Koemitan City and Nahootsoii Town: a new sky for an expanded humanity

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PROLOGUE

Paying tribute to South and North Amerindian natives, the twin cities of Koemitan-Nahootsoii (from Tupi *coemitã*, red dawn; and from Navajo *nahootsoii*, twilight) are aligned with the first topic of the Transhumanist Declaration, which proposes to broaden the evolution of human potential by overcoming our confinement to planet Earth [1] in order to reduce the risk of the *summum malum*, i.e., the supreme evil. Centuries ago, Thomas Hobbes defined the *summum malum* as being the individual violent death, which is comprehensible since in his day and time the idea of human extinction was inconceivable. Currently, philosophers equate the supreme evil with the extinction of our species [2]. Not only can humankind become extinct due to our misuse of technology, but, also, we find ourselves in clear danger from planetary or extraplanetary disasters. In the light of knowledge afforded by science throughout the last hundred years, taking into full account the history of mass extinction events and planetary-wide catastrophes, supporting a project of human cosmic expanse surpasses mere vanity. It is not a question of *if*, but *when* we will have to build cities in extraterrestrial contexts. Not doing so is not an option if we intend to survive – and, incidentally, to carry with us all memory of life on Earth. After all, the saying warns not to put all eggs in one basket. Earth is not our final destination: it is our departure point. The twin City State Koemitan-Nahootsoii waits for humans of good will who intend to build a better life under red dawns. [note: for more detailed information, please check our website: www.brazilonmars.com.]

By the time Koemitan-Nahootsoii were planted on Mars, exploration and limited settling of specific areas had been going for decades and initial settlements explored caves, lava tubes and other sheltering places with easy access to water. The overall conditions of living, working, and prospecting on Mars became common knowledge and standard technological procedures are in place. A small network of water prospecting sites and nuclear power sources is scattered over the planet. Since colonial times, Mars has been permanently inhabited by people who consider the place their home; children have been born, and the roll of generations has begun. Very high-resolution mapping of the entire planet is available; air transportation by vehicles with heavy-cargo ferrying capabilities is routine, complemented by suborbital vehicles. Full terraforming has not yet started, remaining a hot topic of discussion in scientific and political circles concerning its ethical and engineering aspects.

PARATERRAFORMING

The main driver for the City State location choice was the availability of water for consumption, rocket fuel manufacturing and energy production. Water is regularly obtained from buried ice deposits, permafrost and subterraneous aquifers [3]. Several northern, low-latitude small craters were considered for paraterraforming. This approach is widely viewed as the best ethical and practical alternative to full terraforming, and consists in placing a limited amount of terrain under an artificial, large, and transparent enclosing, where a breathable, N_2+O_2 atmosphere is kept, allowing open air activities. The height of the structure is ideally a few hundreds of meters and the total covered area can be of the order of ~1,000 km^2. The internal volume is large enough to possess limited weather and can easily accommodate millions of people, plus agricultural and leisure areas, administration, and some elements of the energy matrix. Solar power farms are placed outside the paraterraforming enclosure.

The NASA Insight probe [4] identified, back in 2019, Cerberus Fossae (Elysium Planitia, fig. 1), at 9ºN latitude, as the epicenter of weak Martian quake: the region shows strong evidence of the action of water in the not too distant past, holding vast areas with large deposits of buried ice. Underground magmatic activity was later found to have generated a large system of aquifers [note: this remains only a hypothesis, though strongly backed by direct evidence]. This region was chosen as the site of Koemitan City. Craters with diameters in the 10-50 km range provide suitable environments for paraterraforming. Nahootsoii Town, in its turn, lies to the southeast of the channel mouths of the Kasei Valles ancient drainage system, at 25ºN latitude (Chryse Planitia, fig. 1). Both locations lie a few kilometers below planetary datum and offer increased protection from radiation, besides a reasonable mineralogical diversity, translating to resource availability. Koemitan City lies in the confluence of a variety of terrain: smooth plains of eolian deposits, crater plains made of lava (coated by loess), plus fissured lava plains and some orogen relics, with evidence of relief inversion, subsurface collapse and ejecta. Nahootsoii Town is located besides lava plains and ancient volcanic shields, showing an abundance of fluvial and eolian deposits.

The siting of the double-city thus reflects flexibility, by having two great centers of population, and acknowledges logistics and sources of income. About the latter, Nahootsoii lies close to interesting landscape attractions such as Valles Marineris and Kasei Vallis: the Tharsis volcanoes are approximately equidistant between the two cities. Aerospace industry interests call for a location close to the fuel producing industries and training centers, and not too far from the equator to gain launch advantages from the planet's rotation. Both City locations fulfill this need. The distance between the two sites is considerable: over 9,000 km, nearly half the planet´s circumference at the equator, but each conglomerate is quite self-sufficient, and this distance is routinely overcome both by air transportation and suborbital flights. One advantage of this wide separation is having a large fraction of the planet's surface not too far from a large population and resource hub well served in infrastructure, and, also, to minimize risks concerning regional hazards such as plagues and asteroid impacts. The array of much earlier, smaller settlements scattered over interesting terrain was easily incorporated into this strategy.

Adequately placed craters with diameters in the range of tens of kilometers lend themselves well to localized paraterraforming efforts [5]. The chosen craters were roofed with plastic, metal and graphene-like structures to a

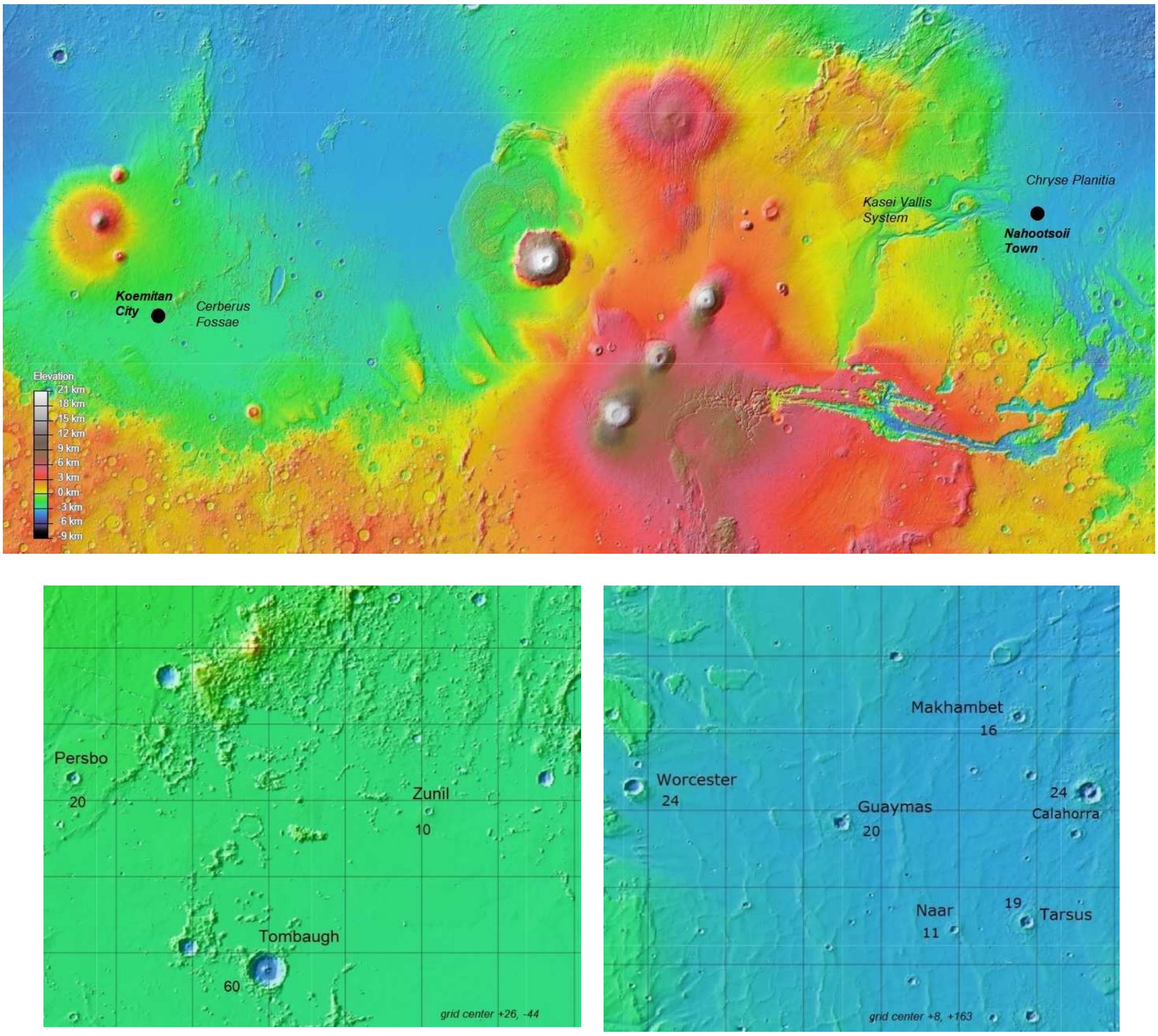


FIGURE 1 - (top): *site locations of Koemitan City, in Persbo crater at Cerberus Fossae, and Nahootsoii Town, in Guaymas crater at Chryse Planitia;* **(bottom):** *details of the Cerberus* **(left)** *and Chryse* **(right)** *locations: illustrative craters, in a range of sizes, are highlighted with diameters in kilometers and are deemed suitable for paraterraforming. Grid centers are given as latitude/longitude, approximately, in degrees – grid size is 2 degrees. Final choice of City location hinged upon immediate availability of water and other resources, as well as practical considerations of terrain for building. Both craters have a "mud splash" aspect in their surroundings, evidence of subsurface ice melted violently during the formation impact (see "trek.nasa.gov/mars/").*

