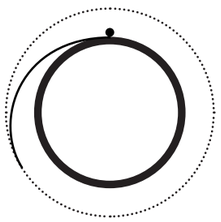
**Elon Musk**
SPACEX



# 71 ORBITAL STOP & DROP

**Orbital Drop**

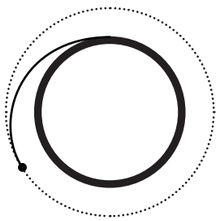
| Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|
| ●●●●● | ●● | ●● | ●●● | ●●●●● | ●●●●● |



One way of descending from orbit to the surface is to let gravity do all the work. An aeroshell and parachute would descend, decelerating through the atmosphere and parachuting to the surface. Despite the thin atmosphere ablative heat shielding is essential and the atmosphere also means parachute braking would be less effective than on Earth.  Cushioning balloons, or retro-rocket would be required for a soft landing.

**Mass Driver**

| Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|
| ●●●●● | ●● | ●● | ●●● | ●●●●● | ●●●●● |



The mass driver offers a one way trip from surface to orbit, by firing a capsule through a magnetic rail cannon at a speed sufficient to climb out of the gravity well, where a tugboat would tow it to the Geostation for the spaceshuttle connection. Ideally this 'cannon' would be miles long, using the steep slope of Mars' volcanoes to achieve a firing trajectory into space. The mass driver would only be used for precious and priority cargoes or VIPS due to expense and energy required to fire it.

> *Civilisation as we know it has been defined by exploration. That is the future of space exploration and human spaceflight.*

**Alan G Pointdexter**
ASTRONAUT

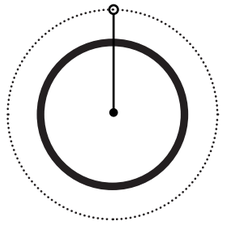
FOR MORE INFORMATION SEE
Atmosphere

> *A Colony on Mars is a philosophical debate.*
> *Many think it is not in our purview as human beings to change anything. I respect that view but I disagree:*
>
> *When I look at the universe I think life is the most rare and precious thing we can see.*
> *It's just incredible.*
>
> *We human beings are uniquely positioned to help spread life from this tiny planet to beyond.*
>
> *That's our gift to the universe, the gift of life.*

**Chris Mckay**
PLANETARY SCIENTIST

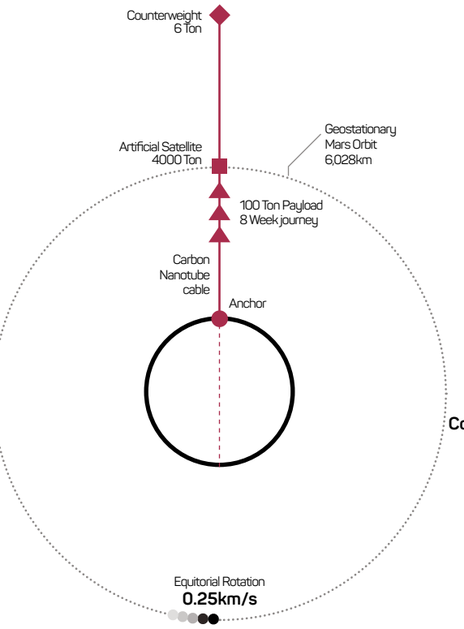
# 73 ELEVATOR TO SPACE

| | Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|---|
| | •• | •••• | ••••• | • | •••• | •••• |

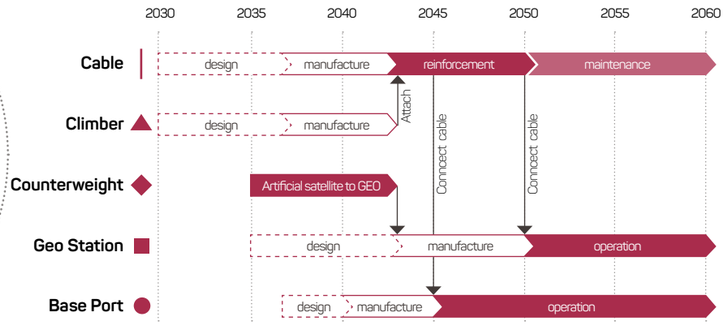


If the space shuttle is the ship from Lisbon to London the space elevator is the carriage from London to Glasgow.  Freight and people travel between the surface and low orbit in relative ease and comfort.
A space elevator on Mars would be essential to the long term development  of a Martian colony, by enabling easy escape from the planet's gravity well and enabling world trade and tourism without the expense of rocket launches. The equatorial Base station at Olympus Mons would quickly become a hive of activity, and a nexus for trade and tourism. The city surrounding the base station would become the Martian capital, attracting an influx of Commerce, Tourism and Industry.

## CONSTRUCTION

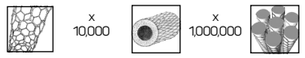



**01** Satellite launched into Geostationary Mars Orbit.
**02** Satellite moves outwards, reeling Cable out towards Mars.
**03** Cable reaches Mars and is tethered to Base Port along equator.
**04** Satellite becomes a Counterweight at end of cable.
**05** Robotic Climbers ascend cable with reinforcement cable.
**06** GeoStation constructed in Geostationary orbit.




### carbon nanotubes

This amazing material is incredibly light yet has a length-to-diameter ratio of up to 132,000,000:1

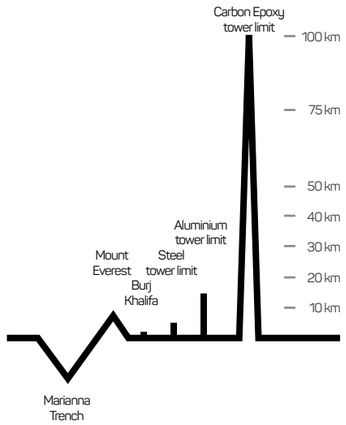


| Carbon Nanotube | x 10,000 | Human Hair | x 1,000,000 | Elevator Cable |
|---|---|---|---|---|
| 0.000000001 m | | 0.00001 m | | 1m |

### space scrapers

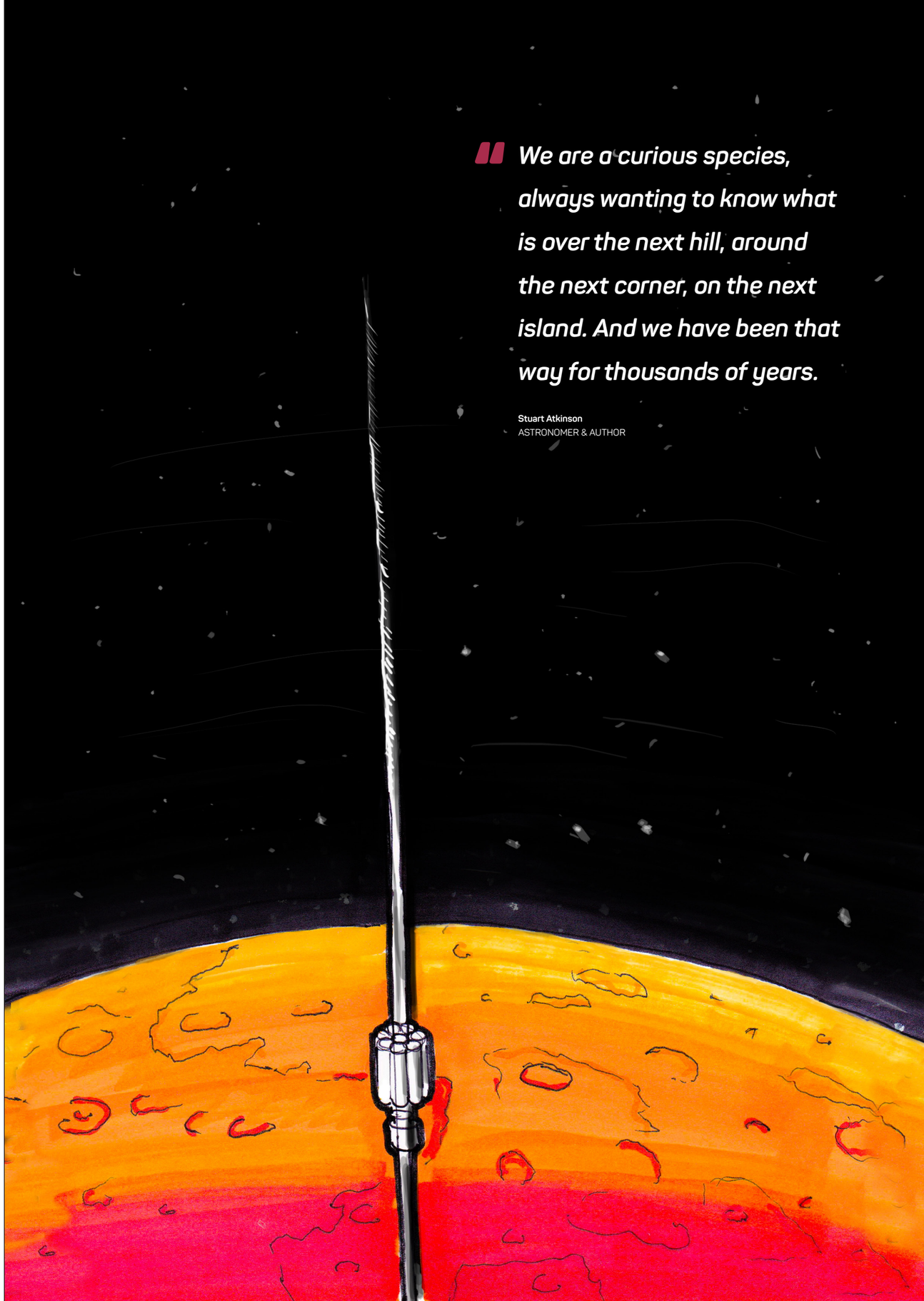
The maximum height of structures that can support their own weight are shown in these towers.

Right now, using current technology, it would actually be possible to build a space elevator on the Moon.




> *We are a curious species, always wanting to know what is over the next hill, around the next corner, on the next island. And we have been that way for thousands of years.*

**Stuart Atkinson**
ASTRONOMER & AUTHOR



# MARS BY AIR

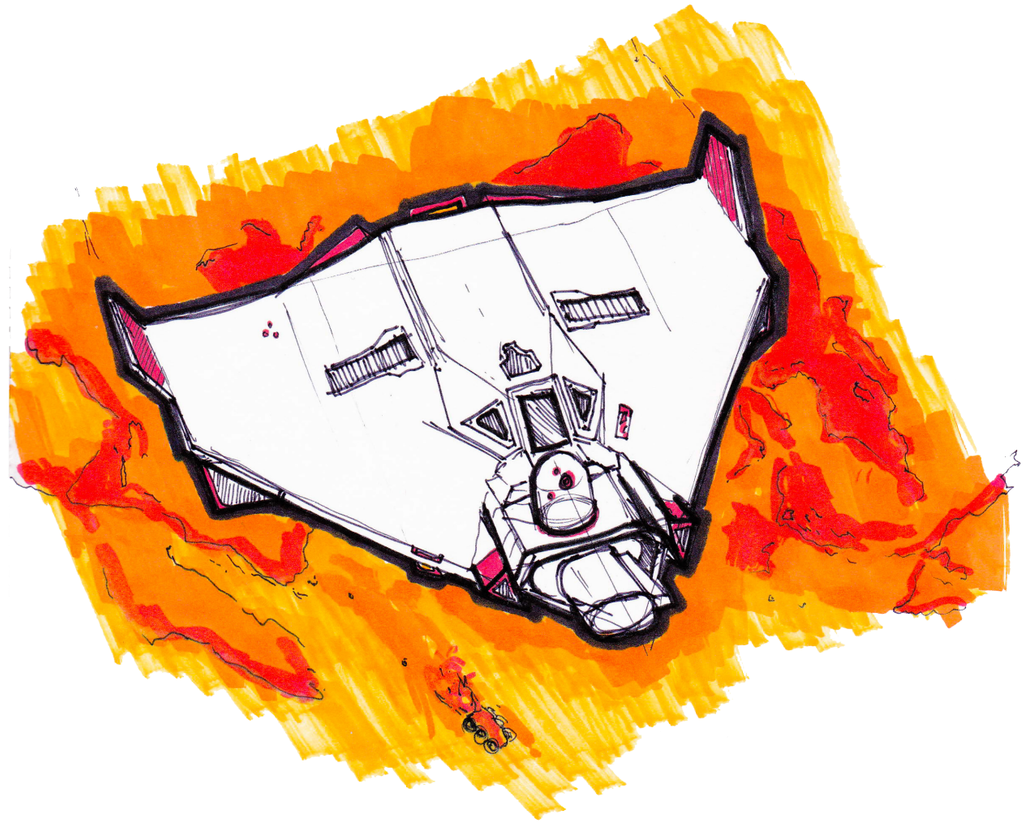
## Dirigible

| Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|
| ••• | ••• | •••• | •• | •• | ••• |

The thin atmosphere on Mars makes heavy planes inefficient, as they would need to travel at extreme speeds to generate sufficient lift through aerodynamics. Yet for long distances air travel allows the traveller to proceed in a straight line, without delays for circumnavigating tricky landscape, and the additional view offered by height is vital for surveying and exploring.
Instead of planes, rigid dirigibles are more realistic on Mars. The low atmosphere which prevents planes means that wind has a less detrimental effect on balloons and dirigibles. Whilst much slower than planes a dirigible would offer a more comfortable, leisurely mode of transportation and freight.

