BOĞAZİÇİMUN ADVANCED
2025
the Legacy

FCC: SPACE RACE

STUDY GUIDE

Under Secretaries General: Zühtü Anıl Tutar, Ömer Alp Şiringöz
Academic Assistants: Vedat Yıldız, Bora Benli

#BridgingTheGap

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Letter From The Secretary-General

Meritorious participants of BoğaziçiMUN Advanced 2025,

It is with warm hugs, sincerity and utmost privilege to welcome you all to this edition of BoğaziçiMUN Advanced. I'm Selin Ayaz, a senior Double Major of Political Science & International Relations and Sociology at Boğaziçi University. Having four years of university Model UN experience (alongside 5 years prior) under my belt, I will be serving as your Secretary-General.

For this version of BoğaziçiMUN, both of our teams have worked from day to night to give you the best experience ever. I would first like to thank my amazing Deputy-Secretaries-General, Maya Gençdiş and Emir Elhatip, for their continuous effort and clever wit. Another person that I'm thankful for is our esteemed Director-General, Irem Ayber. She and our Deputy-Director-General Azra Çökük are some of the most hardworking people I've known, they are tireless in their work and you will get to experience the fruits of their labour when we meet in September.

We've prepared 9 different committees covering a wide range of topics. FCC: Space Race is a one them, a one of a kind committee. As by the theme of our conference, this committee honors the legacy of Zühtü Anıl Tutar, our previous club coordinator as well as the former Secretary-General of BAUXBOUN Train 2023. I would like to thank the hardworking Under-Secretaries-General Zühtü Anıl Tutar himself and Ömer Alp Şiringöz as well as their Academic Assistants Bora Benli and Vedat Yıldız for their efforts in making this committee come to life.

We've always used the phrase "Bridging the Gap" as our motto. This year, we are combining this with the legacy. Each edition of BoğaziçiMUN has been about providing our participants with the best experience they've ever had so far. Each time, we try to outdo ourselves and become the best version so far. This edition has been no different as all of us have vigorously and tirelessly worked so far. Now the ball is in your court. I invite you all to take a step forward and feel the legacy.

Warmest regards,

Selin Ayaz

Secretary-General of BoğaziçiMUN Advanced 2025

Letters From the Under-Secretaries-General

Dear Delegates,

It is an honour to welcome you to the BoğaziçiMUN'25. I hope this conference will be the best experience you have ever had and assure you that you will leave this conference with the knowledge of everything related to MUN and good memories. I am one of your Under-Secretaries-General, Ömer Alp Şiringöz, from Boğaziçi University Department of Chemistry. This Futuristic Crisis focuses on a space race happening in 2070. The future is made today and we hope this projection of ours can create a vision for all of us for what to do today. We think this committee will be a great approach to you, delegates, to demonstrate what you have to plan to come out as victorious in the global race of space. Me and my most esteemed Co-Under-Secretary-General Zühtü Anıl Tutar are more than excited for the outcomes for this committee and we hope you will also share the same enthusiasm as we do. This committee is designed to focus on active action situations and we, as the Under-Secretaries-General, together with our Academic Assistants Bora Benli and Vedat Yıldız, will work hard to make sure that BoğaziçiMUN'25 Advanced FCC will be an experience to remember with a smile on your faces. The space race will be concluded, maybe for the last time, will your cabinet survive the race and come out with a victory, or lose to your rivals, let the committee decide.

If you have any questions, do not hesitate to reach out via:
srngzalp17@gmail.com

Sincerely,
Under-Secretary-General of the Futuristic Crisis Committee
Ömer Alp Şiringöz

Esteemed delegates,

It is my pleasure to welcome you all to Boğaziçi MUN'25 Advanced and to the Futuristic Crisis Committee, which I am honored to have named after me. My name is Zühtü Anıl Tutar, a graduate of the Boğaziçi University Department of Molecular Biology and Genetics. For this conference, I will be serving as one of the Under-Secretaries-General of this committee.

Before joining the academic team for this conference, I had served in various roles in MUN academia, including Secretary-General for BAUxBOUN TRAIN'23, club coordinator for Boğaziçi MUN, and concluding my MUN career with Boğaziçi MUN'24. This conference marks the one and only exception to my retirement since it celebrates many outstanding editions of Boğaziçi MUN, and the club I spent all my university years in.

Because this is a special event, we wanted this committee to be special as well. For the first time in Boğaziçi MUN history, we bring you a futuristic committee. Both Ömer Alp and I share a passion for trying new things in our committees and giving our delegates something they have never experienced before. With our passion combined with the help of our amazing academic assistants, Bora and Vedat, I am confident when I say that we managed to achieve our goal in bringing you a truly unique experience.

Since this is an advanced committee, we will not shy away from presenting you with difficult and demanding crises. In addition, as a futuristic committee, our committee documents are the only source you can refer to when it comes to solving crises and studying. I advise you to carefully study all the materials we provide you with because they will be essential for your success.

This conference is a great opportunity for you to meet and work with many great figures who worked so hard to found, build, and improve one of the best MUN clubs, and for retired USGs like me to have one last dance with old friends. I believe this will be an unforgettable experience for all of us, so make the most of it.

Best Regards,

Zühtü Anıl Tutar

Under Secretary General of the Futuristic Crisis: Space Race

I. Introduction To The Committee

Esteemed delegates, welcome to the Futuristic Crisis Committee: Space Race. In this part of the guide, we will discuss the nature of the committee. It is essential for you to read and understand this section of the guide, as it will provide guidance on your preparation for the committee.

Committee Documents

As you can understand from the name, Space Race is a futuristic committee. This means that all documents belonging to the committee, discussing previous events or the situation of the world, are created by the academic team of the committee. This means that for events occurring after the release of the study guide, you need to refer to the study guide, even if something else happens in the real world.

For this committee, including this study guide, we have four documents. The study guide provides you with all the information you need to know about the important events, organizations, and technologies the committee is interested in. The committee handbook teaches you the special procedures we have designed for this committee and general crisis committee proceedings. The character guide includes descriptions for all of the members of the committee. Finally, the story document includes a timeline of the events that happened after 2025 and a brief historical description. All of these documents are crucial for your success in the committee, so make sure not to skip any of them while preparing.

In addition to the four committee documents, you will receive personal character information based on your allocations. These documents will describe the traits of your character hidden from other participants, character proficiencies and capabilities (in other words, your directive powers), and personal agendas for your character, if you have one. Sharing the information in the private character documents is not forbidden; you can choose to share it with any number of your fellow delegates as long as you think it will benefit your character. However, keep in mind that sharing your private information with other delegates can impact your experience in the committee. We recommend not sharing anything about your characters' hidden agendas or beliefs outside of the official committee sessions for an immersive experience. You can find more information about this in the committee handbook.

Agenda Item

Since this is a crisis committee, the agenda of the committee is open. This means that you will need to solve different crises to reach the end goal of the committee, which is to establish and maintain a functional base of operations on Mars for future projects. The committee will begin in 2070 with the selection of the crew members for the base and proceed with multiple time jumps to the future as the crises are presented. Please refer to this study guide for more information about the mission and to the committee handbook for the procedure involving the time jumps.

II. North Atlantic Treaty Organisation Space Operations Centre

In December 2019, NATO declared space as the Alliance's fifth domain, apart from the other four domains: air, land, sea and cyber. And the ministers agreed on the creation of the Space Operations Centre officially in October 2020.

In January 2023, 15 Sponsoring Nations signed the then-named NATO Space Centre of Excellence's Operational Memorandum of Understanding. Later in 2025, the centre was officially named "NATO Space Operations Centre".

NATOSOC didn't come to an important issue until the USA entered a rivalry with China for space technology. In 2039, all NATO allies were alarmed by Article II of the Treaty and helped the USA with aid and research in the South China Sea region. All NATO allies imposed an embargo on China until the ceasefire in 2047 between China and the USA.

