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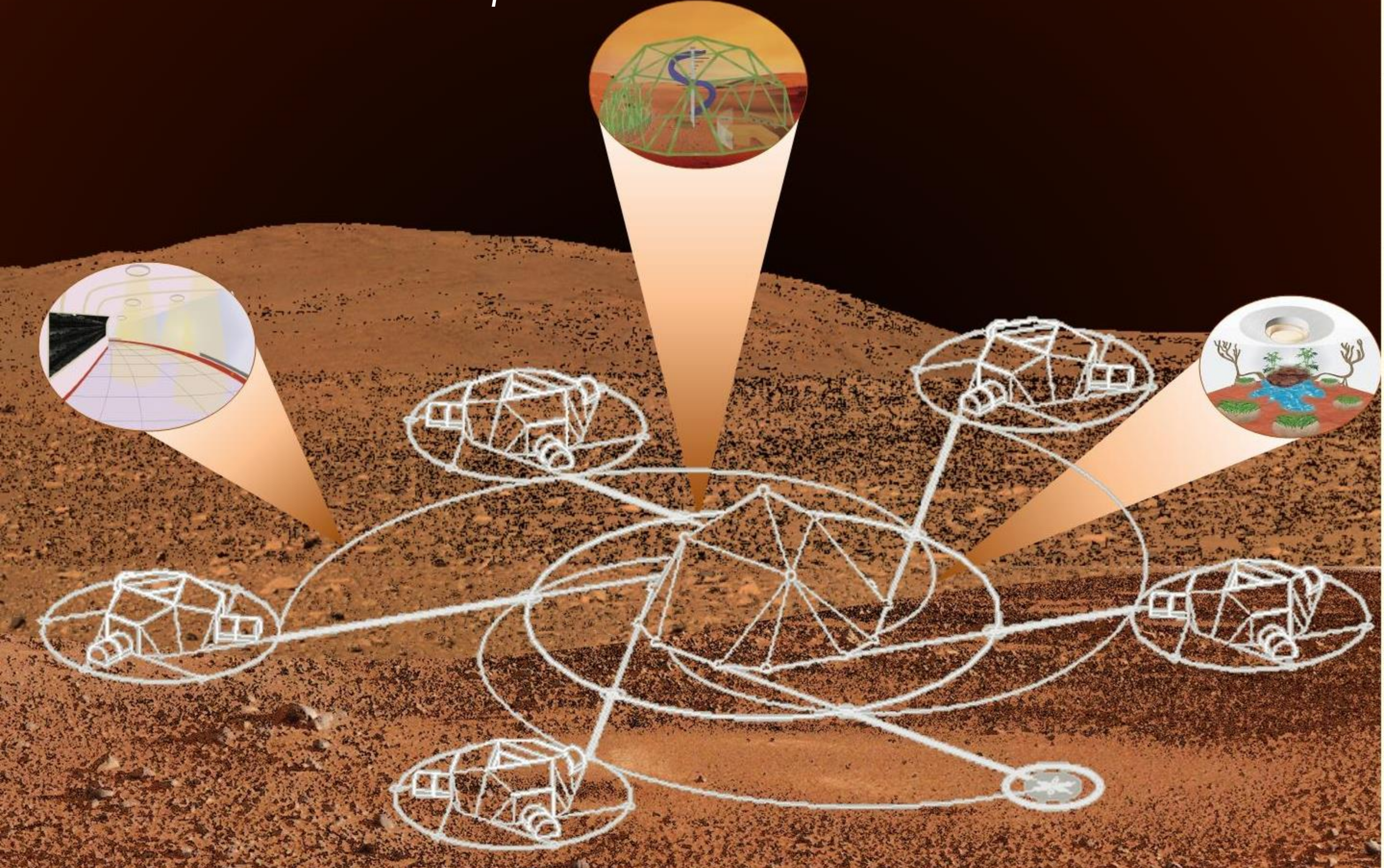
Mars Dichotomy

Prospects for human life on Mars



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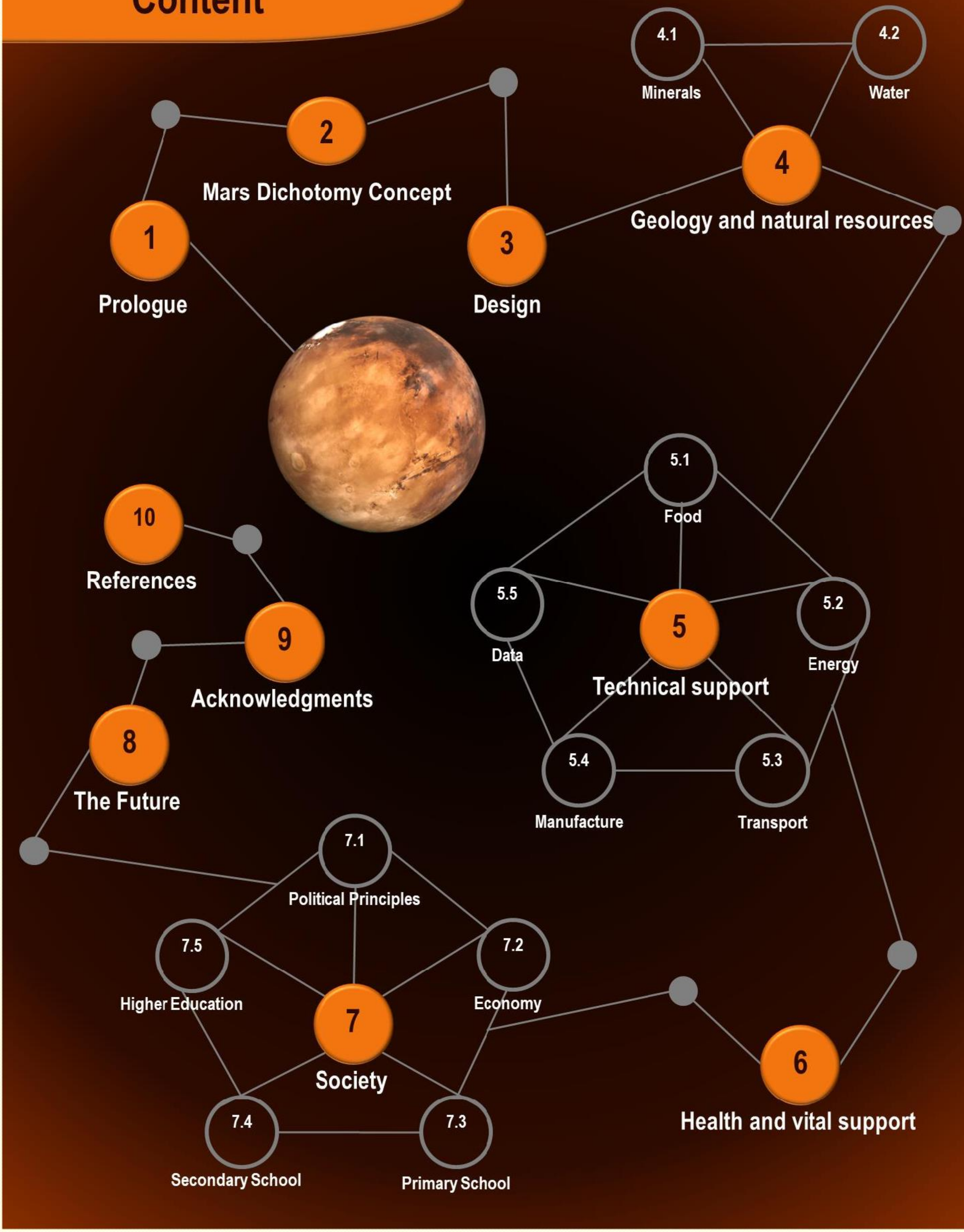
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1. Prologue

The red planet story began with the successful flyby of the American Probe Mariner 4 in July 1965. Eventually, on December 1971 the Soviet lander Mars 3 had the first landing on the surface of Mars. However, the search for life on other planets or the human establishment on other planets was part of science fiction. Only the Viking program, in 1975, changed the mindset of the entire world. Mars Pathfinder, Phoenix, Curiosity and other technical probes, landers and rovers, updated information on the conditions of Mars and thus improve materials, technology, and capabilities to put humans on Mars. Centuries of special Career have allowed to build Martian cities, where Space X, Blue Origins, and different governments and private companies around the world, achieved in 2042 the establishment of Star City [1], the first city outside of Earth with 1000 inhabitants. However, the population has continued to grow and the design of one or more cities that have changed the accommodation of 1,000,000 people is required. The requirement is that the city must be sustainable in resources, economy, and social dynamics. In this way, ***Mars Dichotomy*** proposal will begin its implementation from now on, achieving balance in 2350.