FOR MORE INFORMATION SEE

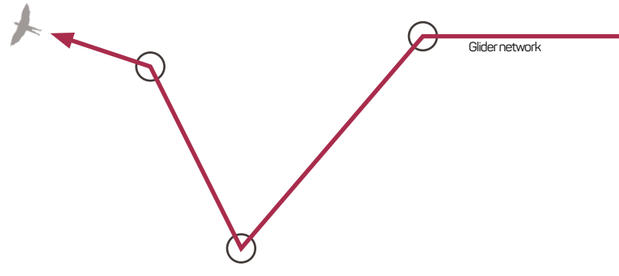
Weather



## Gliders

| Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|
| •••• | • | • | •• | • | •• |

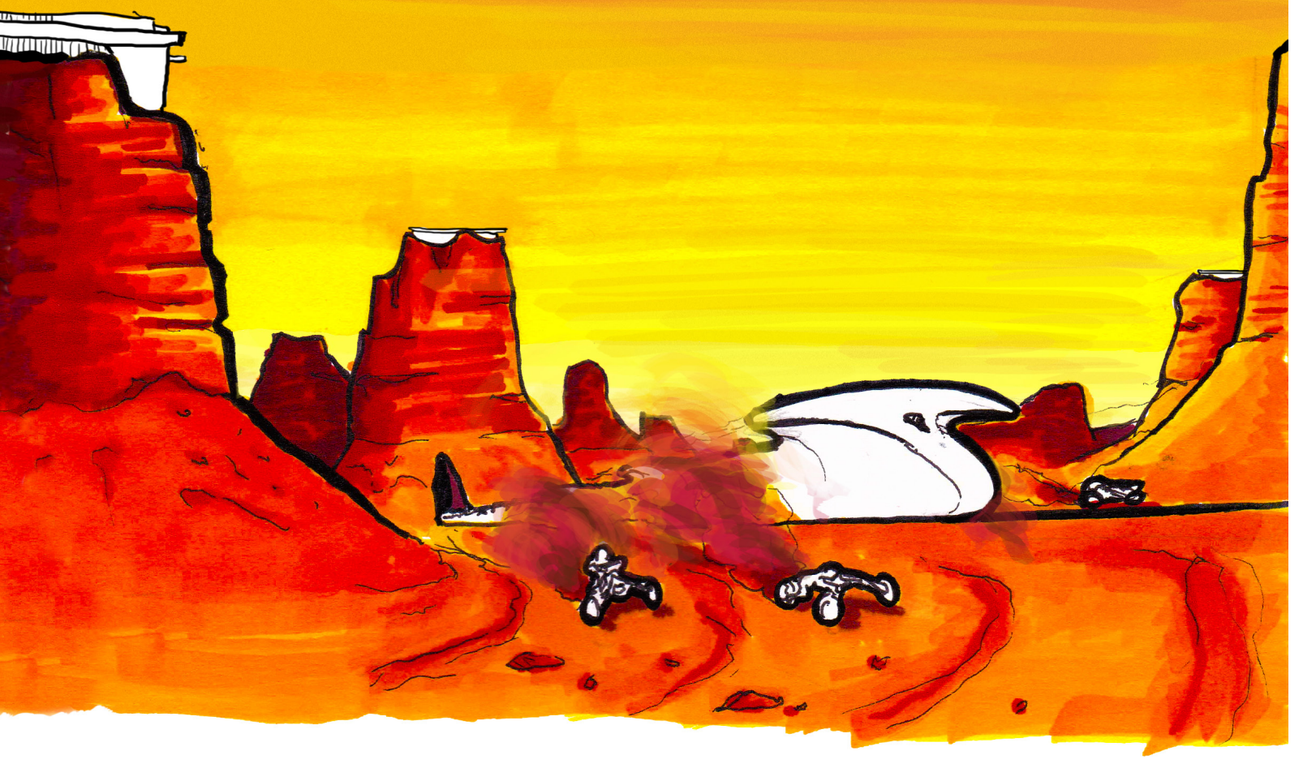
Some settlements are located in remote regions for scientific or resource based reasons. Low volume of traffic travel to these places, so for aside for supply caravans gliders are the best option for low volume, high speed transport. Gliders also have practical uses in geological surveying and exploring new lands. In developed areas Gliders can operate quickly using a network of geothermal updrafts from mohole mining.




FOR MORE INFORMATION SEE

Gathering Resources

# MARS BY LAND

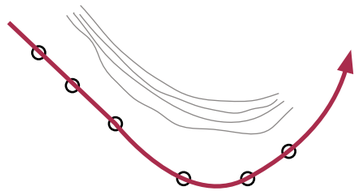


| | Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|---|
| **Rovers** | • | •• | •• | • | • | •• |
| **Bikes** | •• | • | • | •• | • | • |

*Roads?*
*Where we're going,*
*We don't need roads...*

**Dr Emmett Brown**
TIME TRAVELLER

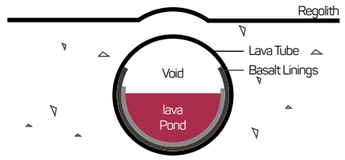
Rovers are the primary mode of transportation on Mars, being versatile, reliable and able to tackle the rugged and varied terrain of Mars. Trailblazers, explorers and road builders venture out on surveys and lay transponder 'roads' along the best routes for future travellers, opening up the planet for civilisation. Light bikes would also be used for shorter exploration trips, but would require the rider to stay in environmental suit during travel and have little in the way of life support. Rovers however can come in a variety of shapes and sizes depending on its intended function, some with large trailers for carrying freight, some large enough to live in comfortably for extended periods, and all equipped with life support, navigation and communication systems.



## LavaRail

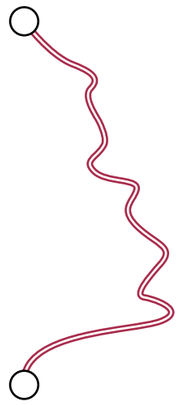
| Risk | Volume | Comfort | Speed | Cost | Distance |
|---|---|---|---|---|---|
| • | ••••• | ••• | ••• | •• | ••• |

High speed bullet trains travel through vacuum tubes at hundreds of miles an hour to connecting far flung major settlements. Many of these tubes take advantage of hollow lava tubes formed by Martian volcanoes. This avoids excavation and offers affordable and comfortable rapid transit system between settlements.



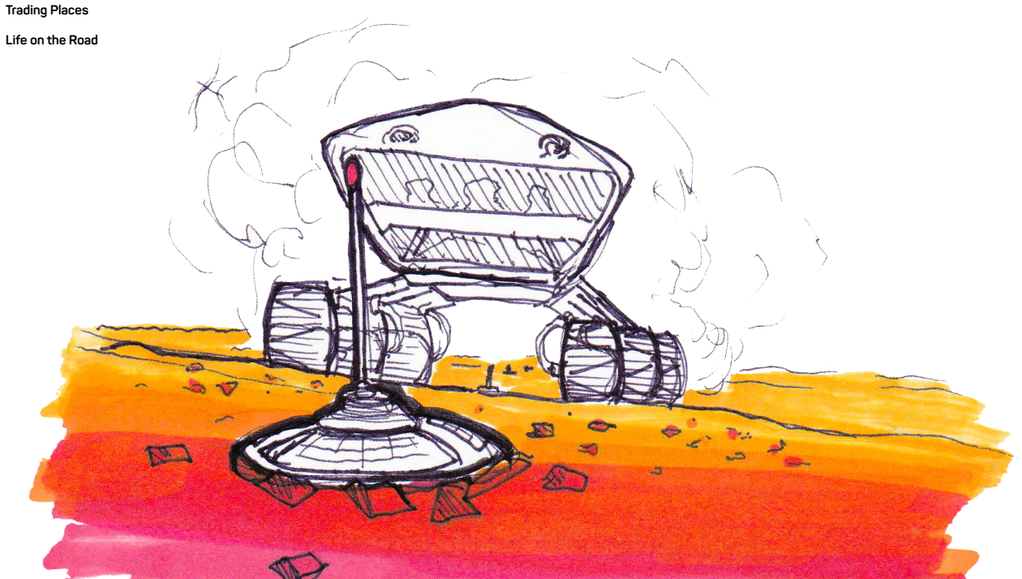

FOR MORE INFORMATION SEE

- **Volcanicity**



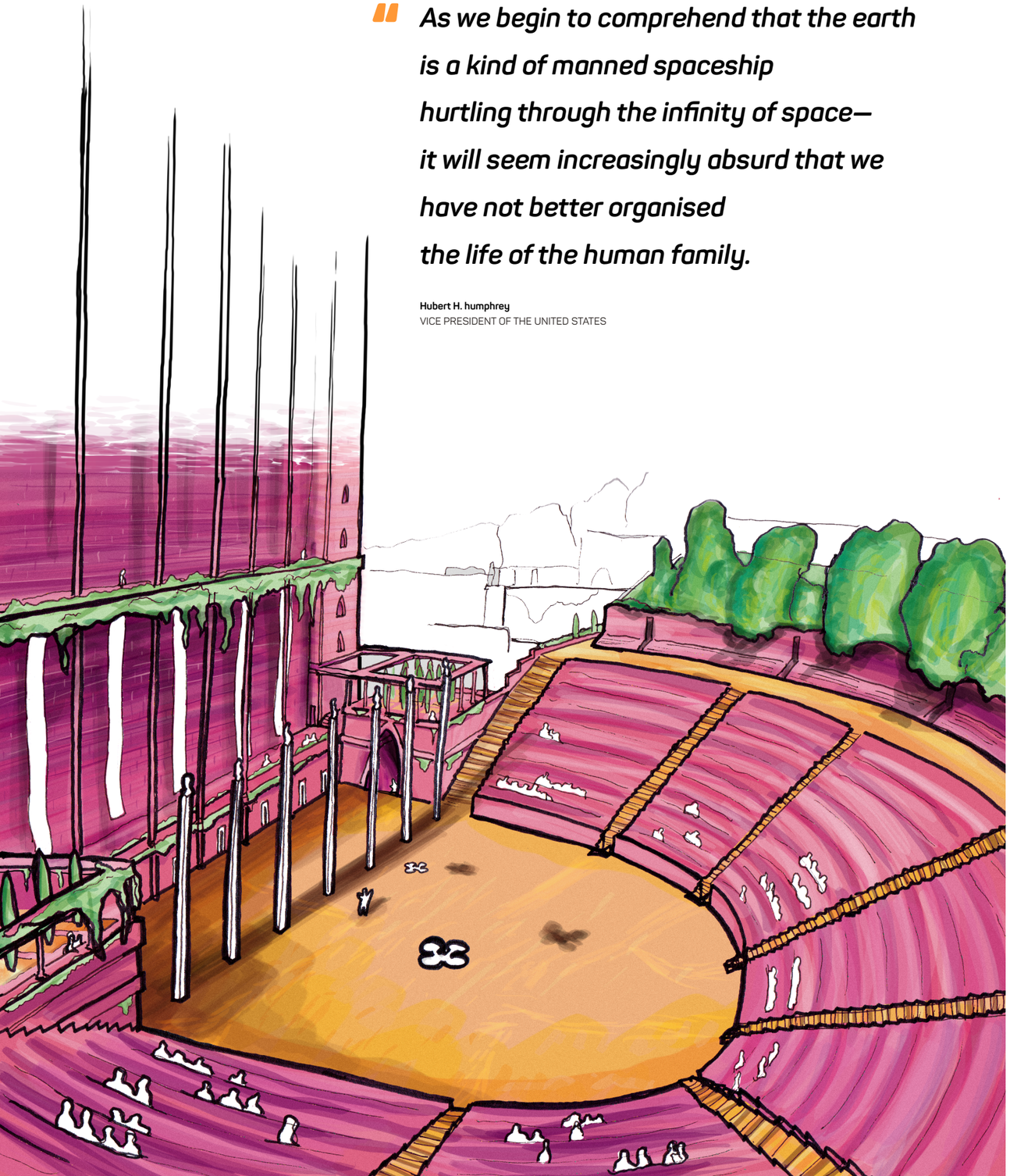
FOR MORE INFORMATION SEE

- **Trading Places**
- **Life on the Road**



SOC

# NEW WORLD ORDER



> *As we begin to comprehend that the earth is a kind of manned spaceship hurtling through the infinity of space— it will seem increasingly absurd that we have not better organised the life of the human family.*

**Hubert H. humphrey**
VICE PRESIDENT OF THE UNITED STATES

80

## SPACE RACE FOR MARS

Many organised bodies are pushing to reach and colonise Mars. These organisations and their respective mission goals will form the basis for a future Martian society.

### NATIONAL

Most nations have some form of space agency however there are only a few major capable of full space flight and exploration. National competition ensures that any advancements on the path to colonise Mars increases effort in competing nations. China, Russia and the US are all determined to be the first to colonise Mars.

### NON GOVERNMENT ORGANISATIONS

Most missions to Mars usually consist of joint private and national funding. There are various non-profit or crowd funded efforts to colonise Mars with varying degrees of legitimacy. These organisations may work in tandem with private and national efforts to reach Mars

### PRIVATE COMMERCIAL

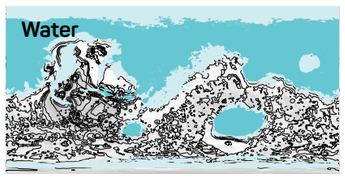
The biggest opportunity for Martian colonisation at present comes from private companies who have a long term commercial interest in developing space exploration and claiming monopoly over infrastructure, provisioning or transport for Martian settlements, as well as securing their own name as forerunners in space technologies.

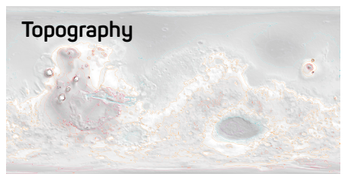
FOR MORE INFORMATION SEE

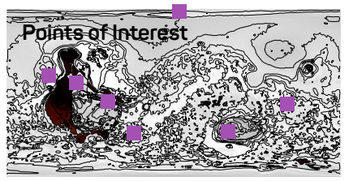
- Expansion Drivers
- Planetary Politics

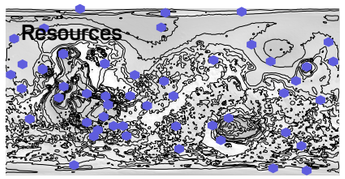
# POPULATION CENTRES

When these organisations achieve their missions to Mars where do they choose to settle?
The reasons for settlement as always are driven by basic human needs: food, water, warmth, security and resources will determine where humans settle on Mars. Various analysis of Mars' surface can be found throughout this book and will be used to determine ideal settlement locations.
6 main factors have been identified as a result of this analysis, which can be seen below. Water and resources will be essential for short term survival. Over a longer period of time the climate, dust and topography will all make a difference to quality of life. Equatorial sites will tend to a warmer climate, whereas lower elevations will offer respite from the Martian weather and protection from dust storms. Considering an even longer viewpoint many of the goals for human settlers will be scientific research and so positioning the settlement as close to these points of interest will be paramount.

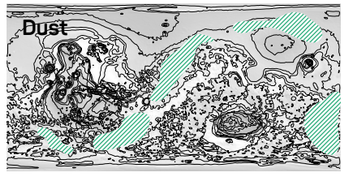


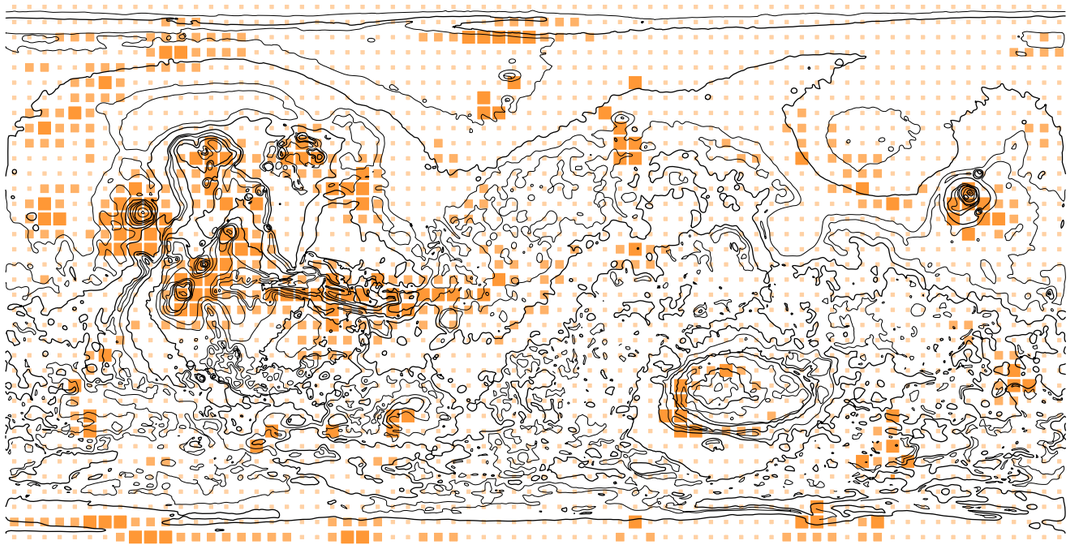







> *Society does not consist of individuals but expresses the sum of interrelations, the relations within which these individuals stand.*
>
> Karl Marx

**Petra, Jordan**
PHTOGRAPHY BY PETER CAREY

## 83 ALIEN NATION

FOR MORE INFORMATION SEE
- Communication is Key

The physical distance and the growing cultural gap between Earth and Mars will inevitably grow until Martians begin to resent Earth's influence from such a distance, at which point decolonisation begins.