After the peace treaty that was signed between the USA and China in 2051, NATOSOC upgraded to a larger entity by the proposal of the USA with the votes of the allies. The UN recognised NATOSOC as a larger commission.

In 2055, the USA and NATOSOC built a lunar base with the help of Japan. The use of the base has been given to NATOSOC and is officially named NATOSOC Lunar Base. All astronauts from countries, whether a NATOSOC country or not, were invited to the base for research purposes, including China and Russia.

NATOSOC, China, Russia, Japan and India signed an agreement in 2058 for free use of all lunar bases under the condition of prior permission.

NATOSOC member countries joined the urgent UN meeting in 2066 and re-signed and reaffirmed all articles of the Outer Space Treaty.

III. United States Space Force

The US Space Force was established on December 20, 2019 as a branch of the armed services under the Department of Defence.
As written in the title 10 of the United States Code, Section 9081:

A. Establishment
There is established a United States Space Force as an armed force within the Department of the Air Force.

B. Composition
The Space Force consists of:
i. the Regular Space Force;
ii. all persons appointed or enlisted in, or conscripted into, the Space Force, including those not assigned to units, necessary to form the basis for a complete and immediate mobilization for the national defense in the event of a national emergency; and
iii. all Space Force units and other Space Force organizations, including installations and supporting and auxiliary combat, training, administrative, and logistic elements.

C. Functions
The Space Force shall be organized, trained, and equipped to:

- Provide freedom of operation for the United States in, from, and to space, including outer planets and satellites;
- Conduct space operations; and
- Protect the interests of the United States in space.

The section was enacted first in 2017 and amended through 2051 with minor details.

The Space Force did not come to use until the building of the lunar base in 2050. During the negotiation meetings with the Chinese and other parties, the USA delegation made it clear that they will obligate the US Space Force to be present at the bases, as for protection matters. During the NATOSOC meetings this idea was not welcomed by allies since the base was to be a common place for all allies. With common terms, the US Space Force got accepted to serve on the moon and the rest. The sponsors of the meeting also gave permission to China to let them bring the Chinese force (Official: People's Liberation Army Aerospace Force) on the moon as well. No skirmish happened since the buildings of the lunar bases and the US Space Force have since become an active service branch of the US Armed Forces.

Like all armed forces, the US Space Force must obey all treaties including the Outer Space Treaty, which forbids the usage, testing and the storage of any weaponry outside of the Earth's atmosphere. After the 2050 revision of the Outer Space Treaty, all space force officers are granted to carry small arms with them, giving them one arm for an officer.

No officer has yet used their weapons to this day since there was no threat and any false usage may result in major consequences for the officer and the country they are serving.

IV. Space Justice

A. Outer Space Treaty (1967)

All legal framework for space affairs goes back to the Outer Space Treaty, which was signed in 1967. It is a foundation for all space-related laws that binds all countries since then.

Article I:

The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

This article solely defines what the treaty was intended to do. But in summary:

- No country can have national sovereignty in space
- Celestial bodies can be used only for peace
- States are responsible for any action made by governments or individuals
- No weapons of mass destruction are allowed in Earth's orbit or on other celestial bodies

Rescue Agreement (1967)

The UN General Assembly passed the Rescue Agreement in 1967. The agreement entitles any state that is a party to the agreement to provide assistance to rescue the personnel of a spacecraft in danger or emergency. The term "personnel of a spacecraft" also includes spacecraft passengers without astronaut training.

Space Liability Convention (1972)

The treaty signed in this convention in 1972 states that all states hold international accountability for all space objects launched from their territory. This means, regardless of who launches a space object, the state over the territory it has launched is responsible for any damage.

For example: If a private company launches a spacecraft from Mexico and it crashes and causes damage, Mexico is responsible for the consequences.

Moon Treaty (1979)

Another treaty was signed in 1979, the Moon Treaty, which basically declared the Moon and its resources a heritage for all mankind. However, since its declaration, major parties such as the USA, China and Russia (and former Soviet Russia) have never signed or deposited due to its restrictive nature for their space operations.

Artemis Accords (2020)

Years later, in 2020, NASA introduced the Artemis Accords, which aimed for much of the same but were more flexible and went with the interests of the USA. Countries that also signed the Moon Treaty are also signatories of the Artemis Accords, but China and Russia opposed it, claiming it only serves American interests. The Artemis Accords were the groundwork for NASA's Artemis lunar program, an opposition to the Chinese-Russian lunar mission named the International Lunar Research Station. Some of the important provisions of the Artemis Accords are:

- Countries/companies can extract and own resources from the Moon or asteroids.
- Countries can create "safety zones" (bases) on the celestial bodies.
- Emphasizes the contribution of private companies to the missions.

Paracel Accords (2051)

The terms were signed after the ceasefire in 2047, for the skirmish had happened in the experimental site of the South China Sea. The Accords were signed in the Paracel Islands in the South China Sea with UNOOSA, NATO and other partners as the guarantors. Some of the terms that the Accords mandated are:

- Both parties ought to exchange and share research regions, the research results and the researchers.
- The protocols must be transparent to the UNOOSA Secretariat.
- Safety zones may be established, but can not be territorial claims.
- Any dispute and the violation of the accords may result in sanctions imposed by the UN.
- Extraction of space resources is permitted under licensing by UNOOSA.

Outer Space Charter (2066)

The Charter was adopted at UNOOSA and the UN General Assembly in 2066. This Charter acknowledges and reaffirms the Outer Space Treaty (1967) and works more as an update to it. The articles of the Outer Space Treaty are still active other than the additions in the 2066 Charter. Important additions are:

- Extraction of space resources is permitted under licensing by ISRA(International Space Resource Authority), created under this charter. Mining or looting artifacts without permission is forbidden.

- Lunar or other celestial body settlements are not sovereign territory but must be administered under multinational oversight councils.
- Safety zones may be established, but can not be territorial claims.
- Military weapons are prohibited from being deployed on celestial bodies, except for the defence of personnel and installations against imminent threats.

V. The Moon

A. History of Human Presence

Humanity's engagement with the Moon is best read as a long, cumulative progression from robotic contact to precision science, then to crewed exploration, and finally to continuous, infrastructure-led presence. The first phase began in the late 1950s when Soviet probes like **Luna 2** impacted the lunar surface and **Luna 3** returned the first images of the far side. Those early missions provided the first physical touchpoints and revealed that the Moon was a varied, geologically complex body rather than a smooth, featureless orb. Decades of subsequent robotic exploration filled in the map: high-resolution orbital missions produced meter-scale topography, polar illumination models, and radiation-environment characterizations that would prove essential for safe landing, habitat siting, and long-term operations.

The Apollo program translated that early reconnaissance into human capability. Apollo 11's landing on **20 July 1969** established the operational repertoire for surface EVA, sample collection, emplacement of scientific instruments, and short-term habitation; later Apollo missions returned suites of rock and soil samples that remain the baseline for lunar geology.

This scientific and technical foundation set the stage for a modern return to the Moon as a platform for sustained human activity. The contemporary revival began with a new crewed mission in **2027**, when NASA's Artemis II lunar lander demonstrated integrated deep-space hardware, renewed crewed landing capability, and critical lessons in mission planning, navigation, and life-support architectures. Artemis II re-established human operational experience in lunar transit, descent/landing profiles, and surface procedures—capabilities that planners used to scale single sorties into rotating, longer-duration missions.

Legal and policy frameworks evolved in parallel with technology. A formal revision of the Outer Space Treaty in **2050** and subsequent national approvals for novel construction and utilization technologies created an updated international legal architecture for permanent lunar installations. With legal barriers clarified, the first permanent, multinational research facility, CITADEL (**NATOSOC Lunar Base**) was constructed in **2055** through collaboration among the United States, NATOSOC partners, and Japan. Designed from the outset as a research hub, the facility hosted rotating international crews and incorporated pre-emplaced robotic infrastructure, high-bandwidth relay communications for continuous Earth linkage, and ISRU testbeds aimed at extracting water and producing propellant and life-support consumables.