2. Mars Dichotomy concept

From the point of view of Mars' physiography and topography, two highly different sectors are perceived. It is possible to appreciate that 40% of the planet displays very few impact craters, while the other 60% are regions with numerous impact records. Because of this it has been called that Mars presents a dichotomy or commonly said: Two faces.

When thinking about the generation of large, diverse Martian cities and where science and technology must be the center of progress, we have also thought about maintaining a dichotomous character, which is why our proposal ***Mars Dichotomy*** proposes the design of two cities with concepts, characteristics and different productive sectors as follows:

A. Wisdom City: At a height of 4 kilometers above the mean planetary radius (MPR), located at Ascraeus Mons region (Fig. 1a). Strategically located because the presence of ore deposits, caverns, and lava tubes, which appear to be open to the surface and can serve as shelter for inhabitants. The name of the city is inspired by the evolution of the scientific knowledge of humanity. The concept of living underground reminds us of the myth of the philosopher Plato, where some people live in caves and what they observe are shadows, until one of them manages to get out and see the surface, observing nature and the world; and then go back and tell others what was observed [2]. In the same way it connects us with our history and our origins, human beings in their beginnings lived in caves and once we went out and knew the world, we were able to look at the sky and recognize stars and planets, dreaming of one day getting there. We are now in the sky looking at Earth planet, to start a new story as space cavemen.

B. Endurance City: The Medusae Fossae region (Fig. 1b) has been chosen for the high presence of hydrogen, therefore a good place for use of water resources. Also, being close to the Equator, this provides a good source of solar radiation. This sector is located close to 0 kilometers above the MPR. Its concept is based on human resilience to face difficulties, as well as that of nature to continue after a catastrophe [3]. It reminds us that science and technology will help us to resist and that now from this new planet, we are that life that resists and advances.

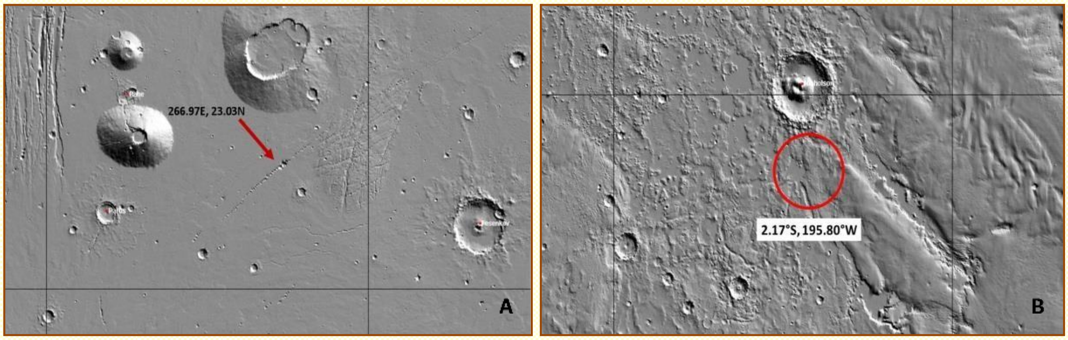

Fig. 1. Location of cities in images from the Mars global surveyor, using the Mars observer laser altimeter (MOLA) instrument A. Wisdom City location. B. Endurance City location.

3. Design

Thinking about inhabiting the red planet, leads us to analyze adverse conditions of the environment that takes a new dimension when settling in another world: how can a city-state be organized in a certain place, considering that it must have its own atmosphere and sufficient nearby resources such as ore deposits or water? Also considering that architectural structures and environmental conditions that provide comfort must be generated.

It is essential to analyze conditions such as location, environment, and materials as points out Pinto [4], who presents us with places that work under very adverse weather conditions, underground cities, those that integrate with the topography and also models of houses built in 3D printing, which is close to the Martian city approach that requires the use of three-dimensional printing technology, directly on the planet, taking advantage of metallic, and non-metallic deposits, to use for example ceramics, metals such as titanium and also carbon fiber [5], as well as, silica for 3D solar printing [6].

It is analyzed that the ideal for a large settlement on Mars would be to use the underground construction, which allows spaces protected from solar radiation, with natural light management, and control of temperature conditions [7]. Taking into account the Martian topography, lava tubes become viable as a potential habitat [8]. The conditions of mineral extraction, as well as the possible availability of water resources are also analyzed, so the city approach will be organized in two central cities as presented in section 2.

The order-generator principle for the city is *sacred geometry*, based on the appreciation of the natural phenomena and its mathematical principles that range from the microscopic scale to galaxies as Bernal and De Hoyos quote "the tendency of the human being towards the search and representation of a principle of proportion and harmony that seems to be omnipresent in the Universe" [9].

In this way, cities are designed based on the utopia of Garden City of Howard, with a Central Radial City, in which the main activities of the city's educational, health, government, institutional, and administrative facilities are concentrated [10]. Therefore, the urban plan of the cities is:

A. **Wisdom City:** Starting from a nucleus inscribed in triangular figures, linear axes start towards other satellite blocks, which concentrate housing complexes with complementary equipment such as trade and service areas. Recreation zones and cropping zones may be located in open areas between the main nucleus and the satellites, communicated with areas built by pipes in the radial direction of the urban scheme (Fig. 2a).
B. **Endurance City:** From a central unit, inscribed in a spiral composition from which several satellite blocks emerge, which, as in the previous city, concentrate housing complexes with complementary equipment such as trade and service areas (Fig. 2b).

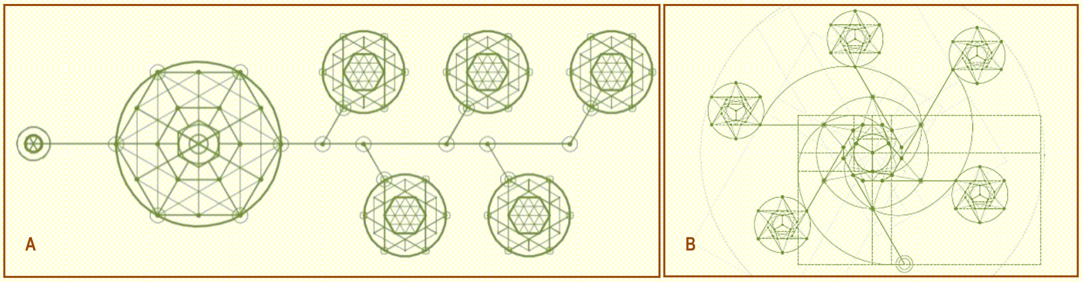

Fig. 2. Urban design plans based on the Garden City of Howard A. Wisdom City. B. Endurance City.

Considering that a simulated atmosphere will be generated inside the structures, according to inputs described in the following sections, except for gravity, which will correspond to 38% of the Earth´s gravity, the urban design plan is generated including key aspects regarding to habitat, aesthetics, and sustainable design:

A. **Multipurpose, mutable and multifunctional areas:** These new spaces must be modifiable superficially, volumetrically, lightly, and acoustically, in order to give the user, the necessary comfort for each use that will be given at a given moment.
B. **Greenhouses:** Conceived for food production and which will have sectors for educational processes and professional practices. Some, in addition to nutritional function, will be integrated to give an organic component to aesthetics.
C. **Heating system:** radiant by means of various energy sources, as presented in section 5.2, and with particular emphasis on geothermal energy, taking into account the evidence of possible current magmatic activity on Mars [11], as well as that obtained from biodigesters.
D. **Educational areas:** The space as a motivator of learning through experimentation [12].
E. **Lighting:** Use of solar tubes to take advantage of sunlight indoors, as well as alternative sources indicated in section 5.2.