**Outer Space Treaty**

In 1967 103 nations signed the Outer Space Treaty, prohibiting any nation from claiming territory in space. The treaty meant that Mars could never become a legally recognised colony, as the USA was originally a colony of the UK. The evolution of Martian colonists from science bases into permanent settlements brought this status into question and the first debate was opened for the matter of Martian independence.

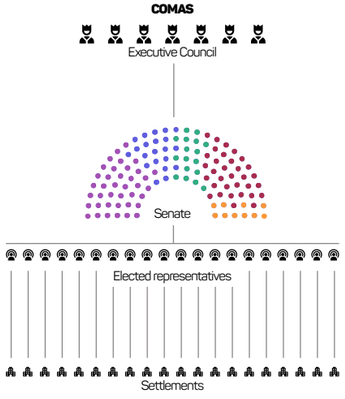
**Articles of Colonisation**

Negotiations break down as colonists, private organisations and national entities fail to find common ground. Peaceful protests giving rise to violent riots spread across planet. Cooperation by colonists and private companies leads to staged sit-ins and blockade of the space elevator and negotiations are reopened. The Articles of Colonisations are drafted as a basis for Mars and future colonisation efforts. Settlements elect representatives and a degree of autonomy introduced where matters such as justice and administration handled within each settlement.

**Declaration of Independence**

Settlements are unified under Coalition of Organised Martian Settlements, COMAS, which determines broad Martian policy, whilst leaving Legislature power at local level.

## 84 PLANETARY POLITICS

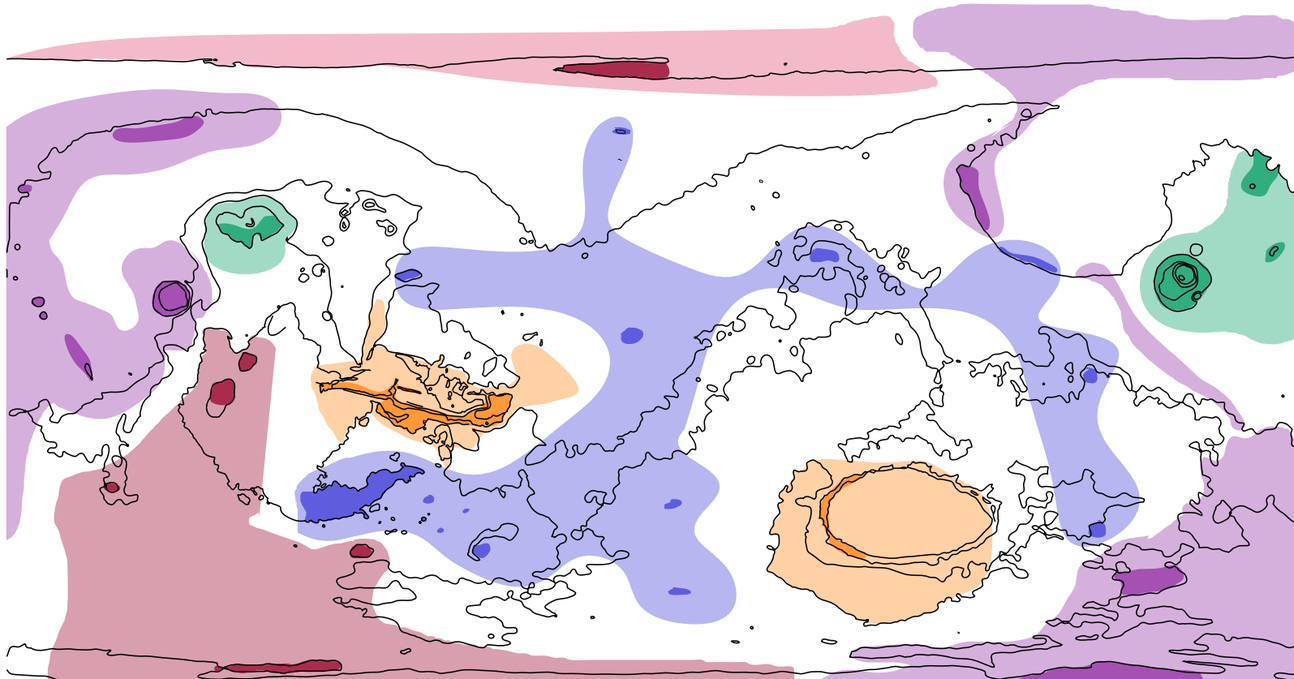



Once Mars has it's freedom it will have to decide what to do with it. Debate over key issues means unavoidable political conflict, leading to the natural formation of political parties from Trade unions, activists and like minded groups of individuals. Although these issues can be hugely complex and there is large grey areas and differences of opinions, the attitudes to these issues can be summarised below.

The new society that will form on Mars will be built by the people of Mars; an amalgamation of ideologies, faiths, beliefs and values from all over Earth. Any government that forms will scavenge ideas from the American Constitution, the Swiss confederacy, the Antarctic Treaty, and many other constitutions and governmental methods. The government will also have to be based upon the reality of the Martian environment and the nature of disparate population. For this reason settlements and cities will be generally autonomous and conduct their own affairs but are subject to a central representative legislature and judicial legal court.

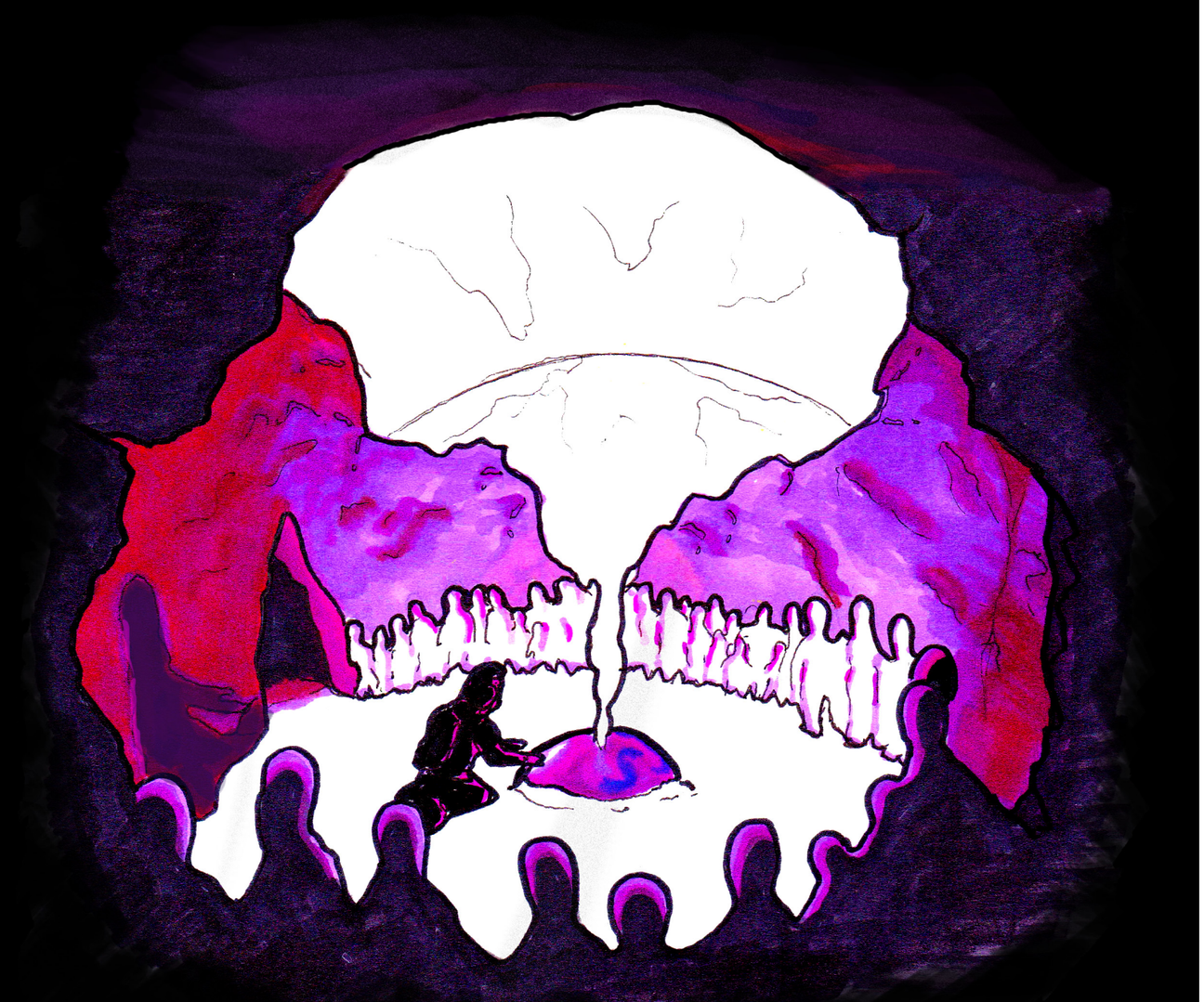
\+ for
\- against
= indifferent or divided
! Key Issue

| | Mars First<br>PRIVATE COMPANIES | Colonials<br>SETTLERS, NGOS, UNION | Transformists<br>PRIVATE, LABOURERS | Reds<br>NATIONAL SCIENTISTS | Socials<br>INDEPENDENT SCIENTISTS |
|---|---|---|---|---|---|
| ECONOMIC GROWTH | ! ! ! | - | - | - | - - |
| OWNERSHIP OF LAND | + + | + + | = | - | - |
| TERRAFORMING | + | + + | ! ! ! | - - | + |
| ECONOMIC LIMITATION | + + + | - | - - | ! ! ! | + + |
| INDEPENDENCE | - | ! ! ! | + | - - | + |
| INFRASTRUCTURE | + | + | + | + | - |
| TRANSHUMANISM | = | = | + + | + | - |
| SOCIAL ENGINEERING | + | - | + | + | ! ! ! |

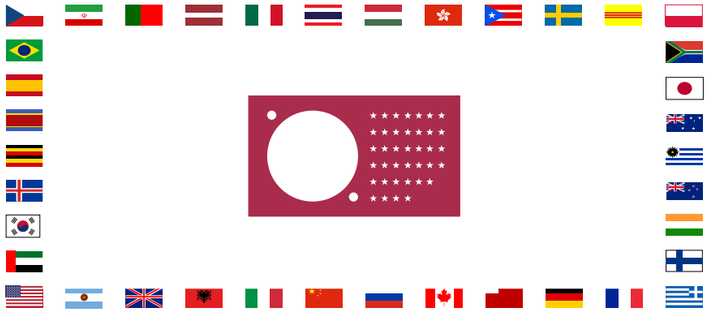


> *What ideas individuals attach to the term 'Millennium', I know not;*
> *but I know that society may be formed so as to exist without crime, without poverty, with health greatly improved, with little if any misery, and with intelligence and happiness improved a hundredfold;*
> *and no obstacle intervenes at this moment except ignorance to prevent such a state of society from becoming universal*

**Robert Owen, 1771**
SOCIAL REFORMIST, FOUNDER OF NEW HARMONY COLONY



## 86 CULTURAL REVOLUTION



*At some point, they will not feel American or Russian or Japanese, they will feel they are Martian. They will carry with them the cultural baggage and ideals of their home culture but when they tear themselves away from traditional structures, they could develop something very new.*

**Frans Von Der Dunk**
PROFESSOR OF SPACE LAW

The population of the new Martian society will be a melting pot from many nations. Haggs-Misra, in New Space (2015), argues that Mars should be established as an independent nation from the first instance, and even goes so far as to suggest 5 tenets as a basis for the Martian constitution.

### Articles of Colonisation

1. Humans who leave Earth to permanently settle on Mars relinquish their planetary citizenship as Earthlings and claim a planetary citizenship as Martians.
2. Governments, corporations, and individuals of Earth cannot engage in commerce with Mars and cannot interfere with the political, cultural, economic, or social development of Martian civilisation.
3. Scientific exploration may continue as long as it does not interfere with the development of civilisation on Mars.
4. Sharing of research and information between Mars and Earth is permitted only to pursue mutual scientific or educational goals.
5. The use of land on Mars will be determined exclusively by the citizens of Mars. No Earthlings may own or otherwise lay claim to land on Mars. Any technology, resources, or other objects brought from Earth to Mars become permanent fixtures of the Martian civilisation. Earthlings may not make any demands for resources on Mars.

**Haqq-Misra**
ASTROBIOLOGIST

> *We are the first Martian colonists,*
> *we are scientists and artists and engineers*
> *and it is our job to think things anew.*

**Kim Stanley Robinson**
RED MARS

CUL

# CULTURAL COLLAGE

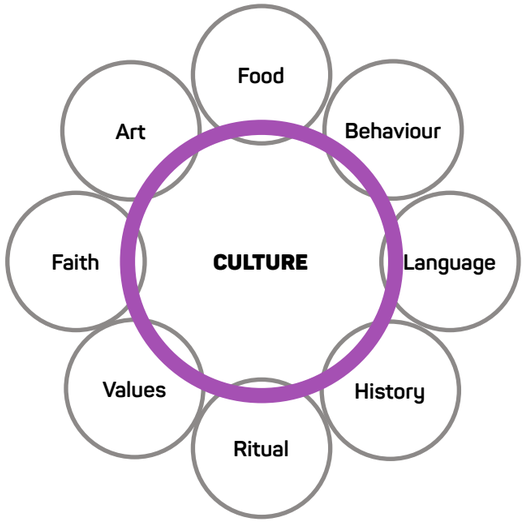
*"We want to build colonies on the Moon and Mars and even asteroids.*

*We want to make space tourism and commerce routine.*

**Daniel Goldin**
ADMINISTRATOR OF NASA



## WHEN ON MARS...



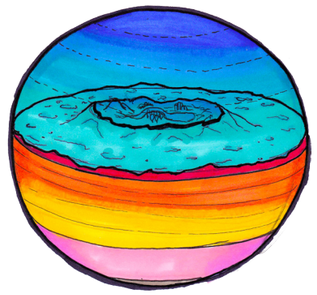

The Martian lifestyle has evolved from a practical, space exploration framework. Thus many of the aspects of mission protocol for astronauts have become a part of daily life for Martian culture.

As such many things which Terrans would traditionally own are considered communal on Mars, belonging to a group as opposed to one person. Items are traded rather than bought.

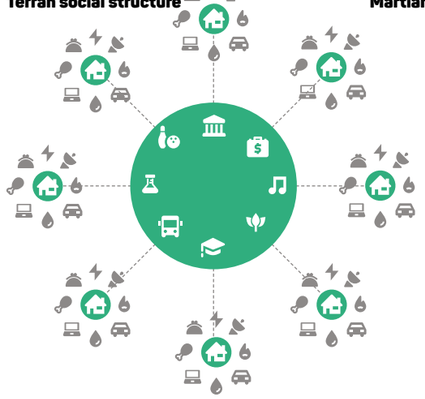
Recycling, repairing and reusing items is also an integral part of Martian culture due to resource scarcity, and environmental safety is drilled into Martians from a young age due to the harsh environment and risk of injury or death.