height of a few hundred meters, taking advantage of the crater walls whenever convenient, and a breathable atmosphere was introduced, constituting a paraterraformed enclosure. A CO_2+O_2 atmosphere of 200-400 mb suffices for agriculture purposes and is maintained in separate enclosures; a higher pressure, 600-800 mb, N_2+O_2 atmosphere is kept inside the City proper. Living and working quarters are placed underground for increased protection against radiation and greater safety against sudden depressurization. Farming areas, parks and artificial ecosystems are found aboveground (figs. 2 and 3) for practical and psychological reasons, offering open air for rest, recreation, and sporting practice. An important aspect of paraterraforming technology is that, upwards of a certain enclosure size, even a large, sudden breach by a striking meteoroid will not deplete the inner atmosphere rapidly. Emergency shelters are strategically scattered above ground, so that people caught in open-air activities speedily find shelter in the case of catastrophic breaches. The hardened sheltering of croplands for the event of breaches is not practical, and an advantage of the double-city design is that crop losses and soil bacteria death or degradation are compensated with help from the Sister City. A rapid response robotic system is kept alert to handle small breaches of the enclosure. Breaches in the scale of one meter are quickly patched with plastic plates and rapid-drying cement, a technique that essentially eliminates the danger from small impacts. Long term repair is subsequently carried out by isolating damaged sections, repairing, and reintegrating them to the main structure. Additionally, the City deploys a system of deep surveillance for space debris that is an integral part of Martian society and constitutes a service rendered off-world for revenue (see section on economics). Present capabilities provide for the early warning against impacts from chunks down to a size of one meter or even less, and it is a very unlikely impactor that passes undetected through this system. As these capabilities are constantly improving and becoming more sensitive to ever smaller threats, fast-response teams are calibrated and the population duly warned and safeguarded, holding the promise of eliminating this danger altogether from Martian society.

General layout and design of Koemitan-Nahootsoii: the general layout of each City is shown in fig. 2: the plan involves a main conglomerate, housing administration and where the bulk of the population lives and works. Mining and exploration sites are located at varying distances from the City, depending on variables such as local resource and geologic interest: these are supplied with foodstuffs and water directly from the City, and have some limited capabilities about power supply and water. A large space launch complex is located nearby and serviced by an underground shuttle: this site is supplied directly from the Cities concerning water and other consumables but possesses independent life support and power supply. The rocket fuel production industry is housed in the main conglomerate. Tourism centers are located close to interesting sites and widely scattered. Exploration and geologic prospecting centers generally reflect momentary needs of scientific and economic plans and are by design mobile and flexible: they lack complex, permanent infrastructure. Mining sites are widely scattered over the planet and always reflect specific places where resources are being extracted, such as nitrogen, aluminum, and phosphorus.

Each conglomerate is divided into an administrative, working and storage area plus three autonomous units (AUs, fig. 2), each containing life support machinery, living quarters, some limited storage, and indoor recreation. This design reduces the risk of catastrophic loss in the event of epidemics, meteorite strikes or other hazards, since each AU is design to perform independently of other AUs. Each AU houses roughly one third of each City´s population. Figure 3 shows a general schematic for paraterraforming inside suitably sized craters. Radiation exposure is an ever present, crucial concern [6], strongly mandating working and living quarters to be placed underground. The paraterraforming enclosures offer additional protection, and the City State design makes clever use of the walls of deep craters, obtaining extra radiation protection from the regolith for particle incidence angles up to 45 degrees (fig. 3) [note: dimensions in fig.3 concerning either height of crater rims and central peak, or depression of crater floor, with respect to the datum, are merely illustrative and can vary by large factors for different craters].

Suitable crater sizes were estimated as follows. Each City is fully contained - the urban model is that of a large city on Earth. We take the suburb of Copacabana, in Rio de Janeiro, Brazil, as a fine example of a heavily urbanized and quite self-contained community (two of the authors possess lifelong experience with this type of community), with very diversified commercial activity, including hospitals and medical services, plus recreation and sports areas. It is a very verticalized community with a high density of buildings, populated in 2013 by 150,000 people, officially in an area of 7.84 km^2. We round these number off to their orders of magnitude: 10^5 people living in 10 km^2. We assumed for the City State a similar verticalization, where buildings translate to underground structures down to some tens of floors. Extrapolating to 500,000 for each City, a crater with 50 km^2 is needed for each, translating to a diameter of 8 km. Larger craters allow for lower population densities, which is desirable, but initial versions of the City State had to cope with somewhat high population densities. Relaxing this constraint to the next order of magnitude, one-tenth of Copacabana's population density translates to an area of 500 km^2 for 500,000 people, and we further allowed for agricultural and recreational areas: the corresponding crater diameter is ~25 km. Suitable craters lie in the 10-30 km size range, available at both the Cerberus Fossae and Chryse Planitia sites. We further validated these numbers considering São José dos Campos, a very prosperous Brazilian town, with a population of 630,000 people sprawling inside ~1100 km^2. This town includes heavy power plants and many crucial Brazilian industries: it could fit inside craters with diameters less than 40 km.

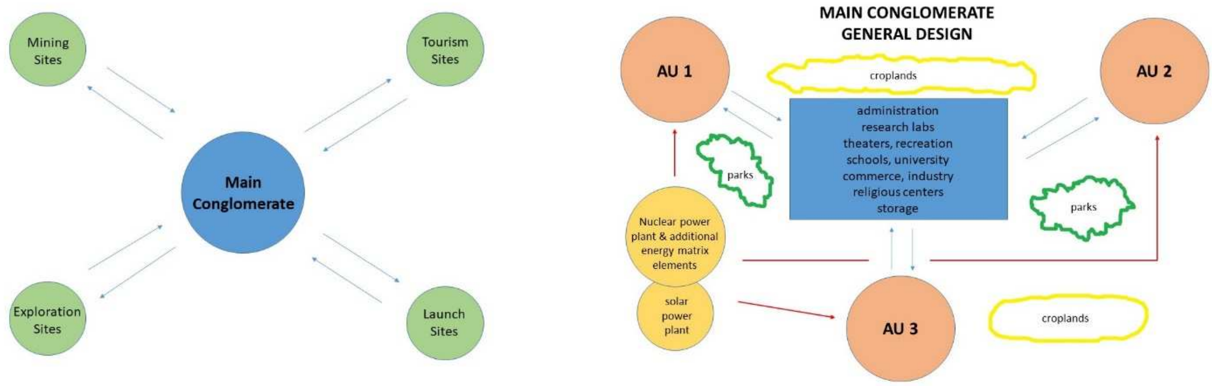


FIGURE 2: (left) *general outline of the two conglomerates of Koemitan/Nahootsoii, and their relationship to other activity sites;* **(right)** *general plan for each population conglomerate: AU stands for "autonomous unit".*

The design assumes that recycling mechanisms do not attain 100% efficiency [note: future technologies will improve current efficiency levels, incrementally, but we chose not to stray too far from proven practical applications] and thus favors redundancy, robustness, diversity and integration, maximizing survivability and expansion opportunities. Figure 4 shows the qualitative flowsheet of material and energy fluxes both inside the AU boundary and through it. Each AU is designed to support ~170,000 people (the 6 AUs house one million people in total) in an essentially independent way from other AUs and to be able to operate connected with the central part of the main conglomerate during normal *modus operandi*. Reliable airlocks connect the working area with each AU, which on its turn is connected to the other AUs. Storage tanks manage residence times of the flux of matter: water, hydrogen, oxygen, nitrogen, methane, and others. Available stocks are used to balance fluxes whenever necessary. Some level of waste or refuse must be admitted, and periodical purges are necessary. Plastic solid waste is reclaimed at some level. The general nature of the purges is two-fold. First there are the **water contaminants**, mainly nitrates, which are difficult to treat chemically, and when exposed to Mars' atmosphere turn into solid deposits (mainly calcium nitrates) after water sublimates. Some of these nitrates are kept and degraded by bacteria. Secondly there are **air contaminants** requiring purges to keep argon levels in check. Carbon monoxide is very reactive and removable by filters. The main inputs to, and outputs from, the City are:

The Martian atmosphere provides carbon, oxygen and nitrogen; CO_2 is dumped directly into the greenhouse and transformed, via photosynthesis, into vegetable food. Oxygen is produced straight from the greenhouse and the electrolysis of water. Both CO_2 and O_2 levels are balanced between photosynthesis, breathing and burning, in a redundant and integrated way. The long term plan for the City is, of course, to grow in population by transforming water and CO_2 into more living tissue. The intake of N_2 insures the renewal of air supply, since periodic air purges to the Martian atmosphere are necessary due to the buildup of contaminants; it also produces ammonia-based fertilizer for agriculture through the Haber process ($N_2 + H_2 +$ catalyst $\rightarrow NH_3$) so that nitrogen fixing bacteria in the soil of the greenhouse are not overtaxed.