F. **Mutable and flexible housing:** Generic rooms that are adapted to inhabitants' needs [13]. Five blocks of houses surrounding or aligned to state services central dome, each block with 3 buildings of 200 m in height each and 34 levels.
G. **Community areas:** Where food and laundry services are provided, for better use and control of available resources.
H. **Spirituality areas:** Designed from the Zen garden, which integrates nature, rest, meditation, and inspiration, taking as a reference the Bahá'í Temple [13]. A space where all religions and spiritual expressions will have access for their activities according to what is indicated in section 7.1.
I. **State spaces:** Multipurpose spaces that work for auditoriums, institutional events, offices, and community activities such as theater and sports.
J. **Public and leisure areas:** The Gaylord Opryland hotel in Nashville's indoor city center design concept is taken as a reference, which integrates areas for rest, interaction, fun and culture, in symbiosis with vegetation and water that provide wellness and relaxation. [14] Augmented reality and holographic screens designed for the multisensory experience through acoustic levitation will be used for entertainment. [15], facilitating communication and immersion in realistic environments, fun and knowledge through educational capsules.
K. **Medical areas:** they are conceived from a futuristic perspective of the services, where there are spaces that integrate intensive care, emergency and post-surgical services, but taking advantage of housing facilities to attend general medicine supported by holographic technology with which it provides to the city, as well as basic level hospitalization. It is hoped that hospitals will not become large buildings, but that they will be able to take advantage of the organic concept of topography, seeking to rethink the way in which the patient interacts with the healthcare environment [16].

Designs on the Mars Dichotomy are available in: https://marscitystate.wixsite.com/marsdichotomy.

4. Geology and natural resources

4.1 Minerals.

Mineral resources and their extraction on Mars are crucial to inhabitants' sustainability of Martian cities. The possibility of using in Situ resources (ISRU) that allow future inhabitants of Mars the possibility of building infrastructure for housing and other buildings necessary for the sustainability over time of human colonies has been raised [18]. Thanks to the geochemical and mineralogical analyzes carried out by mission scientific teams such as Mars Global Surveyor (MGS), Mars Odyssey (ODY), and ExoMars [19] and the availability of a geological map of Mars with their respective geological and geomorphological units [20], It is possible to carry out a detailed study of those areas of interest where mineral resources could be found that can provide future Martian cities with the resources necessary for their operation and sustainability.

A. **Nickel:** Relevant to production of alloys such as stainless steel and associated in some cases to asteroid impact events, which on Mars generates the highest concentration of this element. For its location and extraction, exploration outlets are proposed for large impact craters, as well as superficial excavation of the ground; then they are placed on vibrating tables or using other techniques such as open pit and cut and fill [21].
B. **Titanium:** Required in alloys for machinery construction, reactors, transport, and prosthetics. Titanomagnetite dust particles, as well as ilmenite and rutile minerals, have been recorded on Mars, which are associated with rocks of the Whitstone class in Columbia Hills, being a potential source of Titanium [22]. It is possible to find rocks of this type elsewhere on the red planet in areas with evidence of volcanism or impact events, with a high probability of being found on paleo-martian beaches [23]. Its extraction is carried out with using same methods for Nickel extraction.
C. **Iron:** It is one of the most abundant metals on Martian surface, present in the form of iron oxides (mainly hematite, ilmenite, and magnetite), commonly found in areas of gossan, surface meteorites, and in sedimentary deposits such as oolites and BIF [23]. It is used for most alloys in metallurgy, a raw material for steel and an essential element for agricultural and human health processes. For exploration, magnetometric and geoelectric methods will be used, and *open pit* [24] will be used for its exploitation.
D. **Rare earth elements and others:** Copper, lead and zinc; that it may be associated with massive volcanogenic sulfides; PGE, chromium, vanadium associated with lithologies similar to Hesperian rocks. It is also possible to extract some non-metallic minerals such as carbonate, which has been found located in sedimentary rocks due to hydrothermal alterations [26]; phosphates, common in the regolith, of igneous origin; clays and zeolites, formed by hydrothermal alteration, and accumulated in sedimentary basins [27]; silica and terrigenous sediments that are common in many types of sedimentary deposits [6]. Additionally, field trips and searches for elements for vegetable cultivation will be required, both macro and micronutrients, all detected in meteorites or some regions, such as the Gale crater [24] [28] [29] [30] [31] [32]. For the exploitation of these minerals the previously mentioned techniques will be used, as well as the use of underground mines.

4.2 Water.

Water is a vital resource for the subsistence and sustainability of Martian citizens. Transporting water from the Earth is an unviable option due to its high costs, that is why the possibility of using In Situ resources (ISRU) to extract the necessary water has been raised, and it is also proposed to develop an environmental supply and sanitation system sustainable, through different local water sources on Mars, in order to supply the basic needs of the inhabitants (health, food, life support), as well as its use in industries, artificial ecosystems and for aesthetic purposes. For this, different stages are considered, ranging from extraction to final disposal (Fig. 3). This system is designed to be cyclical and hierarchical in order to guarantee greater efficiency and less losses, since the planet does not have the conditions to generate a water cycle.

A. **Prospecting:** Within the choice of the source of supply, factors such as the availability of water in volume, the distance between the extraction zone and the cities and the climatic conditions of the place are considered, which is why the Medussae Fossae Formation (MFF) (195.80°E, 2.17°S) has been chosen among other similar places on Mars. Water Equivalent Hydrogen (WEH) concentrations are greater than 26%, probably in the form of large agglomerations in the subsoil [28].
B. **Extraction:** Water appears mainly as ice present in permafrost, forming large masses covered with sediments [29], for which reason it is proposed to capture the water by sublimation of the ice through microwave equipment and a system of capture and surface cooling to through which the water will condense [30] [29]. Subsequently, the water will go through a pre-treatment process where the filtering of the captured water will be carried out, through which it is possible to reduce the presence of salts [31] and perchlorates [32] for subsequent distribution by pipes to a storage station.
C. **Storage:** A storage station located at a higher topographic place than the city will guarantee a minimum hydraulic pressure in the system, thus reducing the energy consumption required during internal distribution in the city. This storage will be done through surface tanks, or through the adaptation of waterproofed galleries where a volume of water can be stored that can supply basic services for 3 months.
D. **Purification:** In order to guarantee the availability of water with optimal physical-chemical characteristics for use in essential activities such as agriculture, human consumption, etc., there will be a water purification system with the following phases:
    a. Filtration: Through reverse osmosis equipment ensures the reduction of salinity, particles and ions dissolved in the water.
    b. PH adaptation: In order to reduce the alkalinity of the water, the pH will be regulated by chemical inputs.
    c. Disinfection: The final process requires a disinfection process for which there will be an ultraviolet (UV) radiation system before being distributed in the city's aqueduct networks.
E. **Distribution:** Distribution of water to the entire city will be carried out through a differential water system in order to transport drinking water and less treated water through different pipes. Furthermore, water for industrial use will be separated from water for the use and consumption of people. The distribution system will be cyclical and zoned by levels (Fig. 4), aiming to guarantee a minimum and maximum pressure level through a static piezometric level in a series of tanks according to zones. It is recommended to maintain a minimum pressure of 15 m and a maximum of 30 m of water columns on land, which corresponds to zoning at elevations of 30 m in height, however, due to the difference in water pressure on Earth in Compared to Mars, this height should be 100/38 times higher, therefore the zoning by heights will be approximately 79 meters high. The network will manage a flow of approximately 49,125 m^3 of drinking water for use by domestic, hospital and academic units.
F. **Collection of wastewater:** It will be carried out by means of a sewage system segregated between gray water (of low alteration or contamination) and contaminated wastewater in order to guarantee selective treatment of water and reduce maintenance processes in plants of treatment. In the case of domestic units, kitchens and community laundries, there will be three sewage systems:
    a. Urine: Will only collect this waste
    b. Household waste: Will collect cleaning water
    c. Dry baths: For the capture of feces, allowing their subsequent use in biodigesters, as mentioned in section 5.2.
G. **Wastewater treatment:** Urine, hygiene water, condensate water will be separated from ambient humidity and waste water from industries. Each of these waters will undergo a different treatment, in order to recover the water and be able to re-inject it into the water supply system [33] [34]:
    a. Urine water: Distillation of the urine collected at low pressure will be carried out. Nitrogen and water are obtained in this process. Nitrogen will be used to prepare nutrient solutions for plant irrigation. The obtained water will be used to produce oxygen by electrolysis.

b. Hygienic waste water: An ultrafiltration process will be carried out on the water collected from washing clothes, crockery, body, hands, after that the treated water will be purified by sorption or by a biological activated carbon membrane reactor, the recovered water will be It will have in a gray water tank, then that water goes to the Nutrition Tank, where a nutritive solution is prepared to irrigate the crops.
c. Moisture condensed water: This water is sent to a purification equipment and stored in a clean water tank, then it is brought to purification and distributed to homes (domestic use and human consumption).
d. Industrial waters: The water that leaves factories must have minimum quality parameters before being taken to an industrial water tank, then a treatment will be carried out for its purification and subsequent reuse in the same industrial water supply system.