Martians are bound by a strong sense of national pride, unified by the common goal of building a new society, although opinions on the specifics of this society might differ...

### LIVING ARRANGEMENTS



**Terran social structure**

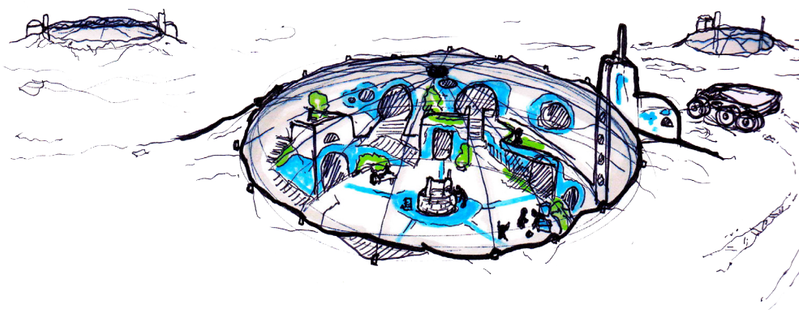


**Martian social structure**

The way in which Martians live is very different to many cultures on Earth. Because sealed space is at a premium Martians live in close proximity, many in small close-knit cooperative communities. The inhabitants resemble a sort of extended family who share resources, roles and infrastructure, trading or sharing with other communes for resources not available to hand. The inhabitants of a commune work towards the settlements common goal, though management structure of the settlement can vary between democracy, elected leadership or councils, who in turn must answer to the planetary executive council.

FOR MORE INFORMATION SEE


- A Sol in the Life
- Closing the Loop
- Trading Places
- CoLiving

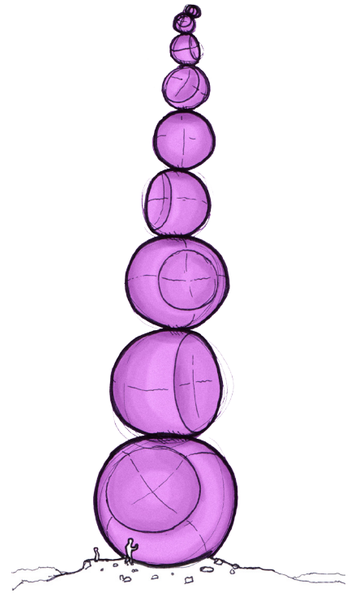



90

# ARTS OF MARS

Mars is a whirlwind of change, it's people filled with optimism for the future, determined to forge a new land from the wilderness. With civilisation comes culture and art, but what form will Martian art take? How will Martian culture manifest itself through the outputs of artistic expression?

HISTORY
FAMILY
LIFESTYLE
WORLD EVENTS
EARTH
ENVIRONMENT
LOW GRAVITY
EXPLORATION
HARDSHIP
PIONEERING
OPTIMISM
TERRAFORMING
SOCIAL PROGRESS
POLITICS
ECONOMY
INDEPENDENCE
IMMIGRATION
TECHNOLOGY
PROGRESS
TRANSHUMANISM

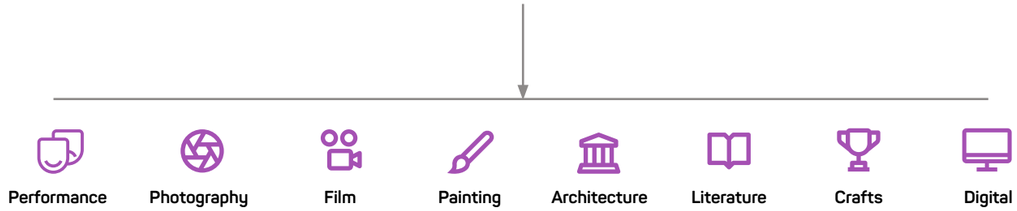


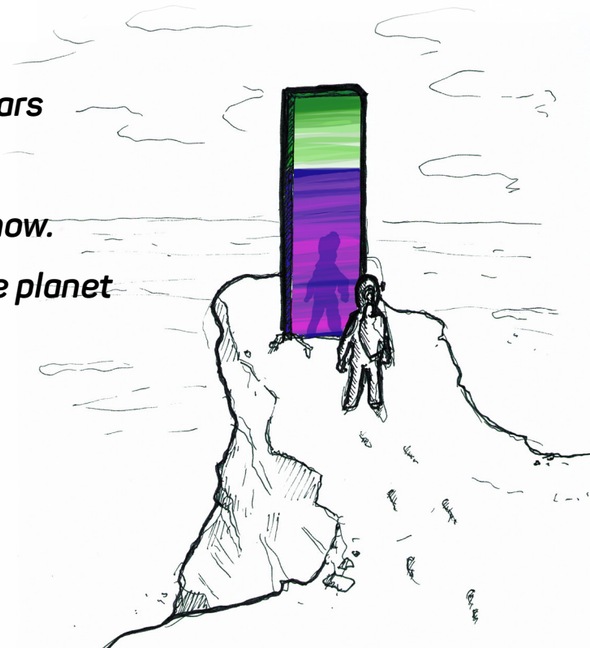
*"People will blog their life on Mars,*
*become celebrities and household names*
*- and people will come.*

*On Earth they will see the greatest sights:*
*the deepest valleys, the tallest volcanoes*
*- and they will come*

*They will see skydiving and dancing and sex in microgravity*
*- and more will come."*

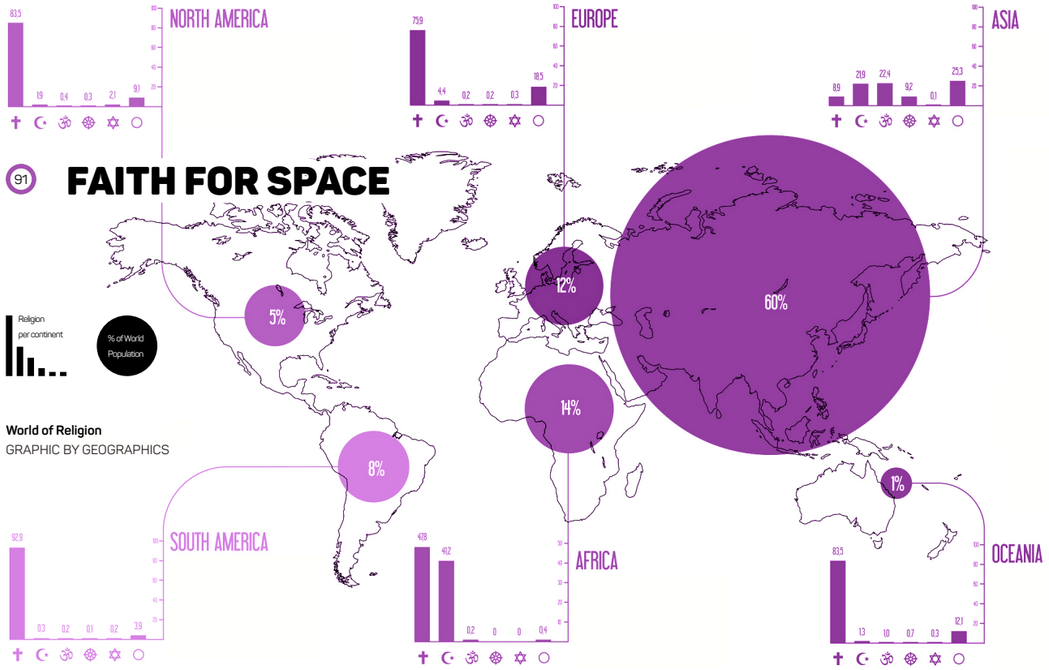
**Stuart Atkinson**
AUTHOR AND ASTRONOMER



*"Who knows what the children of Mars*
*will think is beautiful?*
*This world will be the home they know.*
*So we terraform the planet; but the planet*
*transforms us like a mirror image"*

**Kim Stanley Robinson**
RED MARS




**RELIGION**
NOUN

An organised approach to human spiritualty which encompasses a set of narratives, symbols, beliefs often with a supernatural or transcendent quality that give meaning to the practitioner's experience of life through reference to a higher power or ultimate truth. It may be expressed through prayer, ritual, meditation and art among other things.

**Old Earth Religions**

- ATHEISM
- BUDDHISM
- CHRISTIANITY
- HINDUISM
- ISLAM
- JUDDIASM
- SHINTO
- SIKHISM

**New Earth religions**

- BAHÁ'Í FAITH
- CAO DAI
- JAINISM
- NEOPAGANISM
- RASTAFARIANISM
- SCIENTOLOGY

**New Mars religions**

- AEROPHANY
- SIMULATION THEORISTS
- TRANSHUMANIST
- ?

### Aerophanists

Kim Stanley Robinson (Red Mars, 1993) describes a new kind of Martian religion developing ideas from Shinto and Pantheism which worships Mars itself as a sort of spiritual energy or power and responds to the awe of the universe revealed through science. This religion celebrates a spiritual response to Mars, finding spiritualty and symbolism in the untouched landscape and solitude of Mars.

### Simulation Theorists

Many scientific and influential individuals, Elon Musk included, believe that we are living inside an incredibly complex computer simulation belonging to an advanced intelligent species. What moral values and behaviours might arise in people with the belief that they are nothing but a simulation? Does this lead to the belief that morals are invalid? Should a simulated civilisation strive to be entertaining, or praiseworthy to avoid being turned off?

### Transhumanism

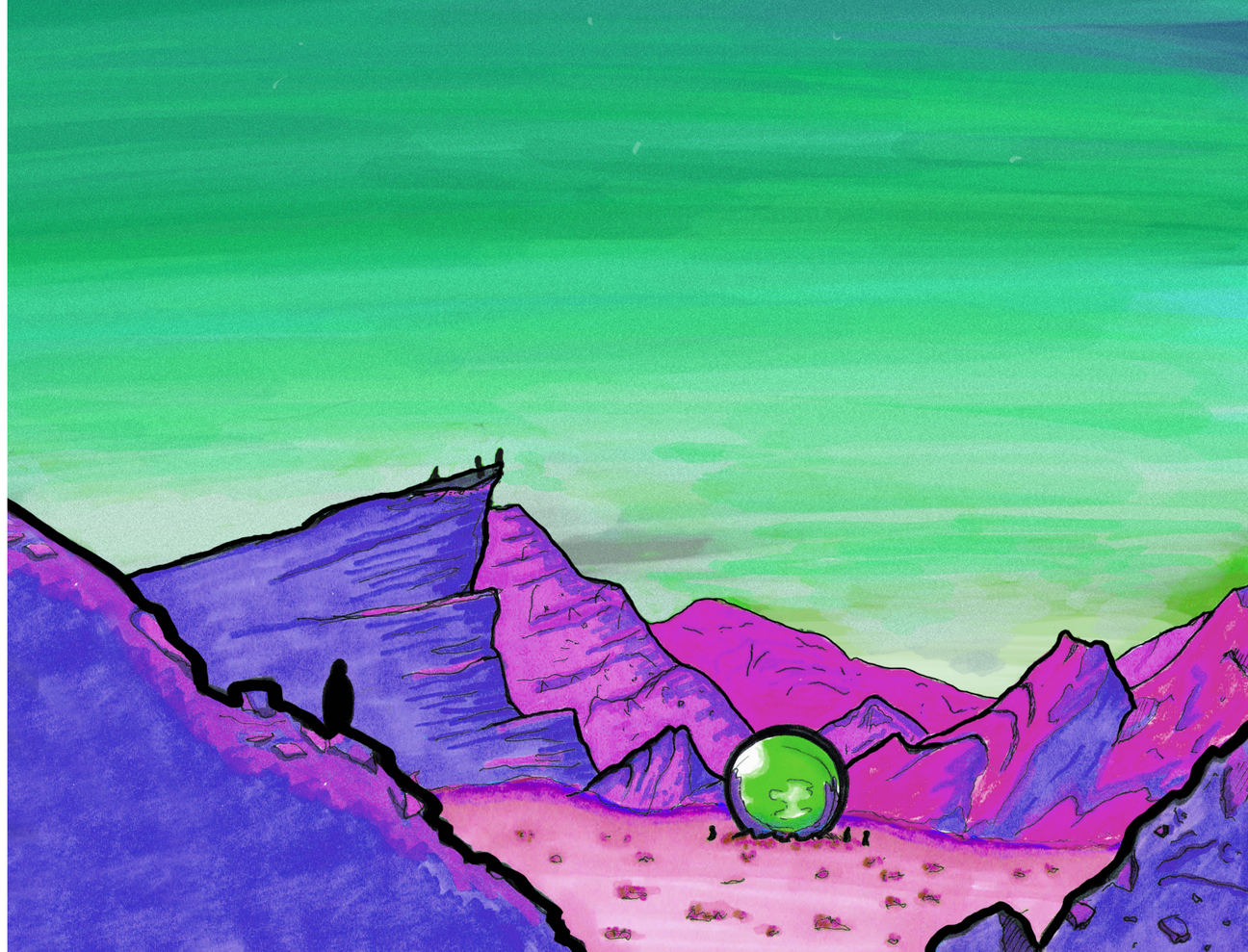
Originally a technological and philosophical movement, the principles of transhumanism can be adapted into a worldview which promotes the accelerating the evolution of intelligent life and overcoming human limitations through science and technology, guided by life promoting principles and values. This movement therefore places great value and reverence for scientific knowledge and intellectual debate.