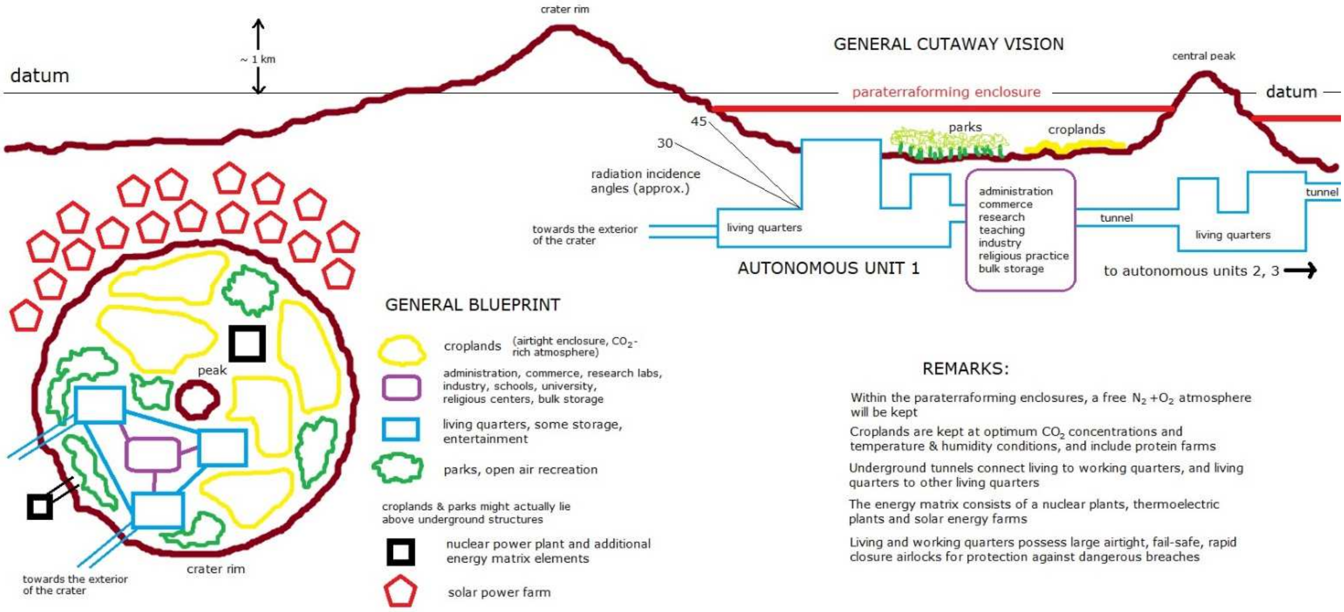


FIGURE 3: *general outline of the paraterraforming project inside a crater: a cutaway view of the City project* **(top)** *and an illustrative blueprint of the occupation of the space within the crater* **(bottom)**.

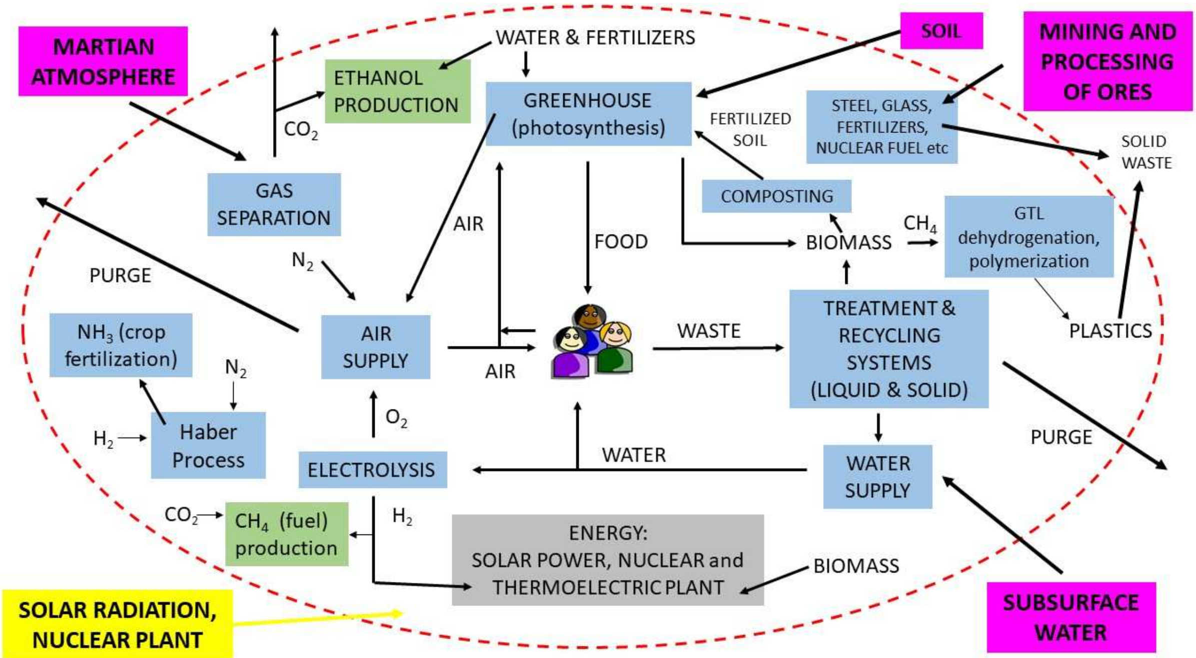


FIGURE 4 - *Material and energy fluxes to and from each Autonomous Unit are inside the red dashed ellipse. Matter coming from the exterior environment is colored magenta; energy coming from the exterior environment is colored yellow; blue boxes are processes that require electrical energy, distributed by the gray box; green boxes represent local energy production.*

Water is input for routine human activities, and to be converted to living tissue. It is a source of H_2 for methane fuel production (through catalytic reactions with CO_2 [7]) and O_2 for breathing, through electrolysis. This O_2 production is balanced against the output of photosynthesis, with temporary storage if necessary. H_2 is also used to produce ammonia or be burned in the thermoelectric plant. The latter is an integral part of the City's energy matrix: it is designed to be versatile, to handle a variety of hydrogen and carbon-based fuels, and to be fully integrated into the matter input and output flows (more details below).

Materials from ore mining and processing: steel (iron alloy) is needed in large quantities, as well as aluminum, glass, fertilizers (phosphorous, sulfur and potassium) and other elements in small quantities such as iodine. A diverse net of mining and processing installations is essential, on the surface, in nearby asteroids, and in Phobos/Deimos. The cost and practicality of the activities dictate the choice, including the possibility of imports from the Earth. Iodine, high-grade uranium for the nuclear power plant and molybdenum for steel alloys are examples of cheaply imported goods due to the small quantities necessary and availability from Earth facilities. The production of plastics employs CH_4 from biomass, through the well-known petrochemical process:

reform with water: $CH_4 + H_2O + catalyst \rightarrow CO + 3H_2$ *(synthesis gas) + catalyst*