H. Final arrangement: For the cases in which the water treatment does not reach the quality standards required by the industry or the volume of wastewater exceeds the demand required by the city, there will be a final water disposal network, the which, once treated and with quality characteristics that do not contaminate the environment, will be discarded superficially in an inert area that does not affect existing or potential sites of economic, social or ecosystem interest for the use of the Martian community.

5. Technical support

5.1 Food

To supply a million people requires the permanent supply of a wide variety of nutritious foods to the population in a sustainable environment, including:

A. Soil and Substrate Management: Martian soil is of the Gelysol type (according to Taxonomy Soil classification) [35]. With permanent permafrost, lithic contact in the first 0.5 m, absent organic matter and little nitrogen; It presents several limiting factors for agricultural production, which is why soil enrichment is necessary. This enrichment includes the increase of carbon, nitrogen, phosphorous, derived from mineral processes or the management of the water resource, as observed in sections 4.1 and 4.2. Likewise, the use of beneficial microorganisms from polar regions of the Earth is proposed, such as cyanobacteria of the genera *Anabaena* or *Hydrocoryne* [36], which favor the protection of plant cells by freezing and thawing, radiation and drying [37] or microorganisms capable of decontaminating perchlorate soils [38].

B. Maintenance of the water resource: According to what is stated in section 4.2, there will be a water resource for crops. However, to guarantee recycling and use in greenhouses, hydrogels are used (crosslinked polymeric materials of natural or synthetic origin, which swell in contact with water, forming soft and elastic materials, with the ability to retain a significant fraction of it in its structure without dissolving) [39]. Plant growth promoting microorganisms are also used, so that adequate growth and productivity of plants of interest can be obtained in terms of food security.

C. Food as a source of protein, carbohydrates, and fats: Considering the photosynthetic rate, the elements from regolith / or the conditioning of the surface for planting or maintenance processes on the planet; some species that can guarantee nutritional requirements and at the same time offer organoleptic variety can be:

a. Carbohydrate source: Carrot (*Daucus carota*), lettuce (*Lactuca sativa*), oats (*Avena sativa*), wheat (*Triticum spp.*), Rice (*Oryza sativa*), beet (*Beta vulgaris*), pea (*Pisum sativum*), corn (*Zea mays*) potato (*Solanum tuberosum*) and tomato (*Solanum lycopersicum*). The manufacture of vegetable hybrids of these species is considered to supply and meet requirements such as low temperature environments, production of higher volumes in an environment rich in CO_2; in addition to adaptation to the Martian soil [40]. These crops also fulfill the function of releasing O_2, recycling nutrients (N, P, K, S) and recovering water through transpiration [41]. The cultivation of some plants such as coriander (*Coriandrum sativum*), onion (*Allium cepa*) and Basil (*Ocimum basilicum*) is proposed, in order to be used as medicinal plants and as spices.

b. Protein source: Protein sources are varied, including plants such as quinoa (*Chenopodium quinoa*), as it is the only plant food that has all the essential amino acids, in addition to offering multiple preparations such as flours, noodles, flakes, granola and hamburgers. thereby favoring the variety of preparations [41]. Another source of protein is beans (*Phaseolus vulgaris*), as well as microalgae and cyanobacteria, such as *Spirulina platensis* [43], which also offers opportunities for energy production (See section 5.2) [40]. The consumption of insects is another alternative for the consumption of proteins, varying in their nutritional values according to the metamorphic stage, habitat and diet. These provide not only proteins but also fats, fiber, micronutrients such as Cu, Fe, Mg, Mn, P, Se and Zn and vitamins [44]. Mushrooms are also included as a source of protein [45], as well as controlled aquaculture systems, which guarantees controlled production of some fish species to obtain protein and fatty acids [46]. An additional source of protein is breast milk that is produced in excess, which will go to milk banks for the consumption of the inhabitants.

c. Fat source: The intake of insects, as well as fish, supplies the needs of fatty acids.

D. Deluxe Foods: For the sake of favoring the celebration of certain events, the production of special foods is proposed. Among these are mycorrhizal preparations [52], as well as the availability of alcoholic beverages [53].

5.2 Energy

In order to supply energy to all sectors that make up society, it is necessary to use a hybrid energy distribution and use system between the different energy sources present on the planet:

A. Solar energy: The average irradiance on the surface of the Martian atmosphere is 500 W / m^2 [52], which can be used thermally and photovoltaic, depending on the environmental characteristics of Mars such as the atmospheric composition, the weather, the seasons and the length of day to determine the appropriate geographical location in which the panels or collectors provide the highest energy conversion efficiency, the necessary area and the mechanisms for collecting solar energy, since the best strategy is to orient the receiving surface always perpendicular to the rays of the sun [53].

B. Geothermal Energy: Geothermal energy on Earth is a sustainable, viable, safe, and renewable energy resource [54]. On Mars, the presence of volcanic structures such as Olympus Mons, Arsia Mons, Pavonis Mons, Ascraeus, Mons, among others, indicate an active past in terms of volcanism [55] [56]. This past (and possibly current) volcanic activity on Mars offers the possibility of taking advantage of geothermal resources for Wisdom City, due to the close location of Ascraeus Mons, providing sustainability over time. Considering that geothermal energy requires water that is injected into the subsoil in order to be heated to generate steam that then moves turbines that produce electricity, it is worth mentioning that this type of energy resource is largely viable due to the availability of water in the Martian subsoil and the efficiency in recycling and taking advantage of the water used in other production or supply tasks for the population, as indicated in section 4.2.

C. Biogas-biomass: The use of residues, due to the scarcity of resources, is crucial for survival in the Martian soil. Food waste will be produced in cities, this organic matter can be used for the production of biomass or biodiesel, which are used as fuel through series of pretreatments and treatments. It is possible to produce ethanol through the addition of *Saccharomyces cerevisiae*, hydrogen from bacteria of the *Clostridium* genus and production through an anaerobic digestion plant [57] [58]. On the other hand, feces will be used for the production of energy from anaerobic bacteria characteristic of fecal matter, which produce biogas methane by means of biodigesters. Additionally, from this process it is possible to obtain H_2, CO_2, CO, O_2 and water vapor [59], these last two usable gases for life support, in addition to being exothermic processes that would guarantee the heating system (Section 3).

D. Physical activity: Seeking to make the most of resources, as well as to motivate the exercise to guarantee health (Sections 6 and 7.1), piezoelectricity will be used as a solution to such interests. By integrating electronic elements into clothing, this technology is known as 'E-textiles'. generating electricity through clothing, from the movement of the human body [60], in addition to being used to monitor health or for technological efficiency purposes such as processing the movement of the hands to record the action of typing without the need for a keyboard [61], likewise the surfaces are covered with these textiles, so that when walking the energy is also stored. Likewise, the derived vibrational movements are taken advantage of, for example, piezoelectric materials related to transport, such as the passage of the train on its rails (Section 5.3) or a running engine [62] [63] serving as indicators of the state of the structures. Additionally, energy will be obtained from the use of bicycles [64], which are manufactured on site by using bamboo [65] (Section 5.4).