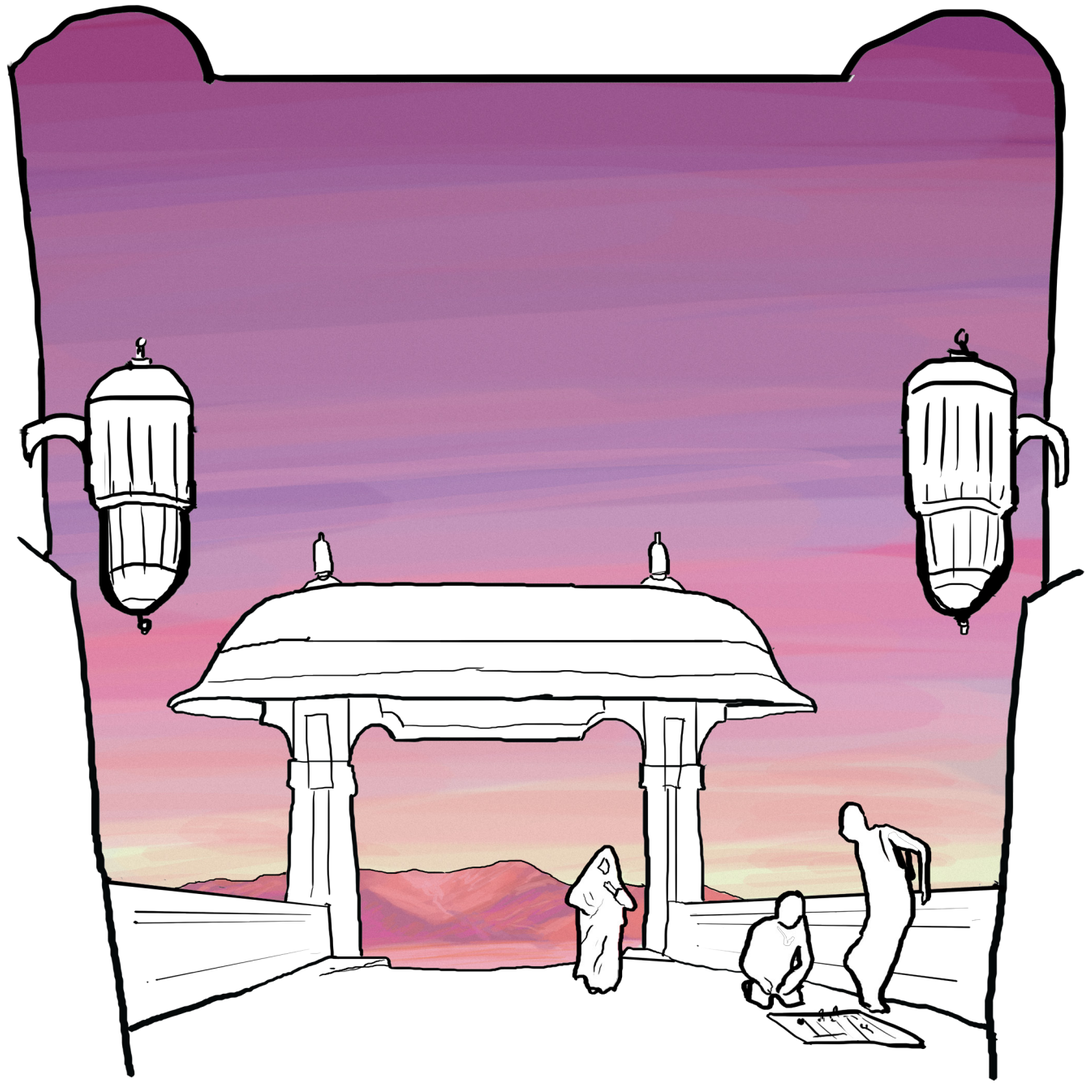
*"When I look at the night sky through a telescope I am filled with feelings of sacred awe and wonder at the overwhelming beauty and power of the universe.*

*A religion old or new, that stresses the magnificence of the universe as revealed by modern science, might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths.*

*Sooner or later, such a religion will emerge.*

**Carl Sagan**
PALE BLUE DOT







# A WORLD OF POSSIBILITIES

Space Tourism will be one of the main financial gains of solar expansion. Until infrastructure has been developed and costs can be brought down space tourism will not be possible but a future Mars colony will rely on tourism as one of it's main financial sectors.

Tourism on Mars will be driven by the alien nature of Martian culture, the unique sights and experiences which aren't possible on Earth.

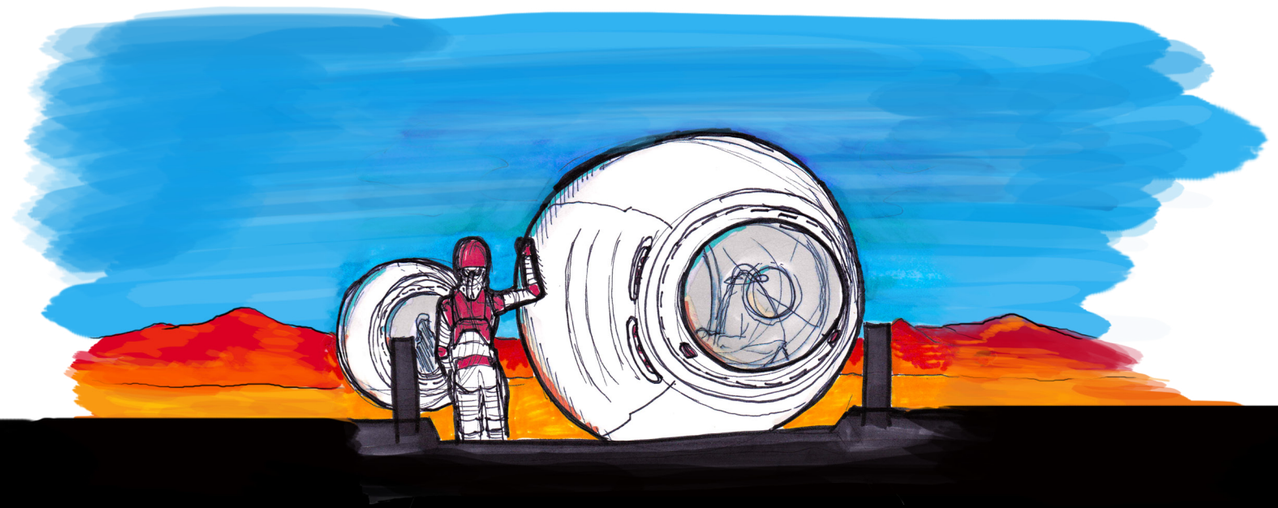
> *In 12 or 15 years, there will be routine, affordable space tourism. Not just in the U.S. but in a lot of countries*

**Burt Rutan**
AEROSPACE ENGINEER & ENTREPRENEUR


**NASA "Grand Tour" Space Tourism Poster**
GRAPHIC BY INVISIBLE CREATURE

> *It was a kind of a landscape religion, a consciousness of Mars as a physical space suffused with kami, the spiritual energy or power that rested in the land itself*

**Kim Stanley Robinson**
RED MARS



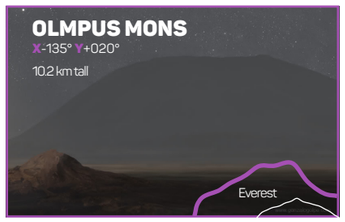
## 95 PLACES TO VISIT

> *Sunset more than any other time of day made it clear that they stood on an alien planet; something in the slant of the light was fundamentally wrong, upsetting expectations wired into the savannah brain over millions of years.*

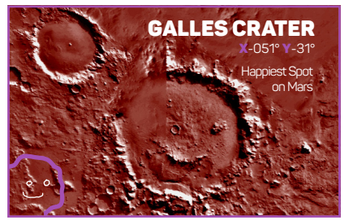
**Kim Stanley Robinson**
RED MARS

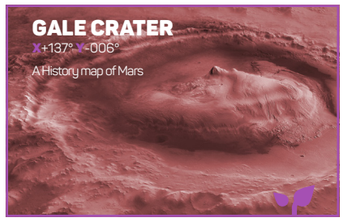
Mars as a natural environment also has a lot to offer in terms of space tourism. The low Martian gravity has led to some of the most interesting geological features in the solar system: the tallest volcano, the deepest impact crater, the largest impact crater and the deepest valley can all be found here.

The very nature of Mars as an alien planet has an irresistible strangeness and lure which many would wish to experience if they could.

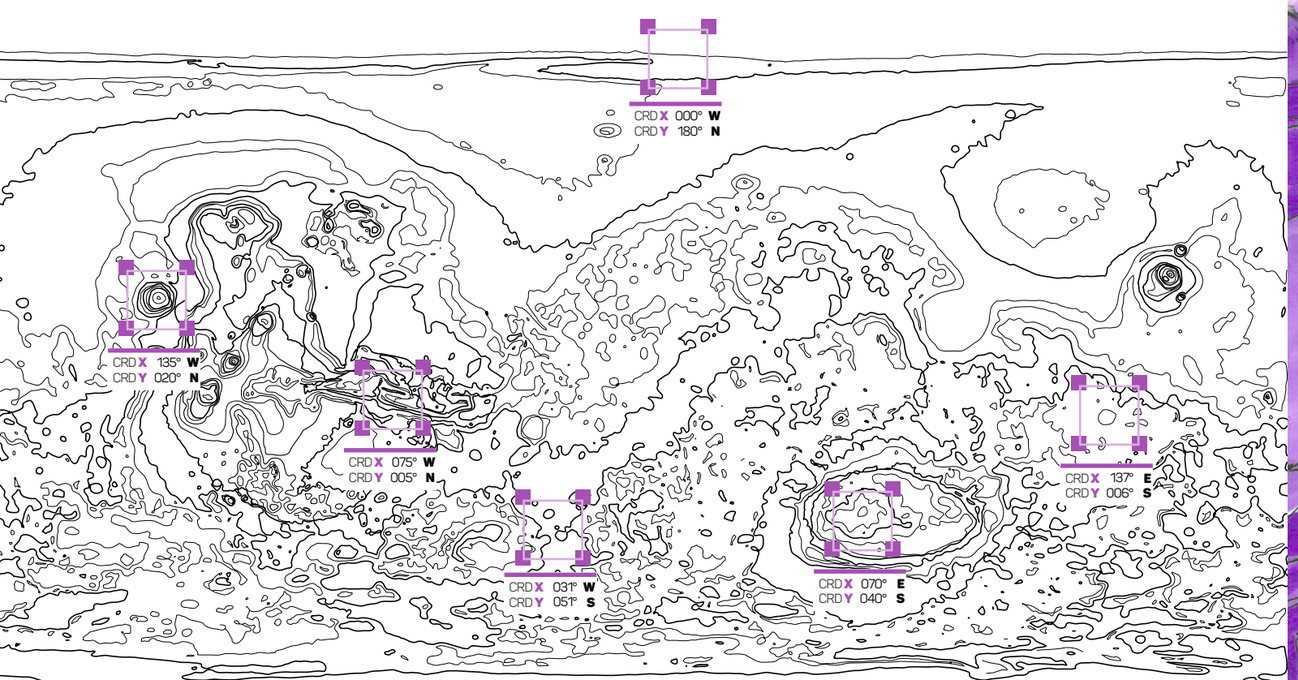




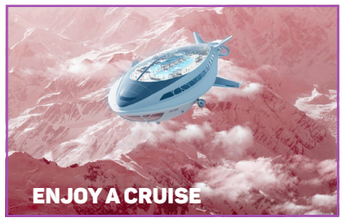


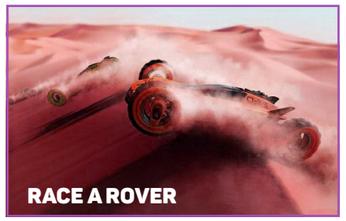





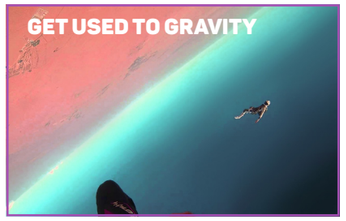




## 96 THINGS TO DO










# SPACE COUTURE


Work → Casual → Couture

### Space Suits to Space Couture

As functional equipment becomes a part of daily life it would see more casual use, eventually transitioning from work wear into fashion wear, just as denim jeans and dungarees and the baseball cap have before.

EVA suits, would be one example of functional wear. Spacesuit designs have already begun to take on aesthetic considerations. On Mars Pressure suits would be worn on a regular basis. How would Martians adapt them into their daily life and customize them to their own tastes and needs?

**Ville Ericsson**
CONCEPT FOR FREMEN, DUNE

HISTORY OF SPACESUITS

> *The love of the New World seemed to be expressed by a certain kind of life: rational, just, prosperous, scientific. Many new immigrants were Martian already, having brought the way of life with them and left the baggage behind*

**Kim Stanley Robinson**
RED MARS

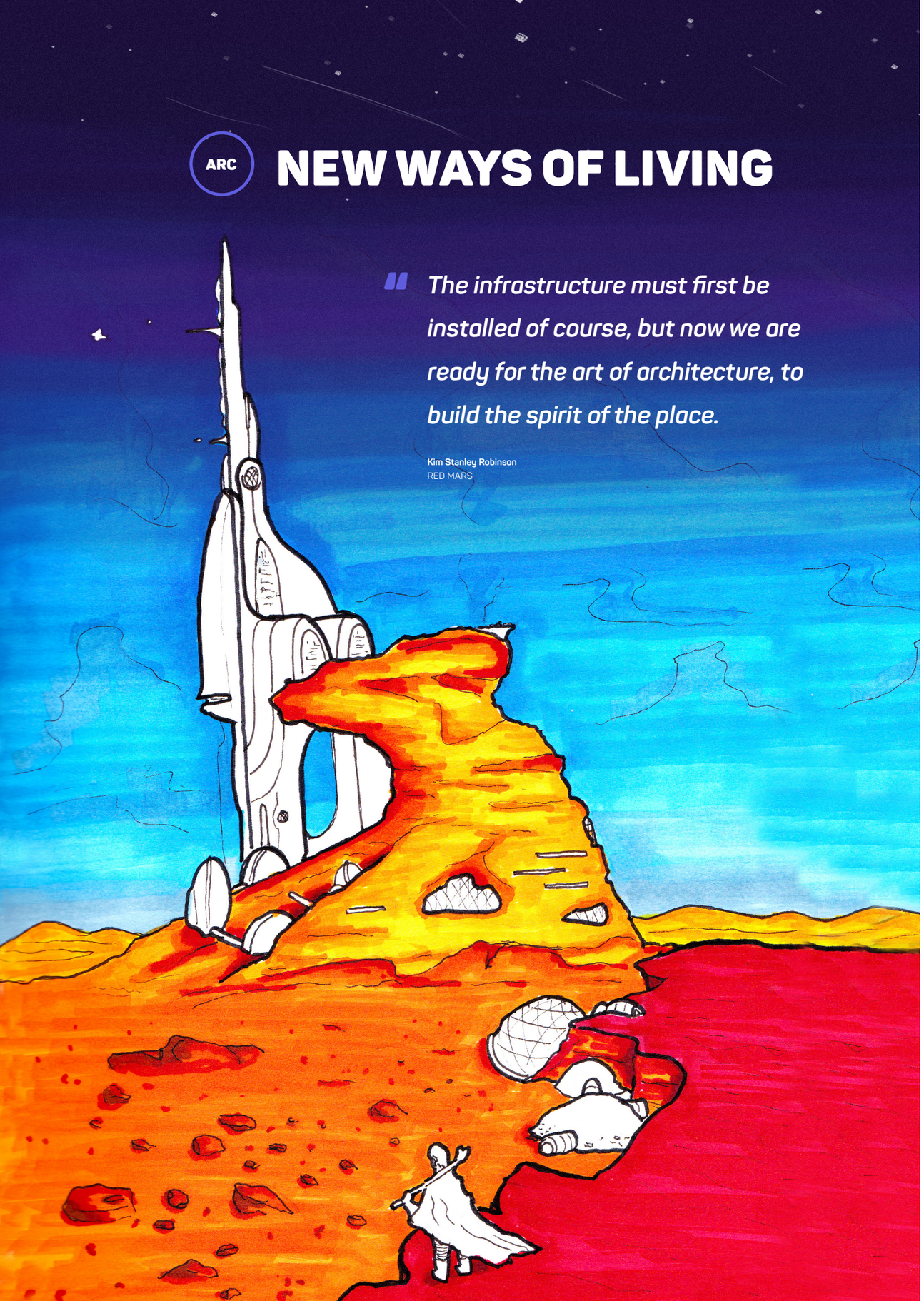
**Mars: Adrift on the Hourglass Sea**
NICHOLAS KAHN & RICHARD SELESNICK

ARC

# NEW WAYS OF LIVING

*"The infrastructure must first be installed of course, but now we are ready for the art of architecture, to build the spirit of the place.*

**Kim Stanley Robinson**
RED MARS



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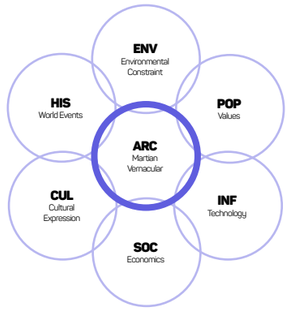
## MARTIAN VERNACULAR



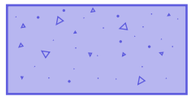

Vernacular architecture tends to evolve in response to environment, culture, technology, economics and history. The vernacular on Mars will be informed by a new way of life: how they use buildings, the size of family units, their daily eating, work and sanitary habits.
On Earth in the Far East it is common to use bamboo, as it is both plentiful and versatile, while arid deserts may use mud or stone. On Mars the vernacular will be determined by the materials to hand. The Culture will also inspire the visual expression as designs are decorated with reference to local customs, beliefs and values.