The international footprint expanded rapidly. In **2058,** China, with Russian and Indian partners, completed a second permanent lunar base. That same year, major stakeholders (including NATOSOC, China, Russia, Japan, and India) signed an agreement codifying a principle of free use of lunar bases subject to a procedure of prior permission. The agreement institutionalized a cooperative access regime while leaving operational control and technical responsibility with base operators, producing an uneasy but workable balance between shared science and national operational interests.

Technology accelerated development further. In **2059**, Indian scientists unveiled a breakthrough remote construction system that enabled automated, large-scale base building from Earth or orbital control nodes without the need for continuous crewed construction sorties. The practical consequences were immediate: China demonstrated remote expansion in **2060**, enlarging habitat and infrastructure footprints without additional astronaut deliveries, and the United States (with NATOSOC) deployed the same remote construction methods in **2062** to extend logistics modules, solar farms, and rover networks.

B. Current State

The Moon now hostages two bases with ongoing research facilities inside. The NATOSOC shared base and the International Lunar Research Station, under the shared control of China and Russia. Countries and private companies make regular travel to the bases to bring all researchers and visitors.

The Moon has been a place for mining since the opening of the bases. Lunar artifacts have been collected and examined by the researchers both in the Earth and on the Moon. Mining or looting artifacts without permission is forbidden, as only the researchers with permission have the authority to take artifacts from the lunar surface. And even with the permission, researchers must examine the artifact first, in order to take them in the Earth, to not carry the unknown to the Earth.

Tourist visits can be conducted by private companies under watch of national space agencies. Tourist spots only consists of the Apollo 11 landing site in the Sea of Tranquillity, the NATOSOC base and the Lunar Heritage Museum inside of it.

C. Bases

1. CITADEL

English:

Center for **I**nterplanetary **T**echnology and **A**lliance **DE**velopment **L**unar

French:

***C**entre **I**nterplanétaire de **T**echnologie et d'**A**lliance pour le **D**év**E**loppement **L**unaire*

The CITADEL is the base controlled and used by the NATOSOC countries, led by the United States. The base is located on Mons Mouton in the southern hemisphere at the South Pole region. The construction started in 2050 by the United States and finished in 2055, with the help of JAXA (Japan Aerospace Exploration Agency) and the NATO allies. The base is open for researchers from all countries. The base is located in the The base consists of 4 parts:

- Resting & Wellbeing
- Research & Development
- Q-BIT(Quantum-Beyond Institute of Technology)
- The Lunar Heritage Museum

The **R&W** part is where all people stay and continue their lifecycles. This part contains bedrooms, social rooms, gyms and other living spaces.

In the **R&D** part there are multiple labs for different purposes and technologies. The base not only focuses on Moon research but also hosts research that can only be conducted in space, to not push all to the Great Space Station. All food generation, terraforming and other technological advancements happened in these labs as well as the research on the Moon artifacts.

The **Q-BIT** is a high-technology quantum complex built by American scientists. The Q-BIT contains different quantum computational gears, including the MQB(Menendez Quantum Bridge). Q-BIT serves as one of the most developed technological institutes mankind has ever built. The Q-BIT also offers an academic program for the most prestigious researchers all around the world.

The Lunar Heritage Museum opened in 2069, for the 100th anniversary of the Apollo 11 Moon Landing. The Museum contains unseen pictures and old rover parts from the mission. The Museum is usually visited by space tourists. The Museum is also being kept safe by the space officers of NATO countries.

All wastes are pushed to Crater Malapert, near the base. NATOSOC has yet to find a solution to contain the waste in a better way.

In 2062, with India's newly developed remote construction system, the CITADEL got expanded since the space wasn't enough for further research. The expansion also made space for the Lunar Heritage Museum that opened later.

2. International Lunar Research Station (ILRS)

The International Lunar Research Station is co-controlled by China and Russia. Its construction started in 2051 and opened in 2058, with the help of ISRO (Indian Space Research Organization) with 11 more countries such as Azerbaijan, Egypt and Venezuela contributing. The station is located on crater Cabeus in the southern hemisphere at the South Pole region. The contributing countries increased over time but couldn't reach the NATO-allied countries. Although all researchers from all countries are working in the station, including the NATO-allied ones. The base consists of 3 parts:

- Laboratories
- Habitat Rooms

- The Vault

The **laboratories** are the place where all research happens inside. The research conducted in the South China Sea continued here to be developed and used on Mars. This part also hosts a high-technology quantum computer built by the Chinese scientists.

In the **Habitat Rooms** different rooms simulate different conditions to make tests. This part is built to be used in both terraforming experiments and Mars experiments. These rooms include the restrooms of all staff as well.

In **the Vault**, all objects that can’t be stored in the labs (like artifacts, wastes and past researches) are kept in. The Vault is protected by the space force officers of the allied countries.

After India’s breakthrough invention in remote construction, the ILRS successfully expanded in 2060 to expand the vault to make more space for the waste.

VI. Mars

Mars is the 4th closest planet to the Sun in the Solar System. Because of its flat orange-red appearance the planet is often referred to as the “Red Planet”. Being the closest planet to Earth has allowed scientists to closely examine the planet using telescopes and drones such as the Mars rover. The planet features water and relatively tame environmental conditions compared to other planets, although it is nowhere near Earth in terms of suitability for life, the planet has often been considered as a potential colony for humans by both sci-fi writers and scientists. The planet experiences a violent swing of atmospheric temperature from -153 to 20°C and high amounts of cosmic radiation and the entire planet is covered with a layer of fine dust which gets spread around easily by even weak winds due to low-gravity. Despite the hostile nature, humanity continues to try and come up with solutions to the challenges the Red Planet raises, such as how to produce food and oxygen in Mars, how to extract water and how to protect personnel and structures safe from harm.

A. Characteristics

1. Orbit and Rotation

As Mars orbits the Sun, it completes one rotation every 24.6 hours, which is very similar to one day on Earth (23.9 hours). Martian days are called sols – short for "solar day." A year on Mars lasts 669.6 sols, which is the same as 687 Earth days.
Mars' axis of rotation is tilted 25 degrees with respect to the plane of its orbit around the Sun. This is another similarity with Earth, which has an axial tilt of 23.4 degrees. Like Earth, Mars has distinct seasons, but they last longer than seasons here on Earth since Mars takes longer to orbit the Sun (because it's farther away). And while here on Earth the seasons are evenly spread over the year, lasting 3 months (or one quarter of a year), on Mars the seasons vary in length because of Mars' elliptical, egg-shaped orbit around the Sun.
Spring in the northern hemisphere (autumn in the southern) is the longest season at 194 sols. Autumn in the northern hemisphere (spring in the southern) is the shortest at 142 days. Northern winter/southern summer is 154 sols, and northern summer/southern winter is 178 sols.

2. Atmosphere

The atmosphere of Mars is mainly composed of carbon dioxide (95%), molecular nitrogen (2.85%), and argon (2%). It also contains trace levels of water vapor, oxygen, carbon monoxide, hydrogen, and noble gases. Weak magnetic field, weak gravity and surface conditions resulted in atmospheric loss of Mars over time and since compared to Earth it has a much thinner atmosphere, said atmospheric loss also happens on Earth albeit at an insignificant rate. The maximum density of Martian air is 20 g/m^3 (Earth's is around 1.29 kg), and the average surface pressure is at 0.006 atm (0.6% of Earth's atmospheric pressure). The currently thin Martian atmosphere prohibits the existence of liquid water on the surface of Mars.

Mars is farther away from the Sun than the Earth. This results in the atmospheric temperature to typically exhibit sub-zero temperatures near 60°C and despite the abundance of CO_2 in the atmosphere, the greenhouse effect is minimal due to the thin atmosphere. The daytime cycle results in significant change in lower atmospheric temperature which can range from −75°C to near 0°C near the surface in some regions.