Fischer-Tropsch: synthesis gas + catalyst → saturated hydrocarbons + catalyst

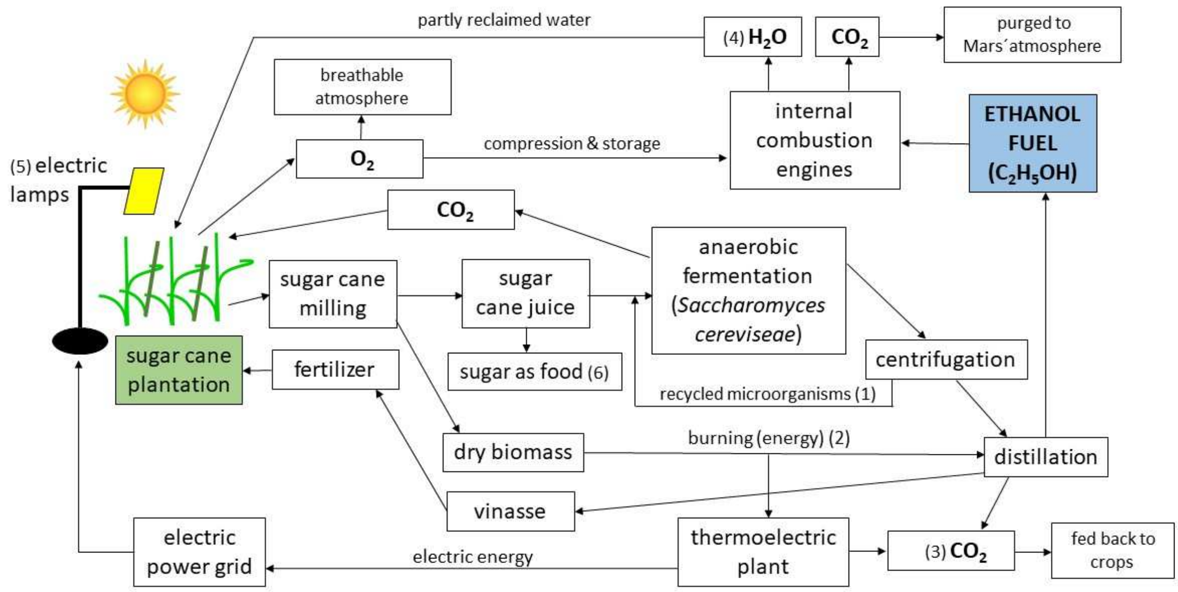
These processes are a.k.a. Gas to Liquid Process (GTL): saturated hydrocarbons suffer a dehydrogenation process, producing alkenes, which finally produce plastics by polymerization. Part of the production attains biodegradable plastic by microorganisms, a process well suited to a general concern about recycling.

Soil: some elements that are important as plant nutrients are generally more abundant in the Martian soil as compared with the Earth's, such as phosphorus, calcium, magnesium, sulfur and iron [7], and these elements are used directly as ingredients to produce soil for the greenhouse plants. The lion's share of soil production, however, relies on biomass composting, following an initial investment of bringing in composting material from elsewhere. Previous greenhouse efforts from initial Martian outposts were thus augmented locally and used as an import kickoff step for establishing Koemitan-Nahootsoii.

Energy: solar radiation is directly used for photosynthesis in the greenhouse and is converted into electricity at the solar power farm. A double nuclear/solar power primary grid allows for flexibility and load distribution, with nuclear fuel saving whenever insolation is adequate, and an increased nuclear role during global dust storms. A single nuclear power plant for each City, servicing the three AU's, is at all-time readiness [note: we assume off-the-shelf fission energy technology; in the availability of practical fusion processes, we replace the import of enriched uranium with that of deuterium, tritium or He^3 fuel].

A third energy source inside the conglomerate is the thermoelectric plant, able to turn H_2, CH_4 and biomass into CO_2, water vapor and electric energy. Although this plant may look like an oddity to futuristic-minded designers and clean-power apologists, it may be simply viewed as a kind of respiration unit, producing energy and closing off the CO_2 cycle, which also includes human breathing and photosynthesis. Further, it provides a backup energy source, adding to the philosophy of robustness, integration, and diversity, which gives the administrators a higher level of flexibility to deal with contingencies. Anyway, the thermoelectric plant need not be a major player in the energy balance. It inputs biomass from the crops (details below) and is physically connected to the electrolysis centers to handle excess H_2 and CH_4 and balance storage capacity against consumption. Design options place it just outside the paraterraforming enclosure, with physical input of biomass and gases provided by piping, or inside the enclosure, piping in this case providing venting outlets

Ethanol as a clean, efficient and synergistic fuel source: while CH_4 production for rocket fuel by a catalytic process involving CO_2 and H_2 [5] is a well-established idea, its use in internal combustion engines for transport, inside and outside the city's boundaries, is not the best choice, compared with an alternative which is liquid at room temperature and pressure and handles almost exactly like water, besides having a high calorific power. Even better, this alternative comes from a renewable bioprocess that is easily integrated within the ecology of the city and its life supporting systems (fig. 5). Such a process has been in use on Earth, in industrial scale, for decades: ethanol from sugar cane, an important fuel source in Brazil [8]. The high productivity of sugar cane [9,10,11], compared, for example, with ethanol from corn in the USA, and the recycling of the subproducts of the industrial process, including thermal energy (fig. 5) made it a great option for Koemitan-Nahootsoii. The Brazilian production of ethanol from sugar cane has been praised worldwide as a green and efficient fuel production [12,13]; its only weakness (on Mars) is the necessity of plenty of sunlight for the plants to grow, a problem solved by introducing genetically engineered varieties able to thrive under less sunlight [note: sugar cane ranks already quite high in the plant realm as concerns photosynthetic efficiency, so there might not be much room for genetic improvement: also, sugar cane may require higher atmospheric pressure than most crops to attain maximum yield;



(1) Microorganisms are reclaimed from centrifugation and put back into fermentation; (2) the burning of dry sugar cane biomass generates heat and the output is greater than needed by distillation: the excess drives a thermoelectric plant; (3) dry sugar cane biomass produces much more CO_2 than H_2O when burned; (4) ethanol is a well-hydrogenated molecule producing H_2O when burned, besides CO_2, and this water is reclaimable during the functioning of internal combustion engines (5) electric lamps use excess energy from the system to complement insolation; (6) sugar as food for human consumption versus ethanol production is fully adjustable according to needs.

FIGURE 5 – *Ethanol production from sugar cane as a cycle, biologically and energetically integrated into the matter and energy fluxes of the City. Sugar cane produces oxygen; sugar cane juice is fermented for ethanol; dry biomass is burned as an energy source to power distillation; vinasse as a residue is useful as fertilizer. Ethanol as is destined to internal combustion engines, and excess energy from distillation powers a thermoelectric plant as part of the City´s energy matrix. Recycling of fermenting microorganisms emphasizes their importance in the ecology of the City, for the process is dependent on the saccharomyces cereviseae species, the first microorganism domesticated by humans. More processual integration with microorganisms means more resemblance to life cycles on Earth, translating to more robustness.*

at worst, one might have to live with sub-optimal yields]. This industry produces surplus energy from burning the dry biomass after milling (fig. 5), and this extra heat goes into distillation. However, since he calorific power of the burn is larger than needed by distillation, an adjacent thermoelectric plant generates electricity (as is standard practice in Brazil), which in turn is used to power electric lamps along the plantation area. These lamps are managed to alleviate or overcome periodic blackouts of sunlight during prolonged dust storms. The ethanol is employed in combustion engines to power land vehicles, but only for open-air use (outside the paraterraforming enclosure). Some water from this combustion is reclaimed and brought back to the City, while CO_2 is simply vented back to Mars' atmosphere as exhaust. The lamp system consists of high-efficiency LEDs with emittance heavily concentrated between 430-530 and 640-690 nanometers, the spectral range where chlorophyll A and B have the highest absorbance, hence lending the highest possible photosynthetic yield.

Illustrative renditions of the Koemitan and Nahootsoii conglomerates are shown in figure 6.

ECONOMIC RATIONALE

Who paid for the initial exploration, and later colonization, of Mars? Initial investors call for some return to their investments, even if only to re-invest in the venture of colonizing Mars. Initially the dependence on external investors was high, which were not exclusively composed of powerful, wealthy countries, economically, militarily and geopolitically influential. Also, world-encompassing institutions with large soft power, such as the Catholic Church, various NGOs, large corporations (from various branches of industry) and even the UN, early on showed an interest on Mars. Logistics demanded that imports were kept at an absolute minimum and focused on first necessity items: fissionable/fusionable material, medical supplies, complex chemical products, electronics. The most valuable exports have always been either activities or products that drew on the Martian population expertise, required only local resources and utilized as little manpower and energy as possible, since both colonies and the City States are constantly preoccupied in investing in its own growing autonomy. Maintaining an advantageous economy balance requires Martian commercial activities to surpass basic needs and find new and