E. Bacterial lighting: To reduce the energy costs associated with lighting, in addition to the solar tubes proposed in section 3, the use of LEDs is proposed. However, making the most of the resources, controlled bacterial cultures are used, due to their pathogenic potential, to the anaerobic bacteria *Clostridium perfringens*, with inserts of *luxA* and *luxB* genes, which encode the production of the luciferase enzyme, which by catalyzing it leads to the production of light and also of water [66].

F. Other sources: Through the heat obtained from the combustion of CH_4, biogas, biomass and the thermal energy received from the sun, it is possible to obtain work using Stirling engines adapted to the pressure and temperature conditions of the atmosphere of Mars, the rejected heat will be used in interior heating. Other thermodynamic cycles can be used from energy obtained in nuclear reactors and by implementing working fluids such as mercury or potassium in a Rankine cycle that provides useful levels of output power at relatively low temperatures. The Brayton cycle is an option that has a lower efficiency compared to the Rankine cycle due to the work involved in bringing gases from such a low pressure to the working pressure and temperature, however it is a simpler cycle, and can be quickly implemented [53]. Nuclear energy is excluded as it is potentially dangerous for cities. On the other hand, low atmospheric density is not capable of moving the wind enough to be a realistic source of energy [52], so wind energy must also be excluded.

5.3 Transport

In order to guarantee transportation, use will be made of:

A. **Hyperloop system:** Guarantees transport between long distances, such as between Wisdom city and Endurance city. Which works inside a network of tubes at very low pressures, around 100 Pa. This system has the capacity to transport between 28 and 40 people in two different types of capsules, with an output frequency per capsule every 2 minutes, reaching speeds of 900 km / h on average [67]. The lines are strategically designed in such a way that both cities and extraction points communicate efficiently. For cost reduction, the most feasible is to build the surface rail system. These tubes will be surrounded by solar panels that allow it to be self-sustaining. The system consumes 1 kW for every 29 km. For cargo transportation, the use of the largest capsules with a capacity of half a ton each, with a consumption of 3.27 MJ / km [67], is proposed. Due to the efficiency found in the Hyperloop type system, for internal communication in cities, a similar means of transport will be used that works in the same way as the Hyperloop, but at a lower speed, preserving the characteristics of sustainability and capacity of people and kilograms of cargo transported per hour with a network distributed throughout the cities that avoids bottlenecks and system congestion.
B. **Rover:** For the purposes of human exploration on the surface, the use of a truck-type rover that allows the transport of people and a certain amount of cargo (distributed between equipment and samples) such as the 2020 Mars Rover designed by Parer Brothers Concepts [68], which is estimated to operate using an electric motor also powered by solar panels and a 700V battery. It would be equipped with a GPS and radio navigation system. The rear, would operate as an autonomous laboratory. The prototype has 6 wheels that allow it to overcome the different types of Martian soil optimally and despite reaching speeds of between 90 and 105 km / h, it is designed to travel at speeds of between 15 and 22 km / h during the stage. of exploration. In addition to serving as an exploration vehicle, its use is also considered as an emergency vehicle, allowing it to move more freely at times when it is required.

5.4 Manufacture

For a sustainable society over time, the production of machinery and products must be guaranteed on site. Some materials are derived from the extractions in section 4.1 and others are from other types of resources, being able to generate:

A. **Clay, glass, concrete and structures:** Basalts on the surface provide silicates of magnesium, silicon and iron. To extract the silicon, a basalt crushing process is performed, then the silicon impurities are cleaned with attrition cells, to then be brought to a high temperature. For extraction, the mechanical form can be resorted to, through the use of human force, as well as the preliminary shipment of machinery. Concrete remains from this process [69]. In turn, it is possible to process clays and glass elements by means of high-temperature furnaces, brought from Earth. Likewise, the cultivation of bamboo (*Phyllostachys edulis*) is proposed since this allows the manufacture of beams and other structures [70].
B. **Powders, pig iron, blocks and lumps:** Clays play a fundamental role in this field. Among these, the smectites mainly, which contain 50% of abundance in Iron and Magnesium. The presence of these allows, through pyrometallurgical processes, their extraction and later manufacture, so as not to cause damage and take advantage of all the materials, it is possible to manufacture powder, pig iron, blocks, lumps or liquids from the slag obtained. From the group of sulfates and carbonates, it is possible to obtain it by traditional or simple methods such as: in the case of sulfates, hydrothermal techniques. For carbonates it would be; extraction, selection, crushing, grinding and classification. The presence of oxides represents an advantage in the investigations carried out by NASA, in which the subjection of these oxides under pressure alters their characteristics and leads them to form a possible glue that contributes to the creation of bunkers as shelter and shelter options, with basaltic materials that with the influence of crops have polymeric and biodegradable properties [71].
C. **3D Printing:** From the beginning of this technology, additive manufacturing, the first material that can be implemented is that of the polymer type that can be manufactured by cultivating corn (*Zea mays*), metals are also a viable option since implemented Sintered, using stainless steel it is possible to apply for dental and surgical applications thanks to the manufacturing possibilities of geometry and sizes that the method offers, copper, steel or aluminum alloys to meet the initial demand for metallic elements for citizens. Its correct implementation depends on a careful selection of materials and design [70]. Other polymers can be obtained by producing exopolysaccharides from bacteria such as *Azotobacter chrooccaracterística* [72].
D. **Parts and spares**: Powder metallurgy is energy saving, offering complex difficult-to-build products compared to other conventional manufacturing methods. It currently plays an important role in the mass production of auto parts [71]. By means of the materials and suitable pickpockets such as grain size, suitable sintering temperature, the appropriate matrix and microstructure can be obtained to manufacture the different parts necessary for the manufacture of parts, spare parts and necessary parts in the city.

E. **Cleaning elements:** The use of clays for the production of elements such as toothpaste, deodorant and makeup is proposed [74]. Two techniques are proposed for the manufacture of soaps, the first one, by extracting vegetable oils that allow their production [75]. On the other hand, the capture of fats from shower waters and face cleaning cloths, the collection of which would allow the capture of animal fats for their manufacture.

5.5 Data

Communication in the Martian city involves three fundamental challenges:

A. **Communication within the city:** It will be based on 3 data centers (approximately 500 m^2 each) in which all the data processing and sending will be done to the different parts of the city as needed. Although the infrastructure of each data center is planned to be similar to those on Earth, two important factors have to be considered: the amount of water used for cooling the system and protecting the equipment to avoid possible damage to the structure. of the data generated by the large amount of cosmic rays, for example, the "bit flip". For this, it is proposed that the cooling of the data centers be done through new technologies that are not based on the use of water and take full advantage of the low temperatures on the Martian surface. On the other hand, for the issue of data integrity, it is proposed to make use of a radiation tolerant design. For this, the different structures that will house the data centers must have extra protection against cosmic rays, in addition, a processing system is proposed in which the integrity of the data is ensured through redundancy in the systems and parallel processing. in order to avoid data corruption [76].

B. **Communication between Earth and Mars:** It is proposed to do it through satellites, there will be (two) satellites orbiting Mars that will be linked to those of Earth using semiconductor lasers (YAG), since it allows a high flow of data to one high speed and reliably. The data is transmitted from end to end over a single network, which gives us better security. The satellites would be placed, one in stationary orbit since no fuel expense would be required, which provides us with energy savings, and the other (s) would be in low orbit. Those of low orbit makes it more reliable without much loss of data and it helps us to facilitate communication between cities, and to make the system more redundant, the stationary or stationaries that will communicate with any of the satellites is added of the Earth [77].

C. **5G Networks:** That allows high-speed communication, high data volume, implementation facilities and connection at low cost, for the area delimited by the city, the 5G network allows good mobility, location and high security of the transmitted information. There is a wide range of devices that can be connected through the different channels such as wi-fi, bluetooth, radio frequency or satellite connection. Through D2D technology, information from citizens' devices can be accessed allowing the generation and feeding of databases in near real time, which will be used in future statistical studies of Martian society. The system could integrate components of both transport, habitat, life support and devices in common use by citizens [76] [77].