The composition of the atmosphere changes throughout the Martian year in a seasonal manner, this can be attributed to changes in temperature, sublimation and deposition of CO_2 ice in the polar ice caps, dust storms, atmospheric movement and potentially the adsorption of gasses by regolith (dust, stones, rocks, etc.). Such effects show significant effects, such as varying atmospheric pressures (up to a difference of %25), differences in the ratios of atmospheric gasses and condensation of CO_2 on the surface to form 1–2 m thick solid dry ice.

Additionally, Mars doesn't have an ozone layer throughout the atmosphere like Earth has; however, it does have patchy areas with higher ozone concentrations, the south polar pole has a more stable ozone "layer" whereas the north polar pole only showcases such ozone presence in spring and summer (both of which provide insignificant amounts of UV radiation protection). Methane is also another mystery with multiple occurrences of methane detected in the atmosphere in tiny but varying concentrations which would be of interest to both geologists and biologists, and point towards a seasonal and/or regional methane cycle. There are however suspicions on these detections and measurements.

The atmosphere of Mars can be divided into three layers as follows: the troposphere (0–40 km), where weather events such as convection, dust storms, and water-ice clouds occur; the mesosphere (40–100 km), which has the lowest temperatures (−173°C to −153°C) and can host rare carbon dioxide (CO_2) ice clouds near the mesopause; and the thermosphere (100–230 km), where temperatures range from −98°C to 116°C.

All-around Mars dust storms and devils can be observed, covering the planet in a coat of dust and put the operations of manmade objects such as rovers under risk, the dust storms also significantly decrease the daily temperature variation from up to 60°C to 5°C. Some dust storms are even observable from earth through colour change and roughly every 5.5 Earth years (3 Martian years) planet-wide dust storms occur. Low gravity allows for the dust to spread around easily even with weak winds; however the exact reason why planet-wide storms occur is not very clear, some have hypothesized that the large-scale storms are related to the gravitational pull of Mars's moons similar to tidal effects of the Moon on Earth.

As a result of no ozone layer or magnetic field present, the photochemical reactions tend to oxidize the organic matter into carbon dioxide and carbon monoxide. The photochemical reactions is also one of the key determiners behind the composition of the atmosphere, by causing atmospheric loss, creating reactive oxygen species (which causes toxic compounds such as peroxides to form in the soil), and destroy gasses such as methane (CH_4) in the atmosphere.

3. Geological Notes

Mars has a diameter of 6,779 km (in comparison Earth's diameter is 12,742 km long) and is less dense than Earth, resulting in a gravity of roughly 3.72 m/s^2 (Earth gravity is roughly 9.8 m/s^2. The planet gets its signature orange-red colour from the iron(III) oxide found throughout its surface.

Much like other planets and Earth, Mars's internal structure can be separated into layers, with a liquid planetary core covered, in order, by a middle mantle, lithospheric mantle and the crust. The middle mantle of Earth is a slow-flowing solid whereas Mars's middle mantle is more stagnant, this allows Earth to recycle its surface with a new crust, experience more quakes and volcanism, long-term carbon cycling and climate regulation and a strong magnetic field. In comparison, because of its stagnant middle mantle Mars has little internal heat flow and this results in the interior to become colder and in turn result in weaker quakes (marsquakes) than Earth, a very weak magnetic field, and hence no protection from cosmic radiation, small molten pockets in its mantle, which results in less frequent but huge volcanic activity, old and ancient surface because of no recycling of the crust and no plate tectonics.

Do keep in mind that it is most likely that Mars had a more active internal structure in the past which resulted in volcanic activity and other geological factors resulting in the formation of its crust as it is today.

The crust of Mars has a depth ranging from 6km to 117km with an average of 42-56km whereas the average depth of Earth's crust is 27.3km, also the lithospheric mantle of Mars is roughly 250km deep making the lithosphere of Mars very deep compared to Earth.

Mars is an igneous planet with rocks and crust dominated by minerals crystalized by molten magma, with majority basaltic composition similar to Earth's oceanic crust (olivine, pyroxene, feldspar and more) with the surface covered by iron(III) oxide (Fe2O3) and goethite dust. Mars's crust also contains alteration minerals (hematite, phyllosilicates (clays), goethite, jarosite, iron sulfates, opaline silica…), many of which require liquid water to form and some of which even require suitable pH levels for life. Layered deposits of sedimentary rocks such as mudstones and carbonates are also widespread, sediments include wind-blown and fluvial deposits. The mineralogy indicates potentially habitable conditions for life in the past including lakes and ground water, moist atmosphere, habitable water pH for life such as microorganisms, thick CO_2 atmosphere; with potential for traces of past life.

The surface consists of minerals containing silicone, oxygen, metals and other elements that typically make up rock. Analysis revealed Martian soil to be slightly alkaline at 7.7 pH, with elements such as magnesium, sodium, potassium and chlorine which are necessary nutrients for plant growth. The soil contains 0.6% perchlorate by weight, concentrations that are toxic to humans.

In Earth the sea-level is used for altitude reference, because Mars is a desert planet with no liquid water the altitude use a reference called the "areoid" (like Earth's geoid), which can be thought of as an imaginary irregular sphere like the geoid which has equal gravity all over its surface, which is the zero altitude or the Martian datum. The equator of Mars is based on its rotational axis just like Earth's and its prime meridian has been chosen arbitrarily to pass through a small crater called Airy-0.

The northern hemisphere consists mostly of flat plains, shaped in part by lava flows, while the southern highlands are mountainous and heavily cratered. The elevation difference between the hemispheres ranges from 1 to 3 km, with the northern plains mostly below the Martian datum and the southern highlands above. The stark contrast between the two hemispheres is often referred to as the Martian dichotomy, which is also the name of the area of transition. This dichotomy is a central feature of the planet, with fretted terrain containing mesas, knobs, and flat-floored valleys with walls about a mile high, often accompanied by lobate debris aprons—rock-covered glaciers showing signs of past movement. Large river valleys and outflow channels further cut through the dichotomy. The northern low-lands cover about 1/3 of the surface area whereas southern highlands make up the other 2/3 and the southern hemisphere is thought to be older.

Mars' surface features include vast volcanic regions. The Tharsis upland hosts several massive shield volcanoes, including Olympus Mons, the tallest known mountain in the Solar System. Olympus Mons rises about 21 km above its surrounding cliffs and spans over 600 km across. Its total elevation change from Amazonis Planitia to its summit approaches 26 km, roughly three times the height of Mount Everest, and slightly over twice the height of Mauna Kea from base to peak. The Tharsis region also contributed to the formation of Valles Marineris, a vast canyon system 4,000 km long and up to 7 km deep, equivalent in length to Europe and spanning one-fifth of Mars' circumference. Valles Marineris may also represent a tectonic boundary, with evidence of up to 150 km of transverse motion. Additional surface features include holes and caves, particularly on the flanks of volcanoes like Arsia Mons, where cave entrances 100–252 m wide and at least 73–96 m deep have been discovered. These caverns may be protected from radiation and meteoroid impacts, offering potential refuges for future exploration.

Mars is scarred by impact craters, with more than 43,000 craters over 5 km in diameter. The largest exposed crater is Hellas Basin, 2,300 km wide and 7 km deep. Other significant craters include Argyre (~1,800 km diameter) and Isidis (~1,500 km diameter). Some craters show evidence that the ground became wet after impact. It is theorized that roughly four billion years ago, a massive impact may have created the Martian dichotomy.

The planet also has polar ice caps, with the northern cap at Planum Boreum and the southern cap at Planum Australe. The altitudinal range on Mars is extreme: from the summit of Olympus Mons at 21.2 km above the datum to the bottom of Hellas Basin at 8.2 km below, a total difference of nearly 30 km. By comparison, Earth's maximum elevation difference (Mount Everest to the Mariana Trench) is 19.7 km.