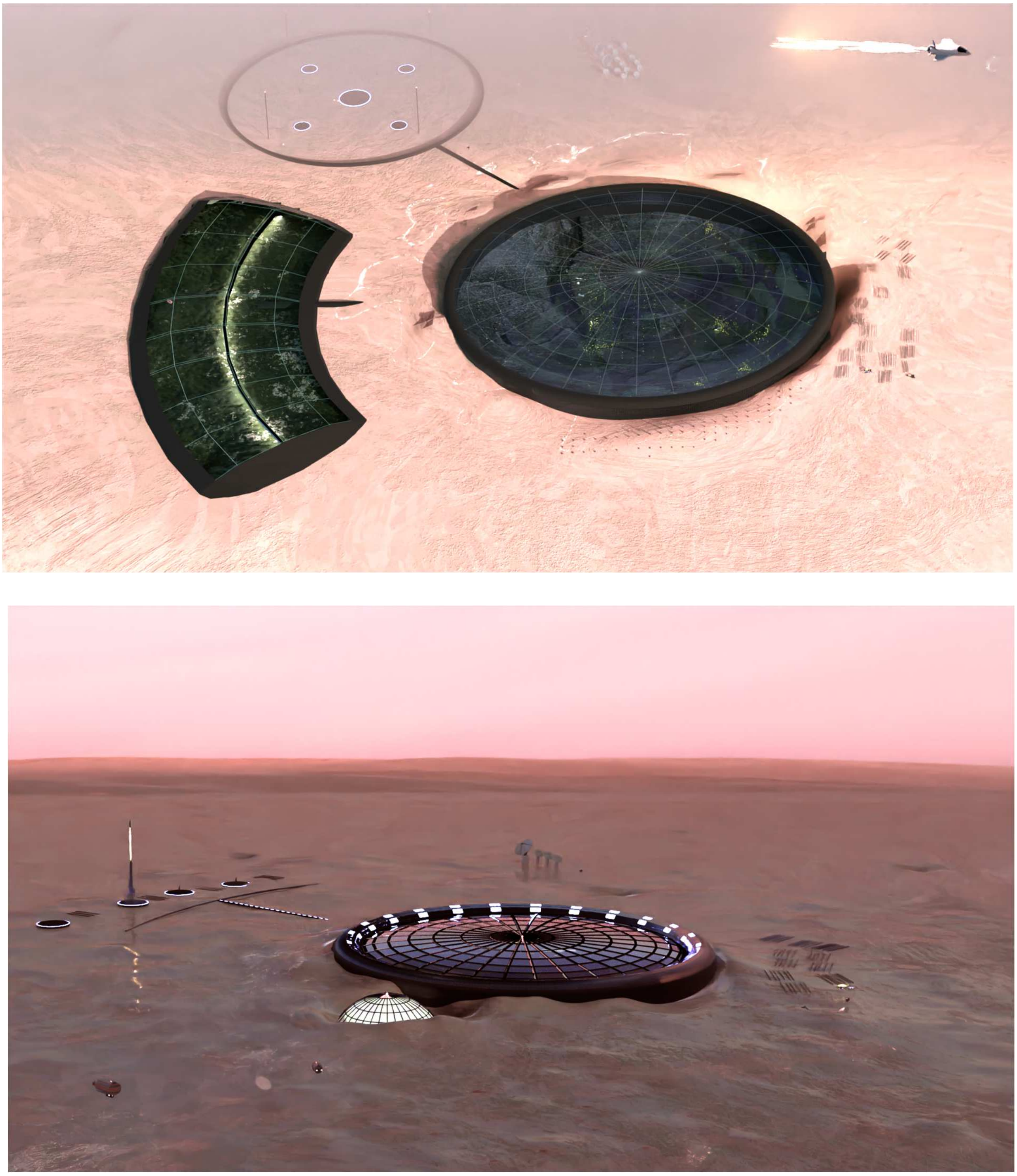


FIGURE 6 – Illustrative renditions of the City State conglomerates, nested inside their paraterraforming enclosure: **(top)** Koemitan City, in Persbo crater, and **(bottom)** Nahootsoii Town, in Guaymas crater.

creative sources of revenue. A favorable trade balance relies on products and services being offered by advantageously using local resources and expertise, the most important being:

Tourism: the cost reduction of space travel has allowed middle class people to aspire to extraplanetary trips, and they are increasingly representing a large fraction of the public travelling to Mars to enjoy the unique experiences of the planet. Top tourist attractions have strong exotic and visual appeal and are very particular to Mars, having few or no counterparts on the Earth or the Moon – these abound on Mars. Valles Marineris and other large canyon systems offer unforgettable experiences. The biggest volcanoes have no counterparts in the Solar System, and many canyon systems offer fantastic views when seen from the air. Also, some geological sites with picturesque and un-earthlike views are popular attractions. Underground caves and aquifers, involving the search for past or extant life, have always had a strong appeal in exploration. The large volcanoes are simply too huge to be of interest as high altitude observation platforms as the shorter horizon on Mars negates most of the good views. Space observation platforms are much better and suborbital and orbital flights offer special treats, particularly to the moons, employed as observing platforms, where infrastructure was built using local resources, offering comfortable and even luxurious services. On the Earth there are no natural orbital platforms offering privileged views of the planet, but Mars has Phobos and Deimos. The view of Mars from Phobos is spectacular and constantly changing, allowing an experience similar to that enjoyed by early 21st century space stations on Earth. The Earth as seen from low orbit spans about 140 degrees in the sky, while Mars as seen from Phobos spans about 94 degrees. Panoramic views of Mars from Phobos are thus wider but nonetheless allow a great degree of detail to be seen on the ground, and most of the interesting terrain of Mars (excepting the polar caps) is accessible as Phobos is observable as far north as 70 degrees.

Aerospace industry: it is natural for Koemitan-Nahootsoii and other outposts on Mars to maintain strong aerospace capabilities in constant use and development, which concerns mobility, keeping ties with the Earth, and rescue and assistance capabilities befitting a frontier world where people will be pushing envelopes on a daily basis. Airborne and suborbital transportation capabilities were essential from the start, and as the network of cheap and reliable ground mass transportation systems expands, this mixed long-range capability reduces costs and gains efficiency. Companies pursue to operate interesting space trips to sell as recreation, and besides the Earth-Moon system, the Mars/Asteroid Belt combo soon became the natural next avenue of commercial exploitation of spaceflight. Probes to the outer Solar System beyond are cheaper to launch from Mars, provided that the local aerospace infrastructure is able to build the probes locally, which was a good reason to set an aerospace industry going in the early days. This was quite a challenge but made instant sense given the local necessities and the strategic position of Mars, much closer to the Main Asteroid Belt, a Solar System region rich in resources being increasingly exploited as the infrastructure improves. A common commercial package is: build your probe on Mars (employing or not Martian experts), launch it from Mars, and Martian facilities handle the telemetry and data storage for you, driving prices down and maximizing profits for the Martian economy.

Food production: intensive agriculture with a large margin of safety is a crucial business in Koemitan-Nahootsoii. Excess productivity from the greenhouses is regulated by storage of processed foodstuffs - an important industry by itself, catering to the domestic market but increasingly also to off-world outposts in the asteroids and beyond, taking advantage of the cost-cutting concentration of effort and the ease with which intensive agriculture is made to work in a large, resource-rich planet as compared to free-floating communities. Supplying outposts in the outer Solar Systems was made cheaper by buying Martian, and the Sister City State is superbly placed to profit from this. Shipping foodstuffs in large scale to outer Solar System clients is a steady and blooming industry.

Scientific installations: by the time Koemitan-Nahootsoii became a reality on Mars, the Moon had already been well exploited as a site for astronomical observation. Any Mars-based telescope, however, offers a very relevant advantage over equipment placed on the Moon: a much larger distance from the Earth, enabling radio-interferometry over baselines 1,000 times larger. The rent of Mars-based scientific equipment to the large astronomical research community of the Earth-Moon system resulted in enormous benefits and much increased capabilities for research into the Kuiper Belt, exoplanets and extragalactic astrophysics.

Spaceguard program: another activity with great strategic interest for the Earth-Moon system, which from the start was taken advantage of, was the development and maintenance of a giant observing multi-wavelength installation, aimed at searching for potentially dangerous small bodies coming from the Main Asteroid Belt or further out and that endanger all inner Solar System communities. Mars is much better placed to monitor such threats, lying much closer to the Main Belt and possessing a much thinner atmosphere, making ground installations, which are much cheaper, practical and effective. Multiwavelength observations, coupling visual, infrared and radar data, not only identify and trace much farther, harder to detect, dangerous objects, but also fully characterize them spectroscopically. This is essential to determine their composition and probable inner structure, thus aiding define the correct strategy for destruction and/or deflection of the body. An early warning, deep sensitivity, multi-wavelength survey service from the Martian City State has enormously increased the effectiveness of asteroid defense strategies for the inner Solar System and provides considerable income to Martian society [note: Arthur C. Clarke vividly described this scenario in his novel *Rendezvous with Rama*: in his vision, nuclear-powered radar pulses maintained the *Spaceguard* project.]

Branding and marketing: large food and drink corporations established, relatively early on, a commercial interest in Mars. Special pre-prepared meals, industrialized and packaged for shipping to Mars, were a practical and cheap way to quickly enable establishment of colonies, and this industry proved adaptable to local infrastructure, employing local foodstuffs. New technologies for food processing, packaging and conservation emerged and had application on Earth's society, thereby returning part of the initial investment. This business soon revealed advertising value, tied to other space related business, like asteroid prospecting and mining, deep space missions, and exploratory manned missions, lending interplanetary visibility to businesses. Technology giant outfits also revealed interest in the strong climate of innovation and envelope-pushing offered by a frontier world like Mars. Also, there is considerable marketing value in the existence of the City itself – the allure of human activities on another planet, philosophically being an accomplished outpost of humanity. Earthling governments, institutions, and individuals make money from the simple fact of being and working on Mars. Blogging, streaming and even reality shows in all the big social media companies have drawn public attention. Governments, corporations, and private institutions keep websites, social media accounts or live video feeds for public consumption, charging modest fees. Powerful institutions have shown sustained interest in building their image as participating in this enterprise. Social media vehicles have allowed people to feel like they are at the frontline.