6. Health and vital support

From a physiological point of view, it is not a secret that astronauts during their stay in a microgravity environment, undergo mostly reversible bodily changes, however, the thought of establishing a colony on Mars brings with it:

A. **Physiological Conditions on Mars:** The physiological effects of microgravity occur primarily in the bones, muscles, kidneys, and cardiovascular system. At the muscular level, significant changes in mass and tone can be observed [81]. Cardiovascular changes with microgravity are mainly explained by the redistribution of body fluids to the cephalic part generating adaptation needs to avoid cardiovascular collapse or strokes [82]. One of the main effects on the bone system is osteopenia generated by the effect of not having a mechanical load on the bone, the low availability of sunlight, therefore the calcium fixation in the bones decreases [82]. In the respiratory system there is variation in the distribution of ventilation and when there is an alteration in the balance of forces on the rib cage, the pulmonary expansion is altered. At the level of temperature regulation in microgravity, due to the conditions of relative dehydration, the loss of sensitive and insensitive body fluid through the skin is reduced and this the ability to dissipate heat [83]. In the digestive system, pancreatic and gastric secretions decrease, air content in the colon and small intestine increases. Gastroparesis, constipation, and increased intestinal gas may be mentioned. Dysregulation of appetite is also documented with increased substances such as leptin [82]. The increase in initial blood volume due to redistribution of body fluid increases the Glomerular Filtration Rate initially and then decreases as blood volume decreases, causing alteration in renal function [84]. There is increased activity of the adrenal glands and pituitary. The activity of the immune system decreases in both cellular immunity and humoral immunity, leading to endocrine and immunological disorders [82]. Additionally, there are alterations to mental health, taking into account the environmental and sociocultural changes that will directly or indirectly affect determinants such as the circadian cycle, mood states and disorders of behavior, personality and judgment.

B. **Respirocytes as a possible solution to the availability of oxygen:** Taking into account that the creation of an environment with terrestrial physiological conditions is a process that can take time, oxygen replacement options should be considered for long periods of time for the Martian colony, that is why an alternative to consider is nanotechnology through the so-called "Respirocytes" [85]. These are described as robots analogous to erythrocytes and that have a 236 times greater oxygen transport capacity than human red cells, allowing prolonged periods of "apnea" [85]. Additionally, from nanotechnology, other agents are being developed as possible nanovectors for pharmacological therapy or even as analogues of defense cells, which could represent alternatives for the Martian colony in terms of survival and evolution [86].

C. **Nutrition and dietetics:** It is important to recognize that due to microgravity, various processes involved in food digestion and nutrient absorption are altered in different ways, even putting the person's nutritional status at risk [87]. An environment with micro gravity generates a greater skeletal muscle effort, so there is an increase in total energy expenditure. Thus, when planning daily food, it is important to calculate a high energy requirement, which covers all energy and nutrient needs and ensures the maintenance of an adequate nutritional state. [87] Due to the diet, mostly of plant origin, it is necessary take into account the indispensable role that the microbiota plays for well-being in the digestion and absorption of nutrients [88].

D. **Skin microbiota:** Since the synthetic suits used for space travel and the stay on Mars can negatively impact the skin microbiome, studies were conducted and it was concluded that the use of the suit for short periods induces changes in the composition of the skin. microbiota of the skin, but these are unlikely to compromise the beneficial skin microbiome. However, a review of studies carried out by Leong et al. In 2015 [89], in addition to other authors, was carried out, the results of which have made it possible to advance knowledge about the effects that various fiber-based materials have on human skin, with the use of bioengineering tools, with a focus on how fiber-based materials change the properties of the skin they cover or have contact with. Additionally, a La bon a chip type monitoring system is proposed [81]

E. **Radiation:** Exposure to radiation, particularly ionizing radiation, could be an everyday condition. Arriving in the case of Mars at levels between 180 to 225 micro Grays per day on the surface, this according to the data provided by the Curiosity rover in the Gale crater. From a radiobiology point of view, galactic cosmic rays, a type of ionizing radiation, can generate various adverse effects on human health [91]. From the point of view of non-ionizing radiation, one of the greatest risks is sunlight, due to the presence of UV radiation, which is one of the main causes of skin cancer such as basal cell and squamous cell cancer [92].

   From the point of view of microbiology, the extremophiles or extremotolerant could present viable solutions. Such is the case of organisms such as *Thermococcus gammatolerans*, an archaea with resistance to doses of more than 5000 Gy of gamma radiation [93], or *Deinococcus radiodurans*, a bacterium, in which the induction of specific genes, proteins and enzymes has been identified. for DNA repair. Likewise, other bacteria, such as cyanobacteria of the genus *Chroococcidiopsis*, have pigments that are sensitive to radiation and that induce DNA repair mechanisms [94]. These and other microorganisms offer alternatives for the production of compounds that could be applied in preventive therapies or treatments against skin cancer generated in a Martian environment, providing resistance.

F. **Epidemiological profile and health model focused on public policies:** The health system is understood as the set of entities in charge of interventions in society whose main purpose is health [95]. In that order of ideas in the Martian colony, it is necessary to structure a public health model focused on the typical needs of the population at least every Martian year until clear epidemiological profiles can be established based on the new determinants of the health-disease process.

G. **Hospital Network:** The construction of a Central Hospital, at least 3 peripheral second level hospitals and 6 primary care units is planned. There will be 5,000 beds distributed as 2,000 beds in the central hospital, 800 beds in each second-level hospital and 600 beds divided into the primary care units. The entire health model is based on the concept of patient safety when providing effective and efficient health care to future Martian populations.

7. Society

7.1 Political principles

A. Foundation of democracy for the Mars society

Each society achieves its maximum achievements as long as the state and society provide objective and subjective conditions to promote the full advancement of 10 central human capacities [98] (Fig. 5) that allow the development of 5 autonomies, of all its members [99] (Fig. 6). The objective conditions derive from the level, quality and progress of democracy achieved by the city-state, which determines the adequacy of policies, the public supply of goods and services and the institutional environment that contributes to the development of the capabilities of the exercise of the rights of the entire population, taking into account differences in age, ethnicity, culture and beliefs. The subjective order is constituted in the internal experience of all people as subjects of rights of how they can be, be, be and have equal conditions and opportunities between different groups and sectors.

B. Political guidelines

1. The Martian Human Society (MHS) is constituted as a sovereign state, politically independent, with full power of self-determination and progressively self-sufficient.
2. The MHS recognizes and expresses its desire to freely and voluntarily establish a confederation with the human societies of planet Earth to address issues common to the survival and exploration of the space of the human species and to enable mutual aid and reciprocal assistance by virtue of being everything, as a single species that constitutes a whole with a common biological, social, cultural and historical origin.
3. Martian humanity and terrestrial humanity will agree on the best way to materialize this confederation through a Single Human Council (UHC), on a strict equal footing, which may expand in the future with the new sovereign human colonies that are formed outside the planet. Earth and with the express exception of not interfering in the internal planetary affairs of each of the parties in agreement, current or future.

C. Constitution

1. The MHS is constituted as a State and an Independent and Sovereign Society with the purpose of guaranteeing the perpetuation of the human species on Planet Mars and building a social, political, economic, scientific and cultural order that guarantees the greatest freedom, plurality of forms of being the greatest democracy, social justice, self-sufficiency and equity, which, in short, seeks the best Good Living, the best Good Life and the greatest Happiness for all, on Planet Mars. Whose unique physiosphere will only be intervened, modified, populated and exploited, by virtue of the exclusive collective interest to achieve the minimum conditions of survival that allow the basic satisfactory of Human Development to be produced within what is relevant for survival.
2. Human dignity and the property of human rights as a positive political achievement, built over a long historical period, will be a condition and a legal property that the MHS grants to its associates, as the self-constituting foundations of historical rights of the human being.
3. The members of the MHS are the depositaries and the source of the founding political will of the Martian political order, on the basis of strict equality before the law, with the same rights and general duties, the greatest social and economic equality, with the greatest recognition of their individual and collective subjectivities, the greatest freedom of conscience and opinion.
4. The Principle of Equality will treat everyone equally. The Principle of Equity will be treated differently, to compensate for differences in individual constitutions, biological capacities and endowments, life cycles and the specificities of sexual choice, ethnic and cultural beliefs, sexual preferences and roles. gender, as long as the treatment does not mean the detriment of one right and an essential good of the other.
5. The MHS will allow and enhance greater individual and collective freedom, greater subjectivity, so as not to harm or harm a particular person and the collective interest of the MHS.
6. The MHS is a socialist society (collective work and collective enjoyment of the fruits of labor) with different forms of property: state or public property, self-managed collective property and private property of the goods necessary exclusively for private life and personal identity.
7. The Saintsimonian maxim will apply: "From each according to their ability to each according to their need."