4. Water

Water is a critical feature of Mars, though it exists in far more limited and challenging forms than on Earth. The planet's thin atmosphere, low temperatures, and low pressures prevent stable liquid water from persisting on the surface for long periods. Instead, water exists primarily as ice in the polar caps and subsurface, as briny liquid under specific conditions, and bound within minerals formed in the presence of water. Despite these harsh conditions, water has profound implications for Mars' geology, past habitability, and future human exploration. Seasonal changes in the polar caps, including sublimation of carbon dioxide, drive small fluctuations in atmospheric pressure and local humidity, affecting dust storms and climate cycles. Mars' water is fragmented, transient, and often locked in ice or salts, making its distribution and accessibility critical for both science and exploration.

Mars has two major polar ice caps: Planum Boreum in the north and Planum Australe in the south. The northern cap is largely water ice with seasonal CO_2 frost, while the southern cap contains thicker seasonal CO_2 layers overlaying water ice. These caps grow and shrink cyclically, recording layers of dust and ice that preserve information about Mars' climate over millions of years. Polar ice caps also influence local atmospheric circulation, and CO_2 sublimation in spring and summer slightly increases atmospheric pressure. Quantitatively, the northern cap contains roughly 1.6 million km³ of water ice, while the southern cap holds about 1.2 million km³ beneath seasonal CO_2 layers.

Much of Mars' water exists as subsurface ice buried beneath layers of regolith. Radar studies reveal large reservoirs of nearly pure water ice in mid-latitude regions, extending over millions of square kilometres at depths ranging from a few meters to tens of meters. These mid-latitude deposits are more accessible than the polar caps and could serve as practical water sources for future missions. Seismic data suggest that small pockets of highly saline liquid water may exist deeper, roughly 1–20 km below the surface. Due to the low temperatures and pressures, these brines remain liquid only because of their high salt content. Collectively, if fully mobilized, polar and subsurface ice could provide a substantial water resource, although still less than 0.3% of Earth's total water volume.

Seasonal dark streaks, called recurring slope lineae, appear on steep slopes during warmer months. Their association with hydrated salts indicates transient flows of briny water. These brines are too salty to support most known life but demonstrate that liquid water can occasionally exist at the surface under suitable conditions, shaping local landscapes.

Mars' surface contains hydrated minerals such as clays, sulfates, opaline silica, and iron oxides, all formed in the presence of liquid water. Layered sedimentary deposits—including mudstones and carbonates—point to long-lasting lakes and groundwater systems in Mars' past. Ancient river valleys and delta systems indicate flowing water once sculpted the surface, suggesting that early Mars had climates capable of supporting microbial life.

Water is crucial not only for understanding Mars' history but also as a resource for human exploration. Polar ice could be melted for drinking water, while hydrogen and oxygen extracted from water could support fuel or breathable air. Mid-latitude ice deposits are particularly attractive landing targets because they are closer to equatorial temperatures, reducing energy costs for access. Understanding water distribution, accessibility, and purity is therefore vital for selecting landing sites and planning future missions.

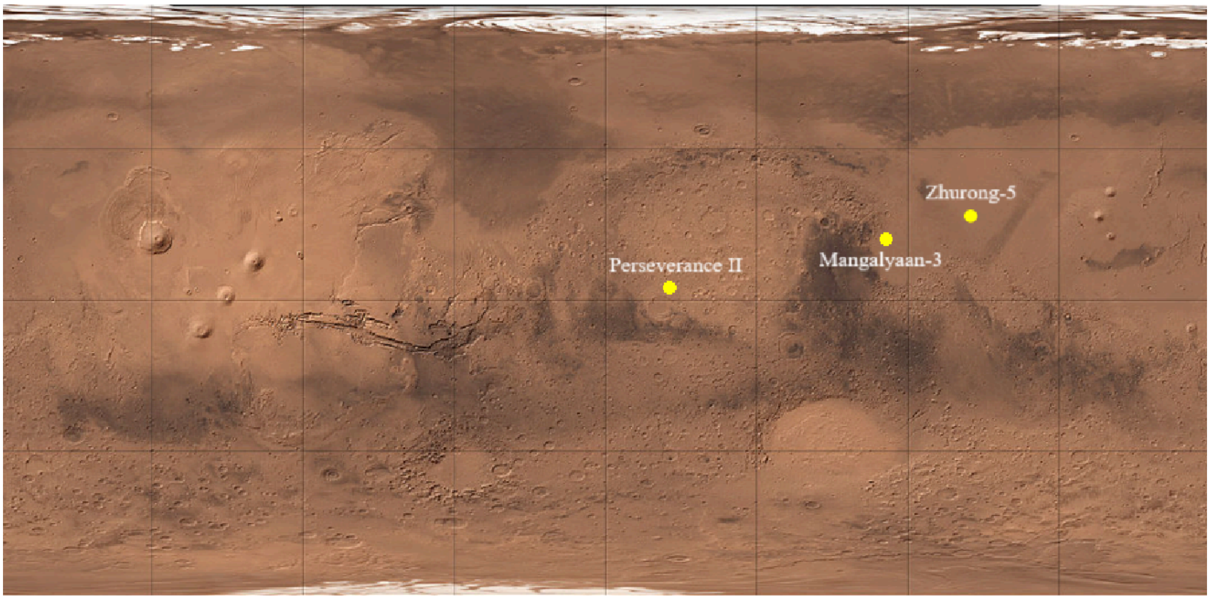
While Earth has vast oceans and a continuous hydrological cycle, Mars' water is fragmented, seasonal, and largely locked in ice or brines. Equatorial regions are dry, while ice is concentrated at higher latitudes. Even small pockets of accessible water could dramatically improve the feasibility of long-term human presence, enabling in-situ resource utilization rather than relying entirely on supplies from Earth.

Mars hosts water in multiple forms, primarily as ice, hydrated minerals, and transient brines. Mid-latitude ice deposits span millions of square kilometers and can be tens of meters thick, while liquid brines, if mobilized, exist only in tiny pockets at subzero temperatures. Overall, accessible water on Mars is extremely limited compared to Earth's oceans, which hold about 1.332 billion km³ of water, meaning Mars' water is less than 0.3% of Earth's total, highlighting the challenges of extraction for future human use.

B. Current State

Mars has hosted many research rovers over the years on its surface. Most of these rovers are left unusable on the surface of the land. Currently, only the rovers that are on landing missions are still working. The United States rovers, China rovers and India rovers are on the ground to prepare and watch the planet to be available for landing.

- Perseverance II rover of the USA is currently on the southwest of Arabia Terra
- Zhurong-5 rover of China is currently on Utopia Planitia
- Mangalyaan-3 rover of India is currently on Isidis Planitia



C. Mission

The mission to build a base on Mars is set to begin with the launch of the base materials for the first phase of building in 2070. Following the completion of the first phase of the base via remote base building technologies, a crew is set to travel to Mars in 2071 to inhabit, maintain, and improve the base. Dr. Abigail Reinhart is assigned as captain to this mission because of her success at NASA and her contribution to space travel by creating the Reinhart Drive. The goal of the mission is to successfully build, maintain, and prepare the base and the planet for the arrival of future crews and eventual colonization of Mars.

The designated crew size for this mission is 6 people, including the captain. Captain Reinhart is assigned to decide on 5 more people to bring with them to Mars. In addition to people from NASA, other people from SpaceX, Nova Terra, Future Company, Space Force, and diplomats from the UN and NATO are assigned for the mission. According to an agreement between NASA and Future Company, Future Company holds the right to send at least one person to Mars; however, this person is to be chosen by the captain from a list of possible candidates.

The location of the base is decided as the Southwest of **Arabia Terra**, over the Schiaparelli Crater, where the Perseverance II rover of the USA is currently located.

In addition to successfully building the base, it is expected of mission command to try and make international laws to ensure the stability of the base for future generations. For this reason, the diplomats in the mission control have a job to report the mission status to their respective organizations to discuss the possible actions.

1. Base Structure

The Mars base plans are designed to build an expandable modular base that can serve different purposes depending on the needs of the mission and the crew members. For this purpose, a three-phase base building plan is designed so that the modules required for the base are separated into three categories, which are: Primary modules, secondary modules, and tertiary modules. Primary modules are the must-have modules that are built in the first phase of construction. Secondary modules are good-to-have additions to the base that are not necessary but provide some benefits to the mission. Tertiary modules are modules that do not grant any benefits to the mission but are more about luxury and the well-being of the crew members.