Development of AR/VR technologies: the amount of people who would choose to live on Mars has always outnumbered those who actually travel there, so a strong demand for virtual experiences, both augmented (AR) and virtual reality (VR), flourishes: people subscribe to special channels, private contents, and a frontline, exclusive experience. In the past, some Earthlings criticized the prospect of living on Mars by alleging that such an experience could cause psychological illness due to the extreme monotony of the red planet's environment. Such criticisms, however, were demystified even in the pre-colonial scenario. Mars proved to be almost as varied and rich an experience as the Earth. Thanks to technical progress, the Martian Cities are available not only as physical buildings but above all as user interfaces. Multiple sensory AR systems, mobile or brain implanted, obtains for citizens intuitive, friendly information wherever they go. Given that sensorial perception of the environment is enhanced through AI-created 3D forms, the only difference between physical and virtual objects is that the latter can be digitally manipulated. Thus, citizens can play, study, work and interact with people across extremely realistic immersive sensations provided by AR. On the other hand, differing from AR by not using real objects, VR is also available offering impressive entertainment experiences, which makes Martian lifestyle everything but tedious! Besides, VR experiences provide behavior and physical data to artificial intelligences (AIs) that help rule the city in a more efficient manner. Due to the importance Martians give to AR/VR, related software/hardware are in continuous progress, and the resulting technology is often exported to Earth.

Mining: extracting ores from the surface of Mars for export earns profits only if the total investment, comprising prospecting, exploitation, refining and launching to Earth becomes competitive as compared to mining on the asteroids or the Earth-Moon system. It had always been considered unlikely that the export of Mars-mined products to Earth could ever become worthwhile, unless exploration teams were to discover some very rare or previously unknown mineral with very important economic application and profitable extraction. Mars-based asteroid mining, on the other hand, has been offering significant advantages: easier, cheaper, and faster access to the asteroids, tied to in-orbit processing, makes the export of refined products to Earth a source of relevant income. Exploration and exploitation teams are supplied with fuel, water, and foodstuffs directly from Martian industry. Many technical difficulties involving low-gravity processing and refining had to be overcome for this activity to become feasible, but the incentive was always high, since resource extraction in the asteroids for the Martian civilization proper became an important activity very early on the colonization process.

The strategic position of Mars was fully brought to fruition by directly tapping into the Main Belt asteroids as sources of an assortment of relevant resources, access to which was planned very early on to allow Mars to outperform competitors within the Solar System economy. Asteroids in suitable orbits and rich in resources are easily identified by the Martian Spaceguard program: specialized prospectors, with heavy use of robotic machinery, deflect these bodies towards Mars' orbit and enable a low energy capture. Large processing structures have been developing in orbit for decades, using Phobos and Deimos as logistic support nodes, to the point that they are presently a booming industrial sector, employing thousands of people. The Martian moons themselves are potentially good reservoirs of raw material, but it was decided to keep their physical integrity at least partly so they can better fulfill their support roles (including for touristic activities). The in-orbit processing of asteroids has indeed become a touristic attraction all by itself, packaged and sold as part of orbital flight experiences.

Metal extraction from iron-nickel asteroids comprises the most important industrial activity of the mining orbital outfit. Carbonyl extraction of Fe-Ni metals gives as byproducts cobalt and the important platinum group metals (PGMs), which are Pt, Os, Ir, Rh, Ru and Pd, all of them sufficiently valuable to be returned to Earth [14]. The average occurrence of the PGMs is between 7 and 2 atoms per every 100,000 Fe-Co-Ni atoms. Profitable return of these metals to Earth was contingent upon the prior establishment of a large in-space market for the ferrous metals Fe-Ni-Co. Koemitan-Nahootsoii, and its attendant economy and development precisely provided such conditions. These ferrous metals are orbit-processed, used in orbit to expand the mining outfit, and brought down to the surface of Mars by a mix of aerobraking, automated cargo tugs, and VTVL (Vertical Take-off Vertical Landing) crafts. On the ground, this material is locally used in construction, complementing the yield from ground mining. Industrial use of the PGMs on Earth requires relatively low quantities, making export not only profitable but environmentally feasible, since bringing this material down to Earth´s surface requires a manageable number of vehicle reentries. This avoids excessive formation of water vapor (which causes radiative forcing) and nitrogen oxides (which harm the ozone layer) during vehicle reentry in Earth´s atmosphere [15].

Another profitable activity stems from enstatite chondrite and achondrite asteroids, in which elemental silicon is present with abundances of a few percent, along with other semiconductor elements. These are raw material for the manufacture of solar cells. This crucial hardware for energy harvesting is manufactured in Mars orbit and delivered as end-products to Geosynchronous Earth Orbit (GEO – an important industrial hub of the Earth-Moon system) at a cost below 200 US$/kg, since the cargo is delivered to high orbit and not to the Earth´s surface. This is competitive as compared to ferrying the items from Earth´s surface to GEO. Additionally, the delivery of Mars-made metallic structures manufactured from ferrous metal alloys to GEO (such as trusses and antennas), and also lightweight structural elements made from aluminum, is profitable. A whole system of automated cargo tugs handles these deliveries in a year-round cycle, taking advantage of periodical, low cost Earth-Mars configurations for orbital transfers. This system is easily expandable to handle exports to Main Belt communities and even to outer Solar System outposts, provided that the cost equation keeps working itself out.

To fully understand the potential of Mars to generate its own economy, we need to frame the planet as an important logistical hub within the Solar System economy. Considering all the logistics demanded to access resources from the inner Solar System, maintaining advanced manufacturing facilities on Martian orbit and its moons considerably reduces costs in comparison to Earth-based activities because of the much shallower gravity well. Earth remains the focus of Solar System economy due to a much larger population and GDP, but the exploitation of the resources of Mars proved it to be a crucial second node for supply chain optimization to keep the Solar System logistics running smoothly. As compared even to Earth's Moon, the possibility to keep a large, permanent, skilled workforce with substantial comfort on the surface of Mars brings enormous advantages over other less life-friendly location within both the inner and outer Solar System.

INDUSTRY AND TRANSPORTATION

Construction material: most construction on Mars requires pre-conditioned material. 3D printers provide a myriad of applications including complex tools and machines, furniture, and large structures. Housing structures employ 3D printers to churn out many desirable shapes and designs for use in several kinds of buildings, made from a mix of glass, steel, plastics and cement. These printed enclosures are designed to protect life against radiation (polymers and graphene give good shielding), to hold thermal variations and to keep tight control over pressurization. Glass, carbon fiber and assorted polymers provide structural elements for windows, small domes and larger enclosures, in a variety of frames allowing for many designs and finishings. Glass and polymers are manufactured in Koemitan-Nahootsoii, and the construction services employ fully automated rovers and drones.

Vehicles: the Sister Cities rely on diverse classes of vehicles: rovers and trucks, lightweight drones, heavyweight airships and suborbital and orbital vessels. Land vehicles mainly handle short distance logistics. Convoys of electric trucks and rovers connect different AUs and handle daily cargo transfers. Rovers are used to rapidly transfer small numbers of people, collect raw material, perform outdoor daily activities and support scientific and prospecting forays. Trucks are employed in heavier cargo duties in industry and crop work, such as supply transfer and storage. Land vehicles are mostly powered by fuel cells and high-performance electric batteries when in use inside the paraterraforming enclosure, but for outside use combustion engines, employing either ethanol or methane, enlarge range and flexibility and provide extra power for prospecting activities, wider-band data links, and heavy transportation. Local industries are capable of manufacturing most parts of vehicles, with some electronics required from Earth as imports. 3D printed drones reliably and quickly deliver light supplies and people. Unfortunately, such drones cannot be deployed outside the enclosure during severe environment conditions. Apart from that, drones are the main logistic vector to perform daily activities, such as surveillance, exploration, replacement of light supplies and advanced sensorial tasks, like weather forecast etc.

Airships provide a crucial logistic vector for heavy duty operations. Although airships are limited on Earth to float either with helium or hydrogen, vacuum airships are desirable for long-term deployment on Mars [16]. Evacuated Airships [note: as called by NASA circa 2018] are unlike other aerial vehicles, which are at a disadvantage in Martian atmospheric conditions: evacuated airships benefit from the Martian atmosphere by virtue of the temperature and molecular composition, offering unprecedented payload capacity and being capable of transporting very heavy cargo over large distances. Suborbital transportation is a complementary approach for human and cargo transportation between the Sister Cities, and elsewhere. Aircraft, though operable, are at a disadvantage for heavy cargo in Mars' atmosphere, so rockets are the best option for fast travel. VTVL are the best choice and reusable technologies provide great flexibility and a high rate of use.