D. Organization

The organization of the MHS state will be given by the general assembly, political-scientific council, executive body of government, supreme court, secretariats and the UHC, interacting as can be seen in Fig. 7 and organizing decision-making as indicated in Fig. 8.

7.2 Economics

A. Macroeconomic model for the flourishing of human life in the Martian city-state:

This model aims to enhance the ten human capacities for complete human flourishing. For which the following structure follows:
In the Human Society of Mars, all people contribute to the maintenance of the collective economy and receive benefits from it. From childhood, children take care of and clean their spaces, and according to age, while they are in the educational stage, they do community work. Upon reaching the properly productive stage, they obtain a card to register their HMW (Martian Hours of Work). Adulthood becomes a stage of life of great importance, because this age group constitutes the intergenerational connection between the population, maintains a vital reference to ancestors, lays affection and wisdom on their descendants and is a reference on how human life evolves. Once each person leaves their peak of productivity, after 75 years, they contribute their knowledge and take care of the common areas, according to their physical capacity. When they die, their bodies are donated as fertilizer, for studies, or to replace other people's organs, according to conscientious objection regarding the rites and uses of different religious or spiritual conceptions.
In Martian human society, all production is under the responsibility of the State and two areas of productive life are recognized:

1. **Production and reproduction of human life:** It is carried out both within families and by the health, food, education, housing and sanitation, recreation and culture sectors. In this scenario, goods are produced for personal use and collective goods and for collective care. The State produces and supplies all the goods and services for:
    a. Take care of human health in all areas and life cycles.
    b. Care in all stages of gestation, prenatal, neonatal, postpartum, childbirth, early childhood, manages the breast milk bank to collectivize what remains for any mother and can deliver it to a nursing mother who does not have enough or for consumption, as proposed in section 5.1.
    c. Food for the entire population throughout the year, throughout the life cycle.
    d. Medicines and hospital medical care, as well as supports in case of hearing, eye, biosymptomatic disability or all sexual / reproductive or affective health requirements. Includes support when they become totally dependent and need physical or psycho-emotional support and those mentioned in section 6.
    e. It provides all fertility prevention medications, protects against sexually transmitted diseases, and provides women with menstrual cups made by 3D printing (section 5.4).
    f. The washing system for all clothing and utensils used by the human population that inhabits Mars.
    g. Nurseries, children's dining rooms, dining rooms for workers and for the entire population.
    h. It provides recreational, artistic and cultural services to cultivate emotions, spirituality, and mental and emotional health, through the spare time areas and spirituality mentioned in section 3.
    i. In the private family order are sexuality, hygiene and personal cleanliness.
    j. The paid leave after having a child is maternal / paternal, minimum of one year and must be shared between the parents.
2. **Production of assets and services for immediate, intermediate consumption and for the expanded reproduction of the Martian economy (All generated in section 5.4):**
    a. Immediate material goods for consumption (clothing, footwear, personal hygiene items, television and the media, among others), as well as implements for cleaning work and group spaces.
    b. Intermediate assets: machines to produce goods or goods for immediate consumption (machines for making shoes, clothes, soap making, etc.).
    c. Assets and supplies for the production of machines that produce machines (robots, large assemblers of transport systems and exploitation of minerals, among others).
    d. No deluxe or deluxe items will be produced on Mars. The axis is production to be self-sufficient and keep the population healthy, well-fed, and therefore happy. The surpluses that they achieve with their work will focus on the collective well-being and access to a greater and better quality of recreation, art, science and culture. Household items will be minimal, since food and cleaning of clothes and personal belongings are collectivized. There will be food care dispensaries throughout the day, for people to eat breakfast, snack, lunch, mid-afternoon and dinner. And they may still have something they need after dinner.

B. Currency and circulation of goods and services:

On Mars there will be no banks, because they are not necessary and their physical facilities and operation would consume fundamental resources for other areas of life on Mars. The internal economy is is regulated by a single state entity. Their functions are:

1. **Facilitate the accumulation and mobilization of MVUs (units of Martian value):** regulate the exchange between the Production of Goods and Services sectors and the Life Care Sector, and facilitate the circulation of the Martianite card. Each person who works will accumulate their working hours on the Martianite card and with this card will pay for goods and services for personal, cultural, artistic and recreational use. The state deducts the payment of taxes directly from the personal account. Any personal consumption will also be made at the site where these products are offered and purchased with your Martianite card.
2. **Use of time and value of human work:** All people contribute to the maintenance of the collective economy, from the age of seven taking care and cleaning their school spaces, and if they exist, they cultivate school gardens, recycle, among other activities within their reach. And as they get older, while they are in the educational stage, they carry out more complex community tasks. When they are already employed, they continue to contribute two hours a day of work to the community. People's work and contributions are measured in MVU, which are accumulated on a Marcianita card considering the five levels of remuneration (Table 1).
3. **The value of objects and consumer goods:** Which is measured by:
    a. The number of hours of socially necessary human work (wage) (socially necessary work means the social average established with respect to the time to produce a good or provide a service adequately).
    b. Materials and raw materials.
    c. The expenses of the machinery used in production.

d. The profit so that the Martian State can accumulate for exchange with Earth.

4. **Work Hours:** Work hours are six hours a day for five days, and holidays are established, in addition to festivals or carnivals, as appropriate for recreation and identity interests for the MHS. It will work in three schedules: Shift 1. 6 AM-12 AM, shift 2. 12 AM - 6 PM and shift 3. 6 PM to 12 PM, according to the production requirements of each sector of the economy. Workers have the right to choose shifts, which are not different in value from each other, maintaining the rule that no one works more than two weeks during the month on the night shift. During the year, people are entitled to a 20-day vacation that cannot be accumulated (to avoid stress from not getting adequate rest).
5. **Wages:** The legal minimum wage covers the requirements of a family or individual, to cover the costs of the State operation and goods for individual or family personal use. The State will provide personal hygiene and personal belongings in the private space. Thus, the following remuneration table exists.

Table 1. Wages

Wage level	Minimum wages earned	% of taxes you pay based on your salary
1 Basic training (high school):	1	15.0%
2. Technological	1.5	17.5%
3. Professional	2.0	22.50%
4. Specialization	2.5	25.0%
5. Masters	3.0	27.5.0%
6. Ph.D.	4.0	30.0%

6. **Incentives to production:** in addition to covering basic needs, the inhabitants of Mars have as incentives their promotion and good job performance, being able to have a surplus to invest in their vacations, recreation, physical improvement through sport, artistic improvement through training. in any area you choose, or improvement in the area of scientific or cultural research.
7. **Paid leave:** those related to diseases, mourning or special rites due to their religious or spiritual beliefs, maternal / paternal leave that will not be less than one year paid and without loss of continuity of work and the enjoyment of all rights as a worker.

C. Exchange with Earth

The Martian State establishes the exchange rate considering a profit margin and for its expanded accumulation and taking into account the principles of the information economy [100] [101], where Martian citizens will have exclusive access to data in Situ, as well as the possibility of carrying out tests and experiments for the Earth, generating exchanges, which allows:

a. Shipment of initial materials from Earth, such as machinery and electronic materials, with a cost of close to $ 2 billion, considering previous missions and installations [102].
b. Constant capital replenishment.
c. Investment in research, science, technology and innovation.
d. Constant improvement of the human flourishing of those who inhabit Mars considering:
   i. Increased life expectancy at birth.
   ii. Increase of incentives and effective increase of people with specialization level and postgraduate studies, with information produced on Earth and Mars.
   iii. Empowerment of the five autonomies.