Primary modules follow a pre-designed structure, which makes the modules connect to each other in a way that the systems can effectively run. After the first phase, any number of secondary and tertiary modules can be integrated into the base structure.

2. Primary modules

In this section of the guide, the utilities of the primary modules of the base will be explained, and the general base structure will be clarified. Keep in mind that this is the initial phase of the base building, and the structure at this point includes all of the modules in this phase in the specified order.

- The Reactor Module

The reactor module is the center part of the base. This module includes the fusion reactor, which powers all the systems and modules in the base, the storage for fueling the reactor, and the necessary satellite systems of the reactor, such as the maintenance and cooling. This module is located in the very center to evenly distribute the power throughout the base without any additional strain.

- The Command Center Module

The command center is where the Menendez Quantum Bridge (the quantum computer responsible for the mission) node is located on the base. This module has a direct passage to the reactor module, and all the other modules branch out from this module. The quantum computer in this module is responsible for monitoring all the base processes in every module, including the fusion reactor, food production, oxygen generation, etc. This module is the meeting room for the crew, and the communication with the command center on Earth takes place in this module. In addition to these, the mission data collected from the crew, rovers, drones, satellites, and spacecraft are stored here along with all the satellite systems of the quantum computer. The command center includes a smaller compartment, which is the captain's study, where the mission logs are stored. This module can be considered the brain of the base, where everything related to the mission is decided on.

- The Living Quarters Module

The living quarters module is the module that contains the sleeping area for the crew, lavatories, showers, kitchen, storage space, and a changing station for protective gear. Since the crew will be in sleepwear in this module, the module has its water supply located in the outer wall for extra protection from radiation.

- The Laboratory Module

The initial construction phase of the base includes a fully equipped laboratory for chemical and biological research. Although this laboratory does not allow for experimenting on every possible case, it covers most standard procedures that might be required in the mission. In the event of the laboratory not being equipped for a certain experiment, this module allows for expansion of the lab with the addition of new laboratory equipment modules if the mission control decides on an addition.

- The Oxygen Generation Module

This module utilizes the two-part oxygen production system to supply the base with oxygen and store it by electrolysing the carbon dioxide in the Mars atmosphere. The carbon monoxide generated by this module is then later converted into carbon dioxide and hydrogen gas for further consumption, and the bioreactors in this module convert the carbon dioxide into organic matter and oxygen via photosynthesis. The module is also the ventilation center of the base and is located in a central position. Oxygen storage of the module is connected to the ventilation system, and the flow can be controlled in the module maintenance system.

- The Food Production Module

This module is used to produce food for the daily consumption of the crew. Using the genetically modified crops developed by Dr. Tutar, this module grows crops in a closed and controlled environment. The nutrients, humidity, oxygen, carbon dioxide, and light can be controlled in the maintenance station in the module. This module is also equipped with the primary devices to process the produce into edible form. Legumes and grains can be produced in this module and can be turned into flour, paste, or meals.

- The Waste Management Module

The waste management module is interconnected with other modules like the living quarters and the food production module to effectively gather waste and process it. Liquid and solid waste collected from the modules are collected in the central waste processing facility in the module. Usable water and recycled solids are packed and stored for further consumption.

- Storage Units

The initial base includes a single storage unit. Spare parts for maintenance, emergency rations, liquid tanks, medical supplies, and other useful materials are stored here. The storage unit can be expanded to increase the storage space if it is necessary and decided on.

3. Secondary Modules

Secondary modules are good-to-have modules that can benefit the mission. These modules increase the versatility of the base when it comes to solving crises, but they might come with some disadvantages too. The modules listed here are presented to serve as an example, and the mission is not limited to the modules listed here.

- Medical Bay

A module specific to the treatment of diseases and injuries. In addition to treating simple illnesses and injuries, this module also grants the capability of performing more advanced operations. However, without qualified medical personnel, the efficiency of the module can be decreased. The module also includes hospital beds for the crew to rest. The equipment of the module can be altered based on the needs of the crew, and the module can be expanded in the future if the need arises.

- Engineering & Manufacturing Station

This module is equipped with a variety of equipment for different engineering applications. The module can be used to refine crude materials, produce equipment or spare parts, and improve maintenance performance for the base modules and equipment. The equipment of the module can be altered based on the needs of the crew, and the module can be expanded in the future if the need arises.

- Rover & Drone Bay

This module can be constructed to serve as a docking bay for the rovers and drones utilized on the planet's surface. This module can collect information from the vehicles and monitor the process of the tasks and vehicle integrity. The equipment of the module can be altered based on the needs of the crew, and the module can be expanded in the future if the need arises.

4. Tertiary Modules

Tertiary modules are mainly focused on the crew's well-being and can be considered extra and a luxury. There is no need to build these modules, but building them may improve the crew's performance. The tertiary modules listed here are to serve as an example, and the mission control is not limited to the modules listed here.

- Recreation Room

A recreation room equipped with media players, a variety of games for entertainment, and a VR compartment may be built to improve the mood of the crew.

- Gym

A gym can help the crew members to maintain their physical qualities over extended periods of habitation and help them improve their mental conditions. In addition to weight training and cardio machines, this module can be expanded to include areas for different sports.

- Diplomatic Meeting Room

A separate module for meeting with crew members/delegations of other countries/organizations can be built to act as a neutral meeting ground.

- Greenhouse & Biodiversity Unit

This module can be used to simulate the conditions on Earth to grow a diverse range of fruits and greens at normal speed. This module can increase the dietary options of the crew in the long term and provide different nutrient types. However, the long production time and the effort necessary for production make this module hard to maintain.

VII. Technological Advancements

A. Waste Management and Recycling

The waste management system can be separated into two, water recycling and solid recycling. The waste management system is interconnected with other life systems of the base like food production and oxygen generation. It is also used to process human excretion.

For liquid (water) waste recycling utilizes the used water from different sources along with urine and purifies it with different methods to yield drinkable and usable water. For solid waste recycling, fecal solids and organic waste is collected and processed for usage as compost, fertilizer or nutrient generation.

This process is integrated into other systems. Recovered nutrients and fertilizer material is diverted into the food producer module while the free carbon dioxide and water in the air can be used by the bioreactors. The waste management system is a crucial part for making the base systems into a closed-loop system and maintaining the base.

B. Solutions for Solar Radiation

To protect the base from the harmful effects of radiation, a hydrogen rich composite material is used to shield the outer surfaces of the base. In addition to this, water storage of the base is integrated in between the outer layers to provide extra protection against the solar radiation. When in need of extra protection, Mars regolith is another solution for the radiation protection so sensitive modules can be designed underground to give them an extra edge against the radiation.

C. Use of Quantum Computers

Quantum computers exploit quantum bits (qubits) and phenomena such as superposition and entanglement to approach certain problems in fundamentally different ways from classical machines. In the context of space science and operations, quantum processors are not a single "magic box"; rather they form part of *hybrid* toolchains (quantum + classical) that can accelerate optimization, enable higher-fidelity simulations, improve sensing/navigation, and strengthen secure communications.

1. Menendez Quantum Bridge (MQB)

In 2052, a group of researchers managed to generate a Quantum Entanglement Network to efficiently relay information between two nodes of a quantum computer system. This system uses lattices of entangled particles distributed between the nodes, and after the observation of the particles on one node, it processes the information to instantly relay the message to the other node by using the entanglement principle. Other devices connected to the nodes create a network, and by using the nodes, can also communicate with other devices on both sides of the network.

Dr. Menendez of NASA used this research to build a quantum computer network for space operations, which he called the Menendez Quantum Bridge (MQB). This network uses two quantum computer nodes, one located in the command center of the operation and the other in the proposed space base, and a network of remote devices connected to the node on the base for the use of crew members.