### MATERIALS

Many low tech, high mass materials similar to, or better than, Terran construction materials can be created using local resources and elements from the Martian regolith and atmosphere.

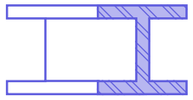
#### RegoBricks

Factories can mix clay & Sulphur from the regolith into a mould and compress it as they cool. The resulting bricks can be strengthened using polymer threads such as nylon to provide tensile strength. Coloured bricks can be made by adding elements: Carbon for black, Manganese for white, Sulphur for yellows, oxides for purple, allowing for artistic expression through colours, patterns and mosaics.



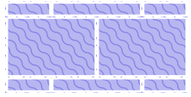
#### Marscrete

Sulphur can be heated into a liquid, mixed with Martian soil as an aggregate, and then let to cool. This mix can be cast in place or shaped into blocks. The fine Martian aggregate & low gravitational compression results in a concrete twice as strong as terran concrete but very light. Unlike Terran concrete, it doesn't require water to produce, and can also be remelted and recycled.



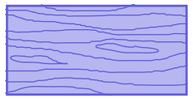
#### Martian Steel

Magnesium on Mars is plentiful and extremely light in Martian G, but very brittle. But it can be alloyed to provide strength and refined into Bars or extruded into profiles to create a light equivalent of Terran steel. Alternatively, the Martian regolith is rich in Iron oxides which can be alloyed with Carbon to make traditional Terran steel.



#### Ice

Subsurface Water can be harvested and 3D printed in a vapour form over an exterior canvas membrane by robots. Water absorbs high wavelength energies, making it ideal radiation shielding, whilst allowing light in the visible spectrum to pass through for natural lighting.



#### Bamboo

Whilst steel, concrete, and brick would be used for structures exposed to the Martian environment, bamboo can be used for interior structural construction as well as beautification purposes. It also has the potential to absorb large amounts of carbon dioxide.


FOR MORE INFORMATION SEE

- **Atmosphere**
- **Geosphere**
- **Gathering Resources**
- **Local Production**


> *The key to Martian construction is Sulphur. Heat it into a liquid, mix it with Martian soil, as an aggregate, and then let it cool. The Sulphur solidifies, binding the aggregate. Voila! —Martian concrete.*

**- Lin Wan**
NORTHWESTERN UNIVERSITY

# 101 MARTIAN COLONIAL STYLE

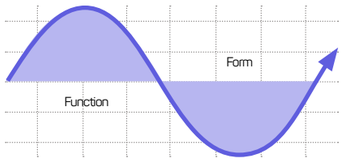
## CULTURAL EXPRESSION

Architecture could be said to be more than anything else, a reflection of the cultural identity of a society; a manifestation of the values, politics, economic, religious and social status of the people within that society. Their way of life is revealed through the buildings that they inhabit in various ways.

ADAM STYLE ADIRONDACK ARCHITECTURE ANGLO-SAXON ARCHITECTURE AMERICAN COLONIAL AMERICAN CRAFTSMAN AMERICAN EMPIRE AMERICAN FOURSQUARE AMSTERDAM ANCIENT EGYPTIAN ARCHITECTURE ANCIENT GREEK ARCHITECTURE ARCOLOGY ART NOUVEAU AUSTRALIAN BAROQUE BAUHAUS BIEDERMEIER BLOBITECTURE BRICK GOTHIC BRISTOL BRUTALIST BUDDHIST BYZANTINE ARCHITECTURE CAROLINGIAN CARPENTER GOTHIC CHICAGO SCHOOL CHILOTAN ARCHITECTURE CHURRIGUERESQUE CITY BEAUTIFUL MOVEMENT CLASSICAL COLONIAL REVIVAL CONSTRUCTIVIST DANISH FUNCTIONALISM DECONSTRUCTIVISM DECORATED PERIOD DRAGESTIL DUTCH COLONIAL EARLY ENGLISH PERIOD EASTLAKE EGYPTIAN REVIVAL ELIZABETHAN EMPIRE EXPRESSIONIST FEDERAL FLORIDA CRACKER FLORIDA MODERN FUNCTIONALISM FUTURIST GEORGIAN GOOGIE GOTHIC GREEK REVIVAL GREEN BUILDING HELIOPOLIS INTERACTIVE INTERNATIONAL ISLAMIC ITALIANATE JACOBEAN JEFFERSONIAN JENGKI STYLE JUGENDSTIL MANUELINE **MARTIAN COLONIAL** MEDITERRANEAN MEMPHIS GROUP MEROVINGIAN METABOLIST MID-CENTURY MODERN MISSION MODERN MOVEMENT MODERNISME CATALONIAN ART NOUVEAU NATIONAL PARK SERVICE RUSTIC NATURAL BUILDING NAZI NEO-BYZANTINE NEOCLASSICAL NEO-GREC NEO-GOTHIC NEOLITHIC NEO-MANUELINE NEW TOWNS NORMAN ARCHITECTURE ORGANIC ARCHITECTURE OTTONIAN ARCHITECTURE PALLADIAN PERPENDICULAR PONCE CREOLE POMBALINE STYLE POSTMODERN POLISH CATHEDRAL STYLE POLITE PRAIRIE STYLE PUEBLO STYLE QUEEN ANNE QUEENSLANDER RANCH-STYLE REPOBLACIÓN ARCHITECTURE REGENCY ARCHITECTURE RICHARDSONIAN ROMANESQUE ROCOCO ROMAN RUSSIAN SECOND EMPIRE SHINGLE SICILIAN BAROQUE SOUTHERN PLANTATION SPANISH COLONIAL STALINIST ARCHITECTURE STRUCTURAL EXPRESSIONISM SWISS CHALET STICK STYLE SUSTAINABLE ARCHITECTURE SOFT PORTUGUESE STREAMLINE MODERNE STRUCTURALISM SUMERIAN ARCHITECTURE TIDEWATER TUDOR TUDORBE UKRAINIAN BAROQUE USONIAN VICTORIAN VIENNA

## FORM VS FUNCTION

Architectural design movements have forever seen a swing in popular opinion regarding which approach should take precedence in aesthetic design of the built environment. In the early stages of Martian society habitations were practical and sturdy, built to withstand the Martian environment. Function was the chief design concern during this time.




As Martian society moves into a new phase and humans have become comfortable on Mars other concerns begin to take a higher priority and the desire arises to establish a Martian design language, distinct from anything Terran. One counter response to the practicality of previous design would be to adorn Martian buildings with elaborate decoration, to embrace new Martian materials and exploit the low gravity to create a new form of architectural expression unique to the Red Planet.

> ***Through architecture it's possible to gauge many things about a culture, such as lifestyle, artistic sensibilities and social structure***

**Mark Damen**
HISTORY AND CIVILISATION

FOR MORE INFORMATION SEE
- **Life in Harsh Environments**
- **Living off the Land**
- **CoLiving**

# 102 MADE ON MARS

Low gravity and an alien environment on Mars offer a unique test bed for pioneering construction materials and cutting edge technologies which can maximize resources and reduce human risk & production time.

### Automation
Habitats and structures can be built beforehand in modules by programmed robots and drones, or built on site using AI or human controlled robotics. This also applies to adaptation and extension of existing structures. The risk of automated robotics is that the finished product is only as good as the programming of the AI or algorithms.

### Biomimicry
Biomimicry is another design principle which uses the solutions of nature to tackle unique Martian problems such as environmental seals, low gravity and radiation protection.

### Augmented Reality
AR can be used to alter a person's reality. A barebones white room could be transformed into a traditional smoking room in a victorian mansion, or a thriving city bar in an instant. This technology can also be create heads up displays for medical biosections, or immerse the user in a complex 3D design schematic.

> *You could easily have robots build habitats as needed ahead of time, and by the time the astronauts arrived, they'd already have a place to hang their hats.*

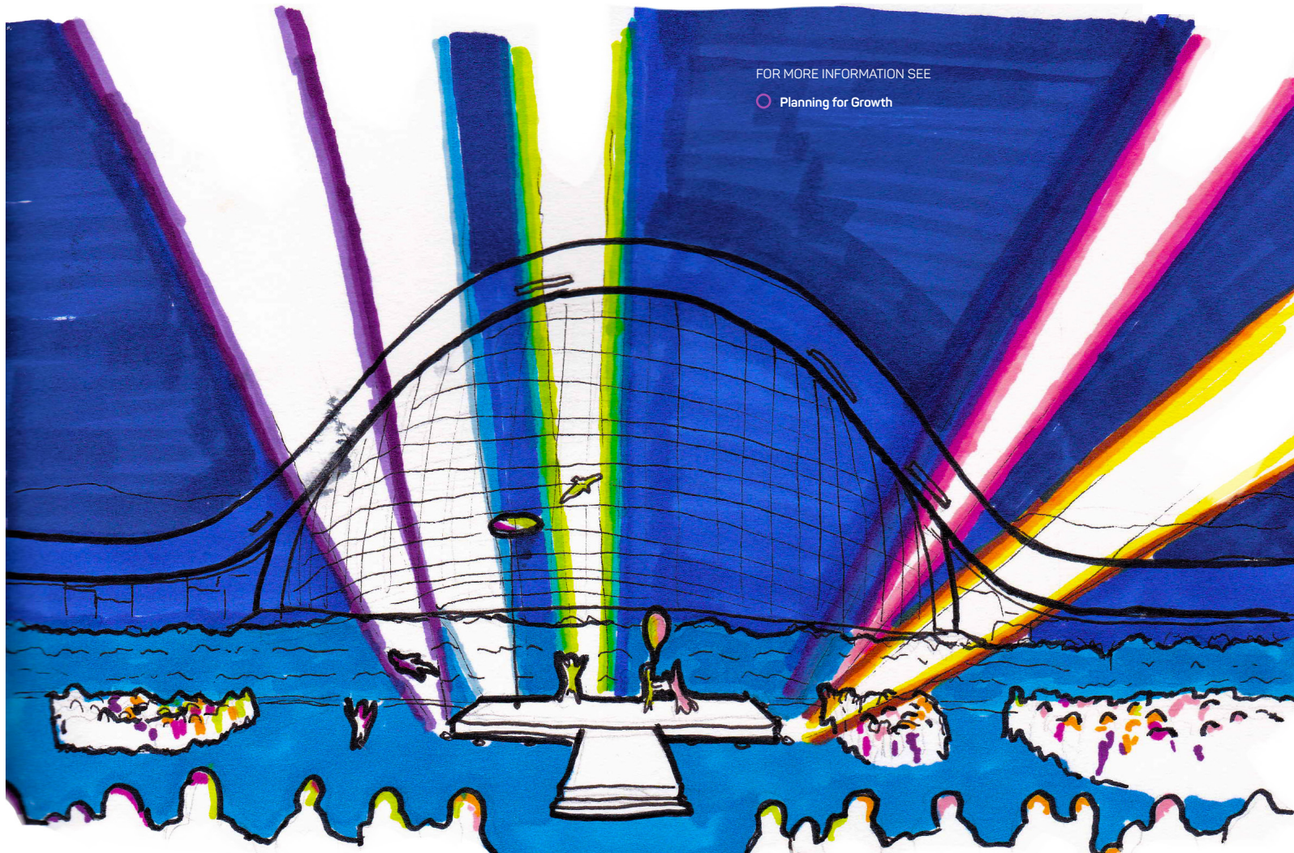
**Robert Orwoll**
INTERNATIONAL SCIENTIFIC TECHNOLOGIES

### 3D Printing
3D printing will enable the production of nearly any structure in a range of materials, colours and structures using resin produced locally from materials mined on Mars. This eliminates the reliance on resupply from Earth, and allows Martians to produce complex products on site and as they are needed, leading to highly efficient economies of scale.

### Modular Design
Another design principle which involves designing spaces or systems which can be subdivided into smaller parts and adapted to different uses and scales depending on the circumstances. Universal building units can therefore be converted from a storage purpose to a habitation module to accommodate an influx of settlers, or a medical lab to cope with an emergency.

### Virtual Reality
Digital technologies such as VR in their infancy on Earth will see a parabolic growth on Mars. Virtual Reality can be used to envisage designs in real time and onsite before they are built. Virtual models can also be used to predict outcomes or experiment with changes in complex systems such as transport grids or nuclear power plants.

### Artificial Intelligence
Virtual managers can be used to govern building systems, control city infrastructure, improve efficiency of services. This level of automation can extend to AIs commissioning robotic drones to build new modules based on predictions of population growth, extending cities with habitats, bars, schools, labs and parks with little human intervention.



FOR MORE INFORMATION SEE
- **Planning for Growth**

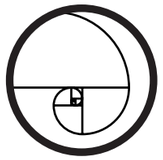
*She still found it impossible to think in terms of Martian Gravity;*
*to trust the designs that took it into account.*
*The columns just looked too flimsy.*

**Kim Stanley Robinson**
RED MARS



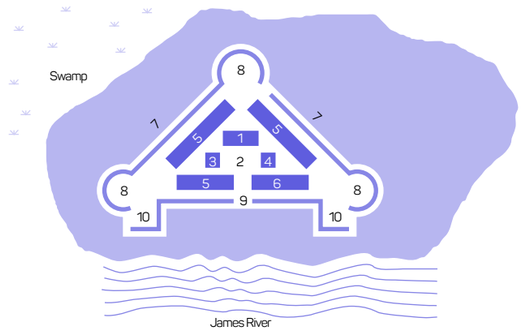
# MARTIAN REQUIREMENTS

## TERRESTRIAL ANALOGUE



When people settle in a new place with nothing but what they brought with them and the resources at hand they will naturally go about setting up an environment suited to their needs as best they can.
The base needs of humanity have changed little since primitive times, merely taken on new forms. By examining previous colonies we can begin to construct a basic table of needs.