7.3 Primary school

Initially, the degrees of formation are established taking into account Jean Piaget's theory of cognitive development, which focuses on the development of human intelligence around the nature of knowledge regarding how human beings gradually come to acquire it, build it and use it [103]. These degrees of training will take into account stages or learning cycles where new cognitive structures will be developed depending on the stage. Thus, mental processes resulting from biological maturation and environmental experience are taken into account to develop this educational proposal, developing a comprehensive education in the sense that it aims to educate in all dimensions of the person. Given that, the intellectual dimension will be worked through the multiple intelligences of Howard Gardner, since these seek that the human being develops to the maximum his intellectual potentials [104], understanding that each person has different capacities, and the other dimensions are worked guided by the 10 human capacities [98] proposed by the Martian Human Society (MHS).

A holistic and interdisciplinary education will be implemented, which is characterized by teaching the necessary disciplines but understanding that no single discipline can provide comprehensive solutions to these problems, but that dialogue, collaboration and interaction between various disciplines achieve the goal of enriching mutually the knowledge given and generating a new one, for which a mixed methodology is proposed that arises from the needs of the context where the proposal is to be developed, thus, they were established as follows: the Reggio Emilia approach fosters a relational pedagogy and participatory, where a learning environment focused on the child is structured, with research and reflection predominating. Meanwhile, the Montessori methodology takes into account independent learning, where specific skills are strengthened and developed that the student is willing to learn [105]. Likewise, in relation to project-based learning, the objective will be for students to work actively, plan, implement and evaluate these [106], which must have an application in the Martian context and go beyond environments. predisposed schoolchildren, generating authentic performances [107]. Initially, initial education is projected from the family with the support of the educational sector to the activities and stimuli generated by the main caregiver in the infant, considering nurseries and gardens as non-compulsory educational centers for the training of boys and girls to later enter to the formal education system, described in Fig. 9. Which allows for the necessary transversal learning in primary education, which will allow the development of a free personality, which the student will go through to secondary education and contributing to the dynamics of the MHS. Therefore, people capable of learning autonomously, who have artistic skills, will be trained, from sensitization to the expression of their personal being, using creative, scientific, analytical and critical thinking to respond to the problems that arise, with a glance from humanistic thinking to the affective, emotional and ethical to generate a response of collective responsibility and awareness regarding the limited natural resources in this environment.

7.4 Secondary school

Secondary education fulfills the function of preparing the student for professional and personal development [108] [109]; that gives meaning to its existence and guides the progress of its potential from a good relationship with society and its environment. In this sense, on Mars it is necessary that people not only recognize the environment, but also manage to generate research on this planet, for this reason one of the objectives of secondary education proposed for Martian education is the development of scientific thought that is understands as the ability to investigate and find solutions to various problems in different contexts [110]. For this, Teaching for Understanding (TU) is proposed as a model that will guide the process of building the educational system at this level.

Project Based Learning (PBL) is a strategy that allows the development of scientific thinking, and from its possible application on Mars allows students to generate a wide range of skills and competences such as collaboration, project planning, decision making and time management, necessary to face the subsistence challenge in this environment. This is how students manage to connect their learning with reality, and by linking this model with Teaching for Comprehension, students get to use higher order thinking, instead of memorizing facts in an isolated context without a connection to how and where they are used in the real world [111], looking for opportunities for synergy between research or projects and theoretical elements for the construction of scientific thought [112] and the development of authentic performances [107]. Taking into account that those who live there require significant experiences that ensure the survival of the human species, making use of technology [113], it is necessary that at the end of secondary school students have the following skills:

- **A.** Think and learn to learn.
- **B.** Cultural competence, interaction and expression.
- **C.** Taking care of yourself, managing daily life.
- **D.** Multiple literacy.
- **E.** Digital competence.
- **F.** Labor competence, entrepreneurship.
- **G.** Participation, development, construction of a sustainable future [114].

The competences of Finnish education are taken as a reference, which summarizes the objectives of contemporary education [115] and the various skills required, along with this, for the approximately 200,000 young people who will be in secondary school. Creating a learning environment, where the feasibility of having a place that meets the needs of students is contemplated, allowing them to perform in different areas, dividing said space into a zone of recreation, research, development and interaction, which They will be both closed and open since they allow the free development of the student [116], with simulated environments using virtual reality, as observed in section 3. On the other hand, the secondary educational system aims at the progress of knowledge and of skills from different educational levels that starts from the EpC, starting from transversal education that allows the student to be the main actor for the construction of their knowledge, comprehensive training and also involve creative thinking that promotes the generation of new ideas by being in a little-explored context [117], like this:

A. **Novice:** a recapitulation of the learning obtained is carried out to advance these through the projects and / or problems proposed.
B. **Apprentice:** use of simulated spaces for the application of new concepts and the development of creative thinking, to propose different solutions.
C. **Intern**: Specialization in personal, technical or disciplinary training to solve a real problem in your area of interest.
D. **Expert:** Elaboration of projects regarding problem situations in the Martian context found by the students, which implies the development of leadership competences and takes into account public policies in their solution.

7.5 Higher education

The design and planning of the educational model is based on the training of professionals with a focus on STEAM, Social and Human Sciences, capable of thinking, proposing solutions and, therefore, solving Mars' own problems. Thus, the different aspects that must be taken into account in the Martian higher education system can be identified:

A. **Training citizens capable of coexisting in society:** Where social dynamics are not comparable to terrestrial ones. The inhabitants of the Martian city during their higher education will be oriented to develop competences, skills and knowledge in areas such as the organization of power in society, administration, decision-making, teamwork, work for the common good, empathy, among others. This knowledge will allow any inhabitant of Martian society, after professional training regardless of their career or area of study, to be able to hold public office of any kind, thus integrating society with the administration of power in it.
B. **All the programs at the undergraduate level are based on propaedeutic cycles**: Training by levels or propaedeutic cycles is a training model that is carried out in stages, cycles or levels which allow the student to progress over time, in their training, according to their interests and abilities [118]. These levels are delimited both temporarily, in terms of the duration of the training, and the skills to be developed in each cycle or level. In other words, to complete a cycle, an individual must comply with the estimated training time and with the expected competencies and skills that are developed. This model of training by cycles articulated with the functional sectors of the Martian city allows satisfying the demand for human resources in society. From this perspective, it is proposed that a student who approves his level of technical training can continue with his training at a technological level, but at the same time perform as a technician in productive areas of the city where his competences, skills and knowledge are required. this same way when continuing with the professional training stage, in this case working as a technologist. Similarly, it is established that the practical component of higher education is carried out in the same spaces in each of the city's production sectors, thereby obtaining savings in infrastructure, energy, furniture and resources. Finally, it is proposed that training be elective up to doctoral stays through all intermediate levels, according to their self-cultivation and remuneration interests (Table 1).
C. **Education by Learning Results (LR):** In order to have a clear purpose of higher education, the competences that each student must develop at different levels of training are taken into account, however, higher education will contribute to training of these competencies from the LR, since the competences are developed throughout life and are developed according to the needs of the Martian context. Therefore, it is proposed that a curricular mesh of each of the programs contributes to the training in competencies, values, attitudes, aptitudes, knowledge, methods, capacities and abilities according to the level of deepening in the discipline, profession, occupation or trade, and seeks the integral formation of the student [119]. Additionally, the curriculum must be flexible for its updating and relevance, in order to make efficient the transit of students through the program and the institution [119], since with this option the students will have the ability to build their academic trajectory to starting from aspirations and interests taking into account certain limits such as the continuity of knowledge, in addition to the demand to form from inter, trans and multidisciplinary.
D. **Pedagogical scope:** A teaching model is proposed for all stages of training at the undergraduate level, this pedagogical model is Project Based Learning (PBL). This pedagogical model is proposed because it allows the student to keep pace with their learning by promoting autonomous work [120] and the continuity of processes at previous levels, this in coherence with what has been worked on at the secondary level where the skills of learning to learn. In addition, the PBL is a model based on learning from problem solving and teamwork, which are essential aspects when thinking about the professional development of individuals who in their real work areas will face challenges and problems in interdisciplinary teams. So this model serves so that students, in addition to developing technical-scientific skills, in whatever their field of study, develop soft skills such as communication, innovation, empathy and mainly teamwork.

8. The future

The construction of this Martian city will guide a new route for humanity, allowing us to correct mistakes in political and economic terms, and without a doubt looking at the stars to go even further. ***Mars Dichotomy*** shows us the value of science, technology, creative thinking, cooperation and collective thinking, which will guide us for the following centuries.

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