The MQB has many capabilities. Its main purpose is to act as the main computer for the command center, giving the mission the power to effectively navigate space and the planet's surface by optimizing the trajectories. The MQB creates secure and fast connections to Earth by using its entangled lattice system, and this connection can also be used by the remote devices of the crew. It also monitors the vital and psychological status of the crew members via the remote devices equipped by the crew members. In addition to these, the MQB runs and is used to manage all electronic systems of the base, helps the research in the lab by powering the simulations, and collects information from the satellite systems connected to the mission, for example, rovers and drones.

D. Medical Improvements for Astronauts

Space medicine today is a systems problem: countering microgravity, radiation, isolation, altered immunity, and the logistical limits of far-flung care requires an ensemble of engineering, pharmacology, biology, and autonomy. The result of decades of research on low-Earth orbit platforms and targeted ground studies is a layered suite of medical improvements that together make long-duration lunar and interplanetary missions feasible. Below, the major advances are summarized, how they work, and why they matter for mission design and crisis response.

1. Musculoskeletal protection (exercise hardware + pharmacology).

Bone loss and muscle atrophy are among the best-documented hazards of weightlessness. Modern countermeasures combine mechanical loading using advanced resistive exercise devices (e.g., ARED-class hardware) with targeted drug interventions when appropriate. Studies and operational use show that resistive exercise markedly reduces muscle wasting and—when paired with antiresorptive drugs such as bisphosphonates—can significantly attenuate bone mineral density loss during long missions. That combined approach now informs preflight conditioning, onboard exercise protocols, and pharmacological stockpiles for long tours of duty

2. Diagnostics, continuous monitoring, and personalized medicine.

Wearable multimodal sensors, compact point-of-care diagnostics, and genomics have transformed in-flight monitoring. Modern wearables capture continuous vitals and feed automated analytics that trigger alerts and remote consults; coupled with pre-flight genomic and biomarker baselines, this enables individualized countermeasure plans and rapid triage when anomalies arise. These platforms also support microbiome monitoring and early detection of immune dysregulation which is critical for infection control in closed habitats.

3. Autonomous & remote medical intervention (robotics, telemedicine, edge processing).

Because evacuation is impractical on interplanetary missions, surgical and emergency care capability is shifting toward robotic assistance, remote tele-mentoring, and increasing autonomy. Demonstrations and reviews indicate that robot-assisted procedures (tele-operated or semi-autonomous) are technically feasible in constrained environments, and prototype surgical demos and robotic tech-demos in orbit have validated elements of these workflows.

4. Microbiome, immune resilience, and mental health systems.

Spaceflight alters host-microbe relationships and immune function; integrated monitoring and targeted probiotic/nutritional strategies now form part of pre-, in-, and post-flight care plans. Mental health support has similarly evolved from episodic counseling to embedded systems: VR therapy, continuous behavioral analytics, and AI-assisted psychological support reduce cognitive load and mitigate the risks of isolation and crew conflict on long missions. These programs are now standard components of long-duration mission planning.

E. Increased Automation

Automation in space covers a spectrum from tele-operated robotic arms to fully autonomous fleets. In practice, it includes robotic assembly and maintenance in orbit, autonomous and semi-autonomous surface rovers, 3D printing / additive manufacturing using local regolith, on-orbit servicing and refueling, and distributed edge processing that lets spacecraft analyse data and act without waiting for round-trip communications. Together, these capabilities reduce human risk, lower long-term costs, and change how missions are planned and governed.

Concrete, proven examples:

- *Robotic manipulators*: Canadarm2 and its dexterous tool-robot "Dextre" perform inspection, replacement, and delicate servicing tasks on the ISS — a mature example of teleoperated maintenance in orbit.

- *On-orbit servicing concepts*: NASA's OSAM (Restore-L / OSAM-1) program developed hardware and techniques for rendezvous, capture, refueling and robotic assembly — demonstrating the technical path to extending satellite lifetimes and assembling larger structures in space (note: programs and schedules have evolved; OSAM concepts remain influential even where specific missions were revised).
- *In-situ 3D printing*: Industry–agency efforts (e.g., ICON/NASA partnerships and research teams) are developing laser-based and extrusion-based methods to turn lunar regolith into structural elements (landing pads, habitat shells). These demonstrations show feasible routes to large-scale, low-mass infrastructure built with local materials.

VII. Scientific Studies

A. Oxygen Generation

Sustainable oxygen generation for a habitable base is one of the most important functions of a space base. For this purpose, a closed-loop, hybrid system is developed. The system consists of an electrolyser module, which generates O2 from the atmospheric CO2, and a photobioreactor module, which converts the CO2 generated from waste management and human consumption into oxygen.

The first part of the oxygen generation loop is the electrolyser module, which uses the CO2 present in the Mars atmosphere. The solid oxide electrolyser heats this gas, allowing the separation of it to oxygen and carbon monoxide with the help of a ceramic electrolyte. The oxygen output is then pressurized and transported into tanks for storage. The CO output of the system is diverted into the CO line. This is a controlled line that can be utilized to use the output CO in multiple ways.

At its simplest course, the CO line can be used to vent out the output CO. Alternatively, the CO can be stored for later consumption on material generation or can be put through a reaction with water to generate CO_2, which can be returned to the system, and H_2, which can be used in different reactions or as fuel.

The second part of the system is the bioreactor module, which can utilize the CO_2 generated from the first module, human respiration, or waste management to generate oxygen and organic matter. The bioreactor module consists of bioengineered cyanobacteria sealed in an automatically stirring tank with internal lighting so that photosynthesis occurs. This secondary oxygen-producing module is advantageous because of the additional biomass produced as a result of photosynthesis.

B. Food Production

To solve the food production problem in a possible space base or colony, genetically engineered fast-growing plants are developed by NASA scientist, Dr. Vincent Tutar. The plants designed this way are mostly legumes and grains, which can feed a lot of people compared to other fruits or greens. Modified crops are designed so that the regular control mechanisms of cell division and autoimmune mechanisms like apoptosis (programmed cell death) are bypassed, allowing for uncontrolled and fast growth, similar to cancer tissues. To boost the growth speed after bypassing the control mechanism, crops are supplied with external growth factors, allowing for harvest in a matter of weeks instead of months, as long as the crops are supplied with nutrients.

This method of growing crops requires a specialized environment module for effective growth in a base. Cultivation occurs in a sealed environment with lights and nutrient delivery systems for constant growth. It also allows for controlling the CO_2, O_2, humidity, and temperature. Produced crops can be harvested and turned into flour, paste, or meal for human consumption. The waste generated by the system can then be returned to the waste management system to generate compost or other materials.

Although this food production method generates nutrient-rich food in a short amount of time, the downside is that bypassed control points and the immune system of the crops can result in unpredictable mutations. For this reason, the crops should be tested regularly for nutritional value, and periodical genetic testing should be performed to ensure the absence of harmful mutations and the safety of the produce.

C. Energy Generation

1. Fusion Reactors

Nuclear fusion is the process of combining light atomic nuclei into heavier atomic nuclei to generate energy by converting a small fraction of mass into energy according to E=mc^2. For this process, typically hydrogen or helium isotopes are used, and heavier nuclei like helium are generated. This reaction releases enormous amounts of energy per mass compared to other available energy generation methods. Fusion reactors practically generate limitless energy, and it does not produce any radioactive waste or greenhouse gases.

By the late 2030s, fusion reactors became a staple for reliable energy production. It works by using powerful magnetic fields to trap plasma in a confined space and raise its temperature, allowing fusion to occur. This either generates energy by converting the kinetic energy of released particles into heat or by generating charged particles via aneutronic reactions.

The most used version after that point is the Deuterium-Helium-3 (D-He^3) fusion reactor, which utilizes an aneutronic fusion, generating helium nuclei and protons. The released particles move along in magnetic fields, and this movement induces electrical currents in collector coils, directly generating electrical energy.