Orbital vehicles use essentially the same technology as suborbital ones but require more energy to reach orbit, are larger and more powerful. The maintenance of chemically propelled suborbital and orbital vehicles is minimal and fast. Silos under the launch pads provide manned and automatic maintenance and refurbishment, with most of the ground operations being handled by robots. Due to water and CO_2 in abundance on Mars, the CH_4-O_2 burn is generally adopted for powering the rockets, with other options such as methanol-O_2, and O_2+H_2, also being handy according to the needed task, in keeping with a diversified energy matrix philosophy.

Satellite Constellations: life on Mars relies on satellite constellations providing essential services such as telecommunications, a Global Navigation Satellite System (GNSS), Mars ground observation, remote sensing, and weather forecast. Despite some specific electronics that still need to be imported from Earth, Koemitan/Nahootsoii handles production of most parts of the satellites. Both Cities are well-sited for efficient use of near-equator orbits, which are desirable for most applications. Near-equator orbits have advantages when compared to high inclination ones: fuel saving when launched from near the equator, shorter revisiting periods, the need for smaller constellations and a reduced quantity of ground stations to track the constellations.

For telecommunications, two medium/heavy "areostationary" (17,032 km altitude) satellites located in the same longitude of each City provide permanent data connection. Smaller satellites were added to different orbital planes and inclinations to provide extra bandwidth to support advanced exploration to other localizations. An IoT (Internet-of-Things) network is in place to keep track of logistics, industrial, farming and urban activities. Each device on Mars is trackable full-time with health/emergency status available. A mix of telecommunication sats and ground infrastructure guarantees reliable solutions. Satellite station-keeping in Mars' orbit is costly due to perturbations from the moons: in-space services handles part of resupply and orbit keeping.

Mars observation and weather forecast are indispensable to keep the safety of outdoor activities. The pace of weather changes is fast and it is essential to deploy constant and detailed monitoring. Low altitude, near-equatorial orbits are used to keep revisiting times short, but sun-synchronous polar orbits are desirable for applications using imaging and to increase the coverage to high latitude regions. Maintaining for the Martian

GNSS system a similar performance to Earth's GNSS requires one-ton-class satellites [note: we need to improve the miniaturization of high precision atomic clocks, something not available in 2020]. Mid-to-heavy satellites are costly to be implemented in-a-row, and thus, similarly to Earth's GNSS implementation, they are deployed in different blocks over time. Since the GNSS is fundamental for all ground and low orbit activities, a Martian "block I" GNSS satellite was implemented along with the very first waves of colonization. When Koemitan/Nahootsoii were established, a full constellation was ready delivering global coverage with permanent availability of a minimum of four satellites with direct line-of-sight to any devices on Mars.

The GNSS constellation has a formation not unlike Earth's system. Inclination and orbital planes are nearly the same; the altitude and number of satellites per orbital plane vary, though. The system attains better than 99.7% reliability. Ground navigation technologies are available in the City vicinity to improve daily activities: millimetric resolution is important to overcome harsh conditions, especially in challenging terrain. Guarding against extreme situations (such as sand storms) requires inertial navigation available as embedded systems for every vehicle on the surface of Mars at all times. To keep all the space activities, the ground segment has fully developed, deploying remote ground stations with extensive sets of antennas covering different wavelengths.

SOCIETY, GOVERNANCE, CULTURE

Politics and economy vis-à-vis off-world players: governance and sustainability of Koemitan-Nahootsoii are based on reality and geopolitics – the spheres of economic and technological influence of national, military, and other societal powers on the Earth have been, and will have to be, acknowledged for a long time. Commercially, the City States entertain partners involving different regions of the Earth, with different political and economic realities, and there is strong incentive to broaden this commercial base of clients as widely as possible, even to societies on the Moon, the Main Belt and elsewhere. The early colonization of Mars received, initially, high investments from many parties, and the City States inherited some debt from this activity. Income and debt must be delicately balanced so as not to develop excessive dependence on a small number of geopolitical players. The transition towards a functional and autonomous society was expected to be gradual and required some political savvy. Economic pressures and instabilities needed to be managed and reasonable agreements have been reached between the various players. Political and economic activities on Mars strongly reflect these realities.

Bioethical and Philosophical Foundation for a State City on Mars: in the light of the scientific importance of the Martian environment and regarding its interest for future generations to know Mars ina pristine way it, Koemitan-Nahootsoii does not advocate terraforming outright. The City States support Martian environmental preservation as widely as possible but consonantly with human prolonged existence and civilization. Koemitan-Nahootsoii is - by adopting Michel Foucault's expression - a *heterotopia*. Neither a utopia nor a dystopia, but *another place* (from Greek ἕτερος, *heteros*: another; and τόπος, *topos*: place). Heterotopias are worlds within worlds [17]: a heterotopia is like a mirror, which squares perfectly with the idea of a Martian city state inasmuch as it has to reflect Earth's conditions to allow our existence. Koemitan-Nahootsoii juxtaposes several Earthish microcosms in a restricted Martian area in order to make human existence possible there. As a matter of fact, by following Foucault's scheme, it is possible to picture the Martian City - philosophically speaking - like a traditional Persian garden: a sacred space supposed to bring together inside its rectangle four parts representing the four parts of the world [17], and the world is the Earth. Not only do we preserve Martian environment, saving aesthetic experiences for future human generations, but we also embrace eventual autochthonous biota. Scientific exploration has not found life on Mars yet, granted; however, as both astronomers Martin Rees and Carl Sagan famously said, absence of evidence is not evidence of absence. In the event that extant autochthonous Martian life is only occupying very limited niches, say, very specific underground environments, in a more or less isolated fashion, it is possible that even extensive terraforming will not harm its lifestyle. In this case some limited thickening of the atmosphere to allow higher temperatures and more extensive agriculture and liquid bodies of water is admissible without disrespecting microbial intrinsic values, a concern expressed by some bioethicists [18, 19]: this is the main reason the paraterraforming strategy has such appeal.

From colonies to a Martian nation: democracy flourishes: politically speaking, Koemitan-Nahootsoii is ruled by its own laws and constitution insofar as independence tends to be a consequence when it comes to a place inhabited by more than one million people. Mars, it was always known, would not host colonies forever. Not only may the autonomy from the Earth be allowed, but it may be also encouraged under some conditions and following cautious steps. On Earth, "independence" is generally a concept applied to several nations that had to fight bloody wars for such. Conversely, Koemitan-Nahootsoii experienced a gradual and pacific process that departed from a first stage in which colonies on Mars came to be understood as a de facto international condominium (like Antarctica), moving to a second stage characterized by autonomy granted by governments of the Earth that retained authority over the Martian territory. Finally, the Outer Space Treaty was amended as humankind moved forward from the second stage, expansion of population to extraterrestrial habitats, to the third and final stage: the autonomy of said habitats. Achieving this stage, humankind was ready to enhance the concept of the United Nations by establishing the constitution of the United Planets. Thus, Martian political independence is based on the following grounds: 1. **Economic sufficiency**, despite desirable interplanetary collaborations; 2. **A critical number of inhabitants**, here defined as one million; 3. **Establishment of a social pact (constitution)** ruled by democratic principles; 4. Last but not least, **a place safe enough for human existence** to allow legal dissent. That is, democracy on Mars was gradually established. It did not make sense to talk about democratic principles in the colonial stage. To deal with a lethal, alien environment made us conservative since radical changes and democratic dissents threaten human existence under stressful conditions. In the interests of the safety of the people, restricted codes of behavior were pursued in a colonial stage [20]. Antarctica offers a good example of a place in which authoritarian commands are necessary. Not surprisingly, the whole place is ruled by military authorities, since one single error may put all inhabitants' lives in danger. Initially, Martian colonies imposed limits to human freedom. However unpleasant, this state of affairs would not last forever. Colonies evolved into Koemitan-Nahootsoii, implying a higher level of safety. Democracy means dissent, distrust, and resistance: but, also, discussion, persuasion, and (sometimes a minimum) consensus. Achieving a democratic state called for designing safe habitats to maximize freedom, to the extent that it empowers the population to strike and to rebel against an eventual corrupt government [21].

Since Koemitan-Nahootsoi is ruled under an eco-conservative bioethical model, its flag does not follow Pascal Lee's inspiration as proposed in 1998. Lee's flag of Mar is tricolor because it represents stages of terraforming: its first third is red, the second is green, and the third is blue. In this case, the natural Martian red shades are represented as something to be overcome. Koemitan-Nahootsoii instead flies a flag (figure 7) that summarizes the proposal of preserving Mars as well as building a dual City State, which is represented by the infinity symbol. To the extent that Martian landscapes are of great importance for both tourism and scientific education, we assert the importance of preserving some aboriginal landscapes in as pristine a way as possible. In short, red in our flag is not a stage to be surpassed, it stands for our dual City surrounded by Martian nature, whilst blue and green mean worlds within. The two black dots represent Phobos and Deimos. Not only does the infinity symbol represent the dual nature of the city, but it also refers to our desire of embracing the infinite.

We thus define the pillars of democracy [note: we base ourselves on The Economist Intelligence Unit, a UK-based company], which are five: 1. **Electoral process and pluralism of the parties** (without pluralism, there is no democracy whatsoever); 2. **Function of government** (how competent it is); 3. **Political culture** (which means proper political education); 4. **Political participation**; 5. **Civil liberties** (which includes free press and the right of association to civil institutions). On a yearly basis, Martian citizens are called upon to electronically evaluate each one of the aforementioned topics in order to favor constant self-criticism with regard to practiced democracy. Final scores from 0 to 3 turn on the danger alert of authoritarianism [note: North Korean level, 2019]; from >3 to 5, the regime is to be considered hybrid, democratic in some aspects but authoritarian in others [note: Venezuelan level, 2019]; from >5 to 8, democracy reigns, but it is flawed [note: Brazilian level, 2019]; from >8 to 10, the regime is considered democratically consolidated [note: Norwegian level, 2019].

Democratic model: a Martian parliamentarism: Koemitan/Nahootsoii are parliamentary, representative, democratic republics [note: San Marino, most ancient republic on Earth, offers inspiration]. Legislature is ruled by a Martian Parliament directly elected every three Martian years. Every citizen over 10 (Martian years) can vote and be voted. Candidates can represent zones, associations, professions, or ideologies. Gender equality is encouraged,

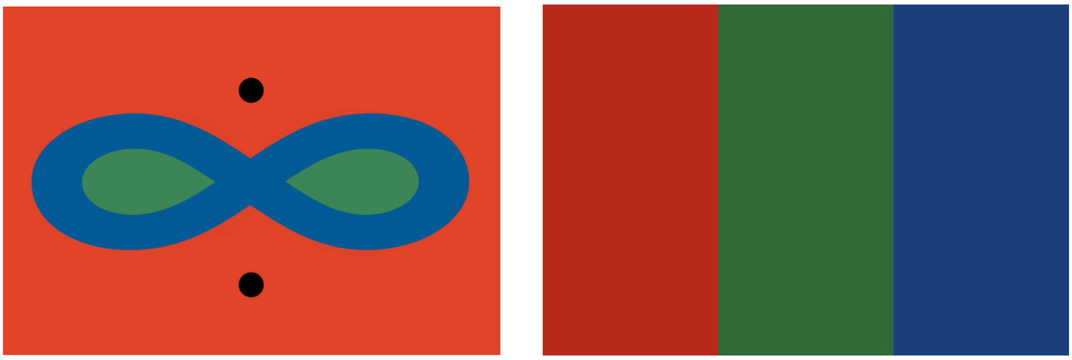


FIGURE 7 - Our eco-conservative flag **(left)**: the dual living, green cities surrounded by the Martian environment and its moons; Pascal Lee's flag **(right)**: stages of terraforming.

and it is forbidden to run for Parliament twice in a row. Candidate integrate parties, and votes are given to parties or candidates. Parties fills vacancies in proportion to votes received. The most voted candidates within a party are chosen to occupy the vacancies, unless the vote is given to the party (unnominated votes). In this case, the elected ones will proportionally distribute the unnominated votes among other candidates of the same party.

For instance, consider there are 100 vacancies available in the Martian Parliament, and the Eco-Conservative Party has obtained 22% of which; however, among all their votes, 100,000 were given for one candidate, 70,000 and 20,000 for the other two, and 30,000 were unnominated (that is, voters have voted for the party, not an individual). Other candidates of the same party received no votes. The party has the right to occupy 22 vacancies, but only three of which were nominated. Thus, 19 extra vacancies are given to other members of the party as follows: directly elected candidates choose their colleagues by merit proportion. In the example: candidate X has 100,000 votes (52.63% of the total nominated votes), candidate Y has 70,000 (36.84%), and candidate Z has 20,000 (10.53%). So, candidates X, Y, and Z share proportionally the 30,000 unnominated votes and choose, respectively, 10, 7, and 2 colleagues (final numbers are rounded) to occupy the other 19 vacancies. In the case of inexistence of other candidates, each elected candidate would represent more than one congressperson.

Regarding the number of members of the Martian Parliament, Earthling nations vastly differ in their ratio of parliamentary members to citizens since they do not follow any universal formula for assigning this number, and in most cases it is arbitrarily defined and remains fixed even when this state of affairs makes little sense. In Koemitan-Nahootsoii the number of representatives varies according to the population, following the Cube Root Rule [note: originally suggested by the Estonian political scientist Rein Taagepera in 1973], defining the number of representatives as the cube root of a given population size. Thus, for one million people, the minimum number of representatives is 100. When the population increases or decreases, so does the number of congresspeople [note: there is a congressional apportionment proposal currently running in the U.S. for just such a rule]. Following a mathematical formula is ipso facto considered to reflect reality. The Martian Parliament is represented for two ministers from different parties chosen by indirect elections, which ensures the balance of power. The ministers' mandate lasts one Martian year, and their role is above all fiscal and diplomatic. Finally, when the mandate of the Martian Parliament is over, complaints about their activities can be filed by any citizen. If the Judiciary Power accepts the complaints, so the representatives may be prosecuted under the terms of Martian law.

Judiciary Power: in order to speed up legal issues, civil cases are initially analyzed by a sophisticated AI that establishes judgment based on pure technical criteria. In the event of appealing, three human judges will evaluate the case and rapidly deny or validate the AI´s judgment. The last instance is the Supreme Court of the Martian Republic. It is composed of five members, the odd number guaranteeing a tie-break. Supreme Court members are chosen by the Parliament; except for the fifth, which is elected by citizens every five Martian years.

Martian Ministries are chosen by the Parliament according to their expertise in a relevant area of research. Our model is a few super-ministries divided in secretariats. Each secretariat is composed by secretaries who are chosen by ministers. Each secretary has three special advisors who are selected among the best college students, depending on their field of research. To serve as a special advisor works as a professional internship for students.

The **Ministry of Human Relations** has three secretariats: 1. **Interplanetary Diplomacy**, responsible for managing diplomatic ties among Mars, Earth, and other extraplanetary communities; 2. **Communication**, responsible for government communication with Martian citizens on a regular basis; 3. **The Ombudsman**.

The **Ministry of Human Intelligence** has four secretariats: 1. **Education**, including basic school, high school and college; 2. **Theoretical Research**, responsible for all postgraduate studies; 3. **Culture and Leisure**; 4. **Tourism**, responsible for implementing travel in the planet and its extraplanetary dominions.

The **Ministry of Science and Technology** is divided into five secretariats: 1. **Paraterraforming and Urban Development**; 2. **Agriculture and Food**; 3. **Martian and Asteroid Mining**; 4. **Progress and Innovation**, responsible for stem subjects; 5. **Public Commuting**.

The **Ministry of Finance** is responsible for four secretariats: 1. **Treasury**; 2. **Interplanetary Trade**; 3. **Martian Entrepreneurship**; 4. **Martian Basic Income**.

The **Ministry of Health** is divided into four secretariats: 1. **Prevention**; 2. **Sports**; 3. **Euthenics**, responsible for the improvement of human welfare and abilities by enhancing the quality of living conditions; 4. **Health Restoration**, which acts in order to provide medical care to arrange general procedures and surgery for those who have been affected by diseases or have suffered injuries.

The **Ministry of Public Security** has four secretariats: 1. **Spaceguard**, responsible for controlling defensive technology against cosmic impacts (and renders this service to Earth and other communities); 2. **Martian Police**; 3. **Rehabilitation**, responsible for those convicted of crimes; 4. **Justice and Human Rights**.

Legal basis for Martian citizenship: firstly, it is worth emphasizing the importance of a Naturalization Act for Earthlings as well as people from other Solar System places, that is, the moment in which the concept of "Martian citizenship" became valid, as a natural consequence of previous Earthling colonies on Mars becoming an independent City State. Thus, the first Martian citizens were all of whom, no matter their ethnicity, gender or age, had been for working at least three whole Martian years when autonomy was granted; therefore, being a first generation Martian did not depend on place of birth but solely on the effort and dedication to build a new world on Mars. In a nutshell, the Naturalization Act granted full citizenship equally for people from all over the Solar System who had dedicated their time and energy to help establish the City. Even while keeping and encouraging diplomatic and commercial ties to outer places, Mars society is not considered a colony anymore. It is sovereign.

Two citizenship models are common on Earth: *jus solis* (right by land) and *jus sanguinis* (right by blood). We advocate the first, the same model valid to all the North and South American nations: whoever is born on Mars is to be considered Martian, endowed with all rights and duties it implies. Even descendants of Martians who were born in alien contexts may be recognized as citizens, provided they are registered to a Martian embassy at a minor age. *Jus solis*, right by land, admits no exceptions. Being born on Mars after the Naturalization Act means to be a citizen. It is a natural right, not a concession whatsoever. The main advantage of *jus solis* regards strengthening relations between a person and the land in which he/she was born. A person who is considered a *jus sanguinis* citizen because his/her ancestors are