### Jamestown, Virginia
1607- FIRST ENGLISH SETTLEMENT IN AMERICA

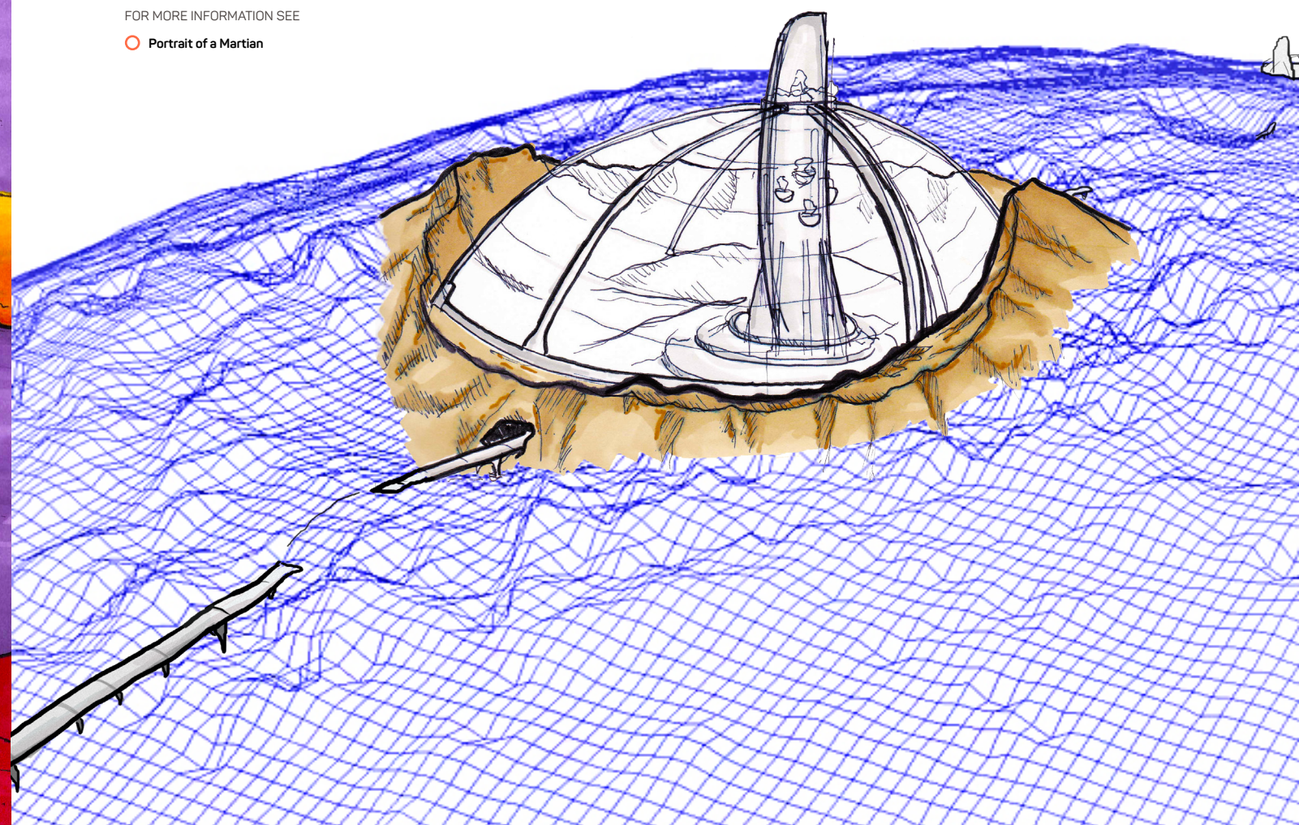


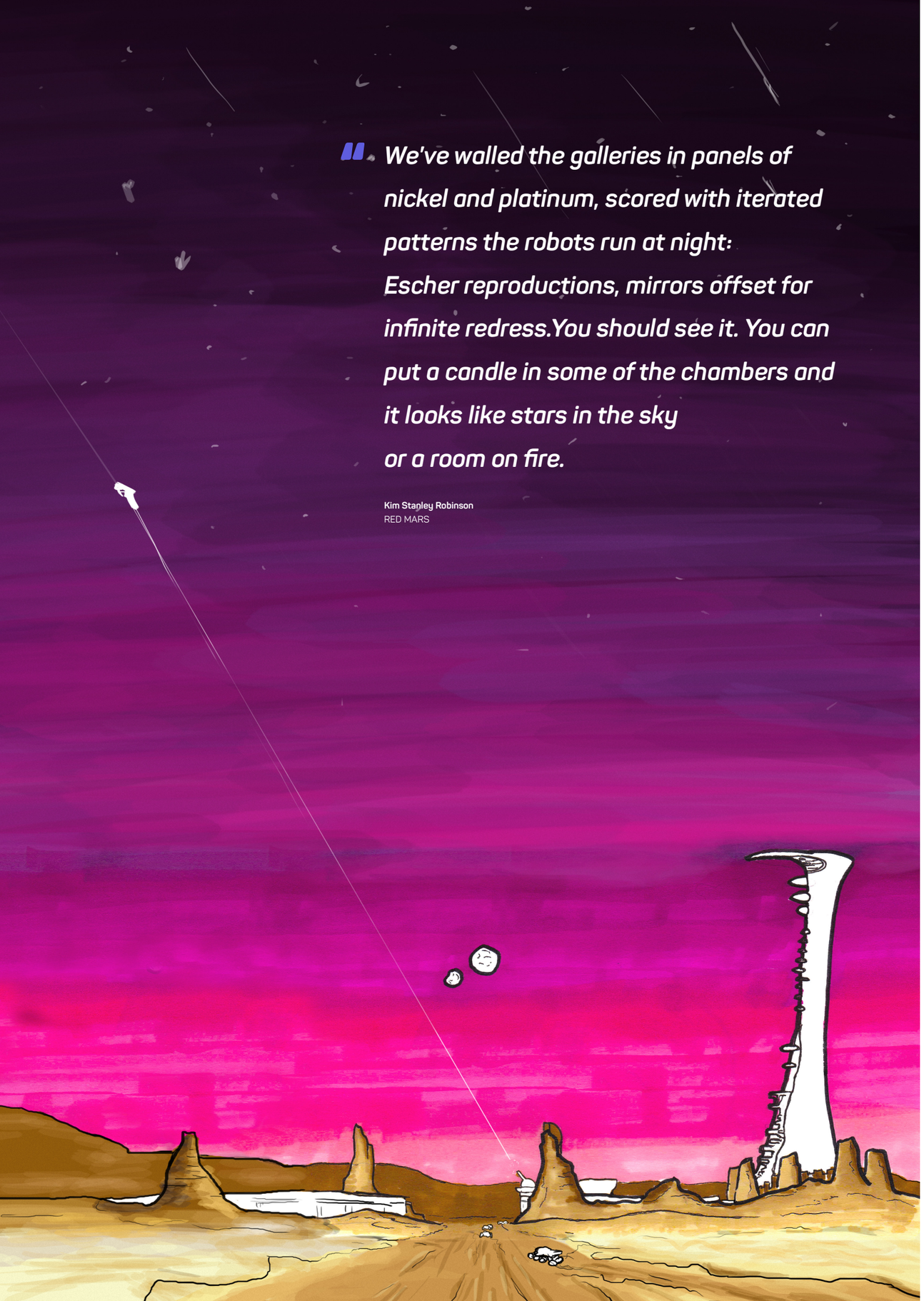

### Requirements

| | | |
|---|---|---|
| **1** | THE CHURCH | = Religious Space |
| **2** | MARKET PLACE | = Commerce |
| **3** | STOREHOUSE | = Storage |
| **4** | COURT OF GUARD | = Administration |
| **5** | STREETS OF "SETTLED" HOUSES | = Habitation |
| **6** | BLACKSMITH | = Workplace |
| **7** | PALISADES OF POSTS | = Privacy |
| **8** | BULWARKS OF HALF-MOON SHAPE | = Protection & Outlook |
| **9** | PRINCIPAL ENTRANCE | = Public space |
| **10** | GATES | = Access / Egress |

FOR MORE INFORMATION SEE

○ **Portrait of a Martian**





> *We've walled the galleries in panels of nickel and platinum, scored with iterated patterns the robots run at night: Escher reproductions, mirrors offset for infinite redress.You should see it. You can put a candle in some of the chambers and it looks like stars in the sky or a room on fire.*

**Kim Stanley Robinson**
RED MARS



# ANTHROPOMETRICS

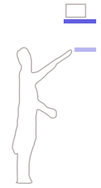
## METRIC HANDBOOK FOR MARS

There are many factors that must be taken into account when designing for Martians. The low gravity alone changes everything from spatial positioning, dimension and scale, while changes to physiology and way of life will require rewriting the rulebook.

**Activity Spaces**

**Stair Pitch**

**Human Scale**



## REGULATIONS

The environment on Mars will require a new set of regulations which will be defined by the lives of those on Mars. The risk of failure and increased cost of consequence mean safety is paramount, while scarce resources mean recycling and zero waste systems will be a core architectural consideration.

**Radiation Shielding**

**Triple Redundancy**

**Atmosphere Control**

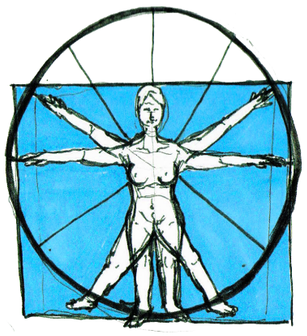
**Recycling**

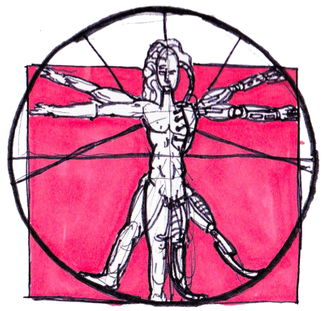
**Structural Strength**

**Emergency Prevention**

> *Good Buildings come from good People. All Problems are solved by good design.*

**Stephen Gardner**
ARCHITECT



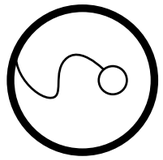


FOR MORE INFORMATION SEE

- Earth and Mars
- Portrait of a Martian

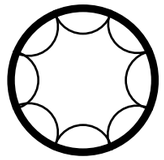
# TYPOLOGIES

### TEMPORARY



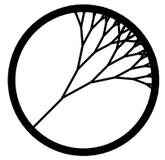
Many Martian settlers will live a life on the move as they chase resources, operate trade routes, conduct exploration or geological surveys, or wander to perform planetary research. Their habitats will be temporary or even mobile.

### PERMANENT

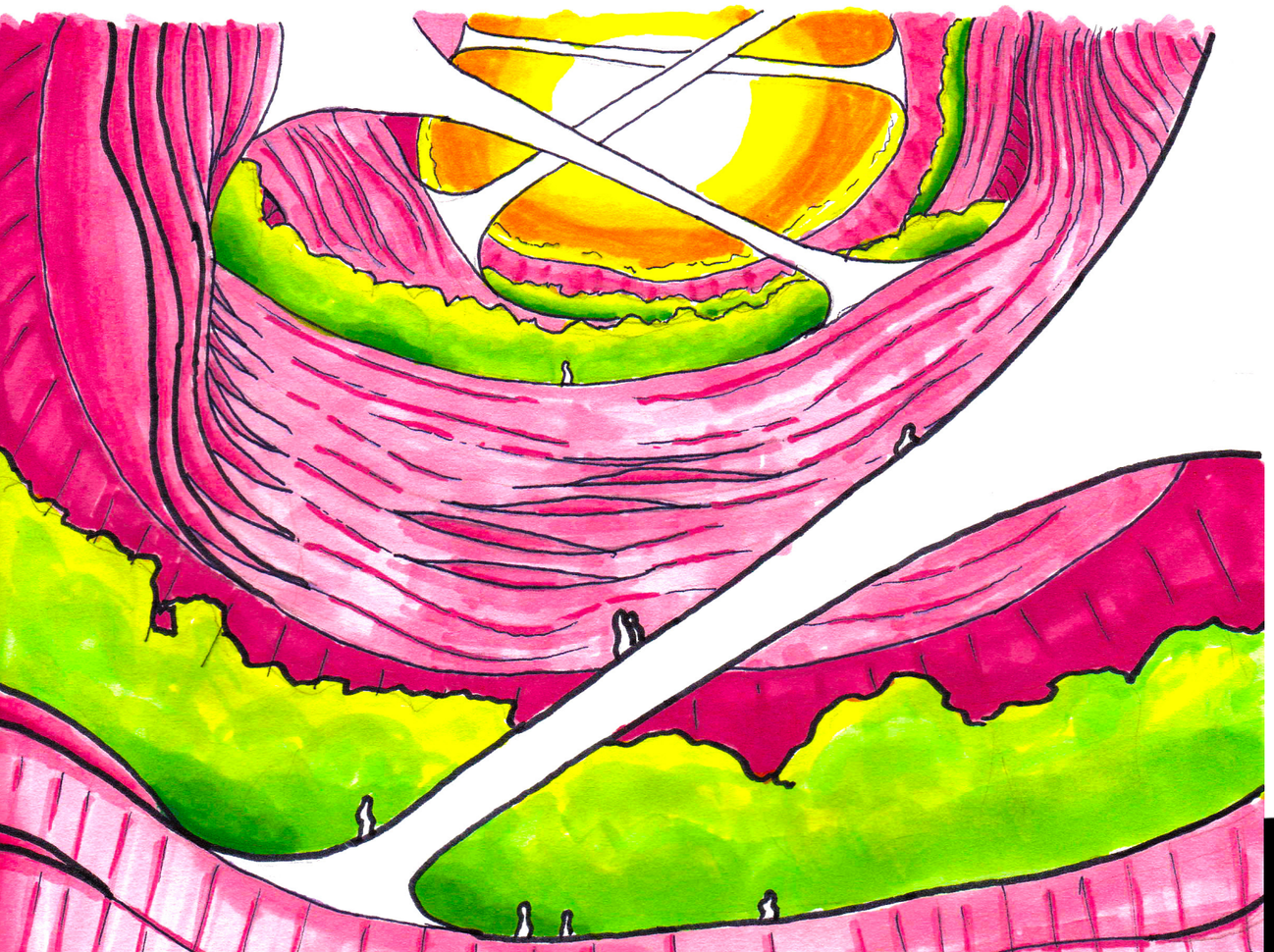


As the population on Mars increases permanent settlements will grow as a natural tendency of human nature to congregate in groups. There will be a symbiotic relationship between permanent and mobile habitats, each requiring the other to survive.

### MODULAR

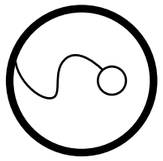


Modular habitats embrace aspects of both mobile and permanent settlements, in that these forms of settlements can grow and adapt quickly according to the needs of its inhabitants with "plug in" modules and units for various uses.



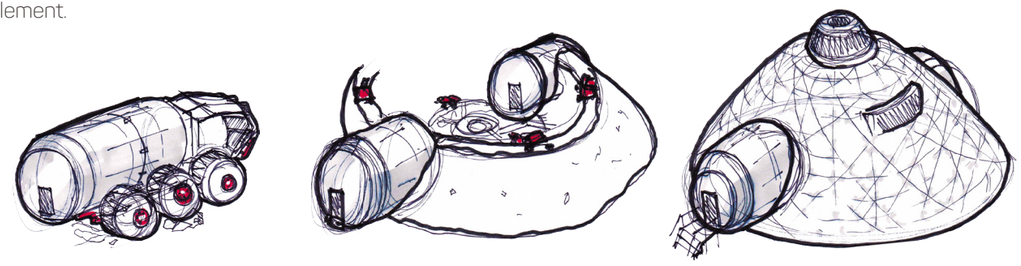


# LIFE ON THE MOVE



Many cultures on Earth embrace a nomadic way of life and have developed vernacular architectural solutions for their human needs of shelter and protection. These solutions respond directly to climate and customs of the inhabitants and can be dismantled, carried and re-erected quickly, or built easily in a new location with each move. With modern technology the form of shelter becomes more complex, but the principle remains the same.