Deuterium for the fusion reaction can be gathered from water. Helium-3 isotopes can be extracted from the moon regolith. Helium-3 isotope used as fuel is extracted from the CITADEL base on the moon according to the Paracel Accords. Reactors are also used in the bases to power the base modules reliably. However, a robust transport between the Moon and Mars does not yet exist for supplying the future Mars base with reactor fuel.

2. The Reinhart Drive

The Reinhart Drive is a high thrust and high efficiency, compact fusion-powered magnetoplasma engine. It has been developed by Dr. Abigail Reinhart (later, Cpt Reinhart) of

NASA by building on the principles of fusion reactors. Similar to a fusion reactor, Reinhart Drive is D-He^3 powered and can be considered a miniature and mobile cousin to a regular fusion reactor. The Drive is installed on spacecrafts for a much faster and efficient travel through space.

The Drive consists of a miniaturized magnetic confinement fusion core, which works with the same principles as a fusion reactor, and electromagnetic accelerators, which utilize the energy generated from the magnetic confinement to expel hydrogen at extremely high velocities to generate thrust for spacecraft. This engine system generates continuous thrust much stronger than a classic ion engine, resulting in much faster travel time on space operations. The fuel efficiency of the engine is also much higher compared to a standard ion engine, allowing for cheaper flights and better space utilization for spacecrafts. The propellant used for flight (hydrogen gas) is mostly inert and lightweight. With the invention of this engine, travel time between Earth and Mars is reduced to weeks, instead of months.

IX. Stakeholders

A. Countries

India

ISRO (Indian Space Research Organization) has been active in the field and has accelerated its activity over the 21st century. Their Moon mission, Chandrayaan, and Mars mission, Mangalyaan, were the fastest developing space projects at their start.

India has never sided with one bloc and has tried to keep ties with both the USA and China/Russia. In 2020, India was one of the countries which signed the Artemis Accords to keep a closer relationship with NASA to be more active in space research. And also during the 2040s, India actively contributed to China’s experiments on the South China Sea, also exchanging information.

In 2059, Indian scientists made a breakthrough invention that allows remote construction on celestial bodies. This development quickly drew all attention to India. China was the first country to reach an agreement with the government for the access and use of this technology and successfully expanded its lunar base, using this particular technology. China also previously worked with India on the construction of the Chinese/Russian lunar base ILRS.

In 2062, India also partnered up with the USA and gave access to use this technology to them as well. With the upcoming Mars mission, this technology holds an important place in space activities.

China

China was one of the countries which started space research relatively late to other counterparts. With fast development, CNSA (China National Space Administration) has become one of the biggest in the field. Their Moon mission, Chang'e, tried things that NASA had not tried back in the day during the Apollo missions, and also went to the Moon before the Artemis missions. Their Mars mission, Tianwen, came along with the exploration rover Zhurong.

China, cooperating with Russia, has built the Tiangong Space Station and finished it in 2026. Since the International Space Station was also going to be shut down, the opening of Tiangong meant they hold the only station in space, unlike a shared station like ISS. In 2049, NASA and CNSA signed a unification agreement to join their space stations under The Great Space Station, and currently regulate it together.

With China starting tests in SCS (South China Sea), relations with the Western world got heated as China was a threat both to the SCS territory and with a possible base on the Moon. China has executed many experiments on the site between 2035-2047, and after the ceasefire shared all works with the whole world and the problem settled.

China built their lunar base ILRS, in 2058, together with Russia. India also assisted with technology during the build of this base. With India's breakthrough technology of remote construction, China has expanded their lunar base in 2060.

Now, China is aiming for the Mars base just like the USA. First attempt to go on Mars was in 2069, however the Chinese have failed. Now they are doing their best to build the first base on Mars as quickly as possible.

Russia

Russia is the most experienced country in outer space, considering the first satellite in 1957, Sputnik-1 and the first man in outer space in 1961, Yuri Gagarin, were sent by Soviet Russia. The Space Race of the 20th century as a result of the Cold War between the USA and Soviet Russia, brought many space research into life. Russia never put a man on the Moon unlike the USA, however they achieved the first soft landing on the Moon with Luna-9 in 1966. And in 1971 with Mars-3, the Russians achieved the first successful landing on Mars as well. The Soviets also made breakthrough discoveries with Venera missions to Venus. By the 1970s NASA and Roscosmos (Russian Space Agency) worked together on many things, as well as the ISS.

After the declaration of the closure of the ISS, the Russians made a new and stronger partner that wasn't in the field, the Chinese. ILRS is designed to be both controlled by China and Russia in code. During the SCS tests, Russia regularly assisted China with equipment and researchers.

In 2058, the ILRS officially opened its doors for all researchers. Russia has always been a big contributor to space research and still is. Although many Roscosmos scientists work together with NASA scientists on many projects, Russia has joined China in their Mars mission against the USA.

Japan

Japan is a minor but important ally to the USA as a Far-Eastern country. JAXA scientists have partnered up with NASA and ESA in many projects, most importantly the ISS, with the whole world. Japan became the first country to ever put an operating rover on the surface of an asteroid with Hayabusa-2 in 2018 made to the surface and operated on the asteroid Ryugu.

Japan actively exchanges technology and has scientists working with NASA since the build of the Great Space Station and the CITADEL. Japan has also sided with the USA during the SCS Crisis and expected to contribute on the ongoing Mars mission.

A. Companies

Future Company

The Future Company was founded by American Billionaire Edgar Dowson in the year 2043 as a paramilitary and intelligence company that provides protection to companies and organizations with space operations. In addition to this main purpose, the company also owns its own spacecrafts and employs personnel with training to join missions in outer space. Since its foundation, Future Company has worked with many different organizations across the globe, and it is clear that Future Company has no clear allegiance to any country, as also stated in their company motto.

"Do whatever is necessary for the future of humankind" is the official motto of Future Company. However, in reality, the benefit of their work to humankind is debatable. Future Company operates in areas and missions in which the ethics can be questioned. And the vast amount of information they have about many different countries' and organizations' space operations raises some concerns. However, despite all negative opinions and opposing beliefs, Future Company employs a diverse group of agents suitable for all kinds of operations, and they always deliver, which has granted them a special deal with NASA for the first manned Mars operation in which a space base was going to be built.

SpaceX

SpaceX was founded in 2002 and played a pivotal role in the era of commercial spaceflight. It was the first private company to successfully launch and return a spacecraft from Earth orbit and the first to launch a crewed spacecraft and bring the crew to the ISS. Also in 2037, they succeeded in launching the first commercial lunar tourism flyby. This department later started commercial travels on the Moon.

The former CEO and founder, Elon Musk, was a signature figure of the era. His governmental position and controversial life brought Musk under fire, eventually causing him to be fired from the board of directors of his own company. The new board slowed down the spacecraft missions besides the space tourism department and focused on ground research.

Even after the Musk era, SpaceX frequently collaborated with the government and NASA in their missions, but after the rise of the Future Company and their deal with the government, it pushed SpaceX into a more independent company. This is also one of the reasons why the missions leaned more on ground research.

After the partnership with Nova Terra company started in 2065, the projects gained acceleration and a fresh restart for SpaceX. SpaceX still holds a large number of private spacecraft and crew, and is still in contact with NASA. As a result, SpaceX was chosen as one of the three companies to contribute to and join the Mars Mission.

Nova Terra

Founded in 2049, Nova Terra became the biggest of the young companies in the USA in its field. The progressive approach of Nova Terra drew attention to the company and helped them to improve much quicker than its counterparts. The motto of Nova Terra is "*From the land up to the sky, always search for the high*", depicts the progressive perspective they carry.

One of the distinctive characteristics of the company is its effort in the ethics of its work. Nova Terra publicists frequently criticise rival companies, especially Future Company, for their non-transparent policies and questionable acts. This position pushes Nova Terra in dividing comments on them. Yet, the company is the third biggest scientific research contributor in the country.

The lack of both financial and spacecraft resources pushed Nova Terra to find new allies. As a result, SpaceX and Nova Terra started a partnership benefiting them both. Nova Terra is the third, and the last company to get to contribute to the USA Mars Mission.

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