The shelter must withstand the local environment and respond using resources to hand: Ituri Pygmies use saplings and mongongo leaves which are plentiful in the environment to construct temporary domed huts on a daily basis which are left to decompose afterwards; Mongolian nomads meanwhile move less often and carry their yurts with them on horseback and reassemble them onsite.
The vernacular in these situations is determined by the scarcity of resources, the availability of transportation. and the frequency of relocation. And so it is on Mars: a science team may assemble a modular habitat and lab base using robotic construction for a study of Summer's effect on the polar ice caps, only to dissemble it come winter. Conversely a caravan of traders might live in their rovers permanently, constantly moving from settlement to settlement.

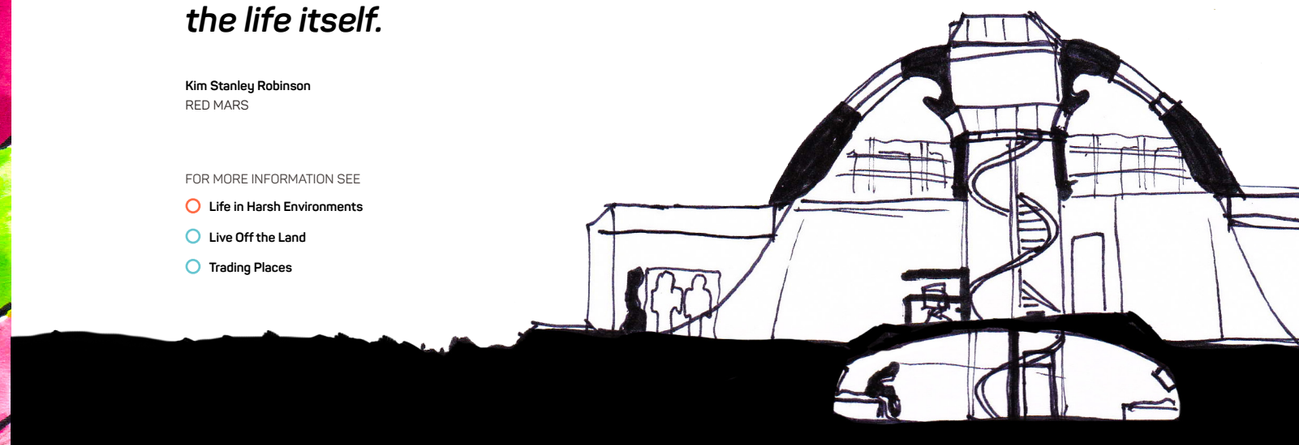


> *People who had lived in cities all their lives went to Mars and moved around in rovers and inflatable tents.*
> *The excuses for their ceaseless travel included the hunt for metals, areology, and trade, but it seemed clear that the important thing was the travel, the life itself.*

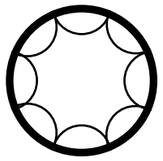
**Kim Stanley Robinson**
RED MARS

FOR MORE INFORMATION SEE

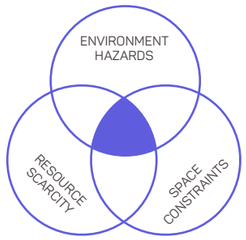

- Life in Harsh Environments
- Live Off the Land
- Trading Places

# CO-LIVING



Whilst permanent settlements and even cities will grow on Mars, the nature of these settlements will be very different to traditional urban environments on Earth. Co-living is a Martian response to the environmental hazards, resource scarcity, and space constraints.




REST

We are at our most vulnerable while resting and so rest can be a highly private experience, but in extreme cases of overcrowding bunks can be shared between people who wake and sleep on opposite shifts.

FOOD

The Martian staple diet is low maintenance crops grown in semi-autonomous high density aeroponic vertical farms. Meals tend to be vegetable based, however meat can be cultured in chemical vats.

> *It's the best of small town living. It is a fundamentally different way of living. It's a response to social, economic and environmental challenges of the 21st century*
>
> **inHabitLA**

ENTERTAINMENT

Traditional forms of entertainment are present and largely unchanged on Mars: Bars, Sports Halls, Museums, Cinemas and other forms of leisure are an important part of Martian settlements. Social entertainment has the important role of dispelling stress and tension as well as strengthening human bonds, so the communal social area is often the nexus of a Martian settlement.

WORK

"Jobs" on Mars are less binary that on Earth, where one person tends to fulfil several roles or trades within a settlement, and work towards the communes goals, rather than to earn a wage. This might be physical labour constructing or maintaining facilities or it may be research or scientific endeavours through remote live work schemes.

TRAVEL

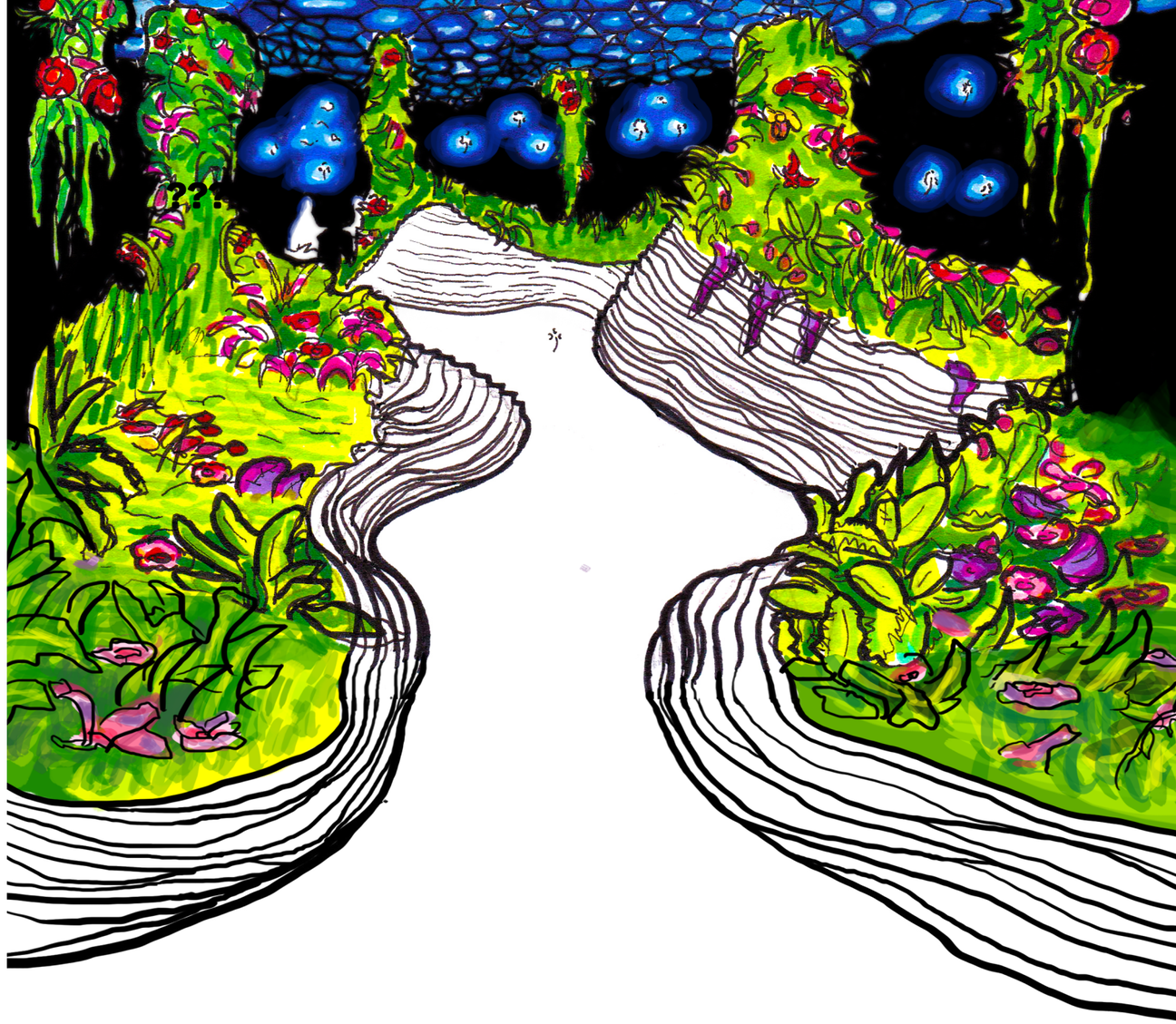
Long distance travel on Mars would make use of public transport systems such as lavarail or dirigibles, however most settlements will possess communal rovers which are shared by all members of the commune and can be checked out by any member with permission to use it.

RELATIONSHIPS

Members of a commune tend to be a close knit family, eating, drinking and living together in close quarters. Observation of similar small groups in remote locations such as research stations in Antarctica leads to a unique social environment. Relationships in these situations can often take on unconventional forms.

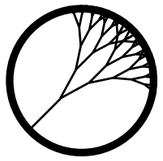
> *I don't think all buildings have to be iconic but the history of the world has shown us that cultures build iconic buildings for their major public buildings.*
>
> **Frank Gehry**
> ARCHITECT

FOR MORE INFORMATION SEE
- **A Sol in the Life**
- **Closing the Loop**
- **Trading Places**




> *The greens of the Marsjars glowed intensely in the reds of this world. The bamboo was growing 3cm a day and it was easy to see they would need more soil. The Alchemists were using nitrogen from the airminers to synthesise ammonia fertilizers.*
> *They were going to have to construct soil from scratch, just as they had the magnesium bars, and everything else they needed on Mars*
>
> **Kim Stanley Robinson**
> RED MARS

# PLANNING FOR GROWTH



Mars is in the unique position of being able to design a new civilisation from scratch. Settlements will be designed and built from scratch, with a limitless number of sites to select from. Design of permanent settlements must accommodate future growth in a way that does not compromise access to infrastructure or quality of life: inhabitants must have access to all the human requirements of entertainment, transport, greenspace, commerce and culture.

## ARCHITECTURAL PROGRESSION

**10**

### Stage 1
EXPLORATION

The first stage of Martian colonisation relies upon low tech resources, expressed through functional vernacular structures. The majority of development would not be by traditionally trained architects. Habitations used for short term stay and typically constructed underground to shield from radiation with small surface protective dome structures for access/egress and communications.

**1000**

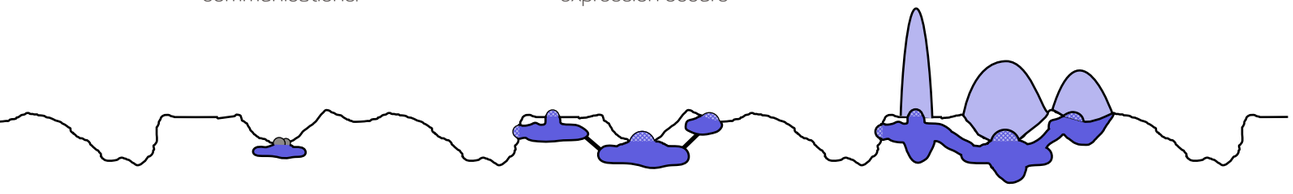
### Stage 2
COLONISATION

Martian Colonial Style emerges as a distinct architectural discipline from the vernacular of subterranean abodes, geodesic domed structures and new Martian materials. Confidence in building materials and technology increases and permanent settlements poke up into the Martian air and deeper into the Martian regolith to accommodate swelling population. Some experimentation with visual expression occurs

**100,000**

### Stage 3
FORMATION OF SOCIETY

Martian society and culture boom leads to an explosion of architectural expression led by technology. Architects rush to take advantage of low Martian gravity and revolutions in materials technologies to produce space scrapers with elaborate decoration as a response to the functional restrictions of years past.



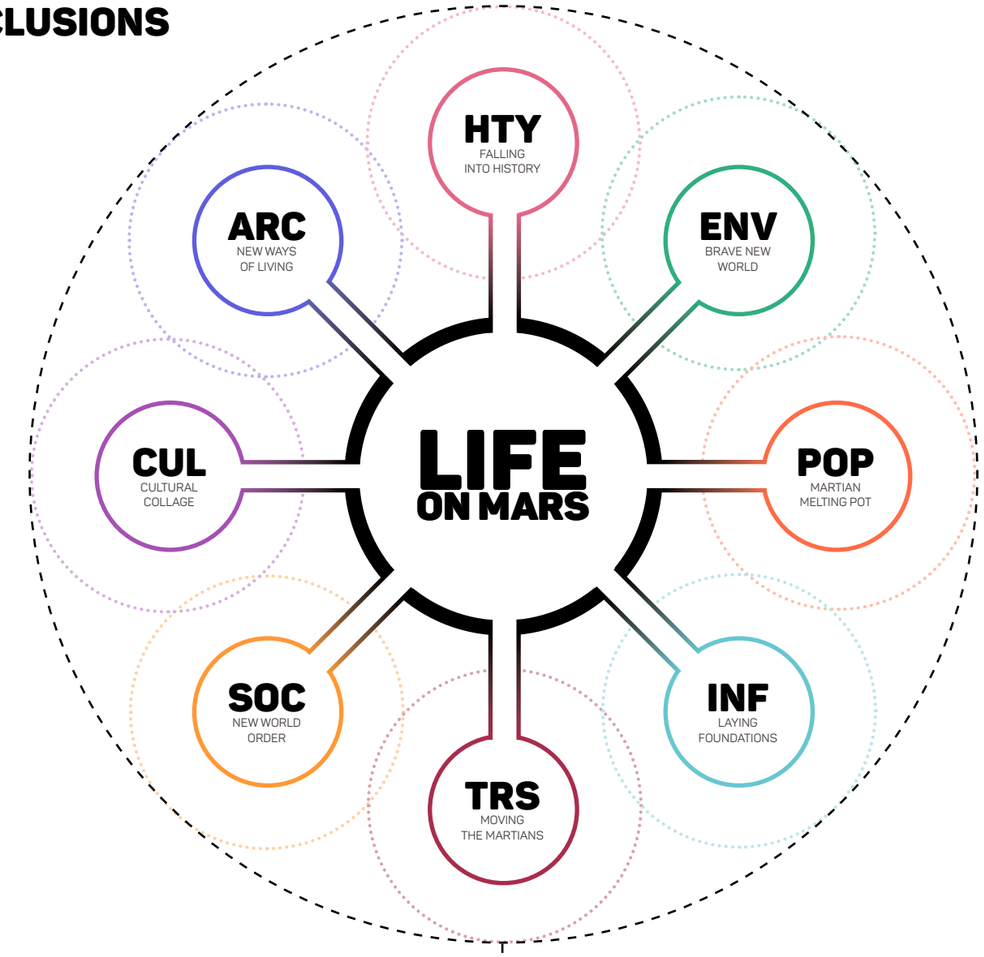
> ***It was the first town of any size to be built upon the Martian surface. It was giddy stuff. They were on the surface. They were out of the trenches and mesas and craters. The horizon stretched to forever and the buildings stretched up towards the heavens.***

**Kim Stanley Robinson**
RED MARS

FOR MORE INFORMATION SEE
**Martian Settlement**



# CONCLUSIONS




The aim of this project was to research, predict and present a future Martian society, identify their needs and address how architects can respond to these needs for a design brief sited on Mars.
In 5B I will use insight gained from 5A to extent this vision of the future to a more specific aspect of Life on Mars.

**2B**

## ACKNOWLEDGEMENTS

I'd like to thank studio tutors Michael and Greame for their advice and their unrelenting enthusiasm which pushed me forwards with the project in times of doubt.
I can't thank Immy enough for the unwavering moral support, sound artistic advice and a steady supply of cake.
Finally thanks to Poppy and Clive for helping out when things got hairy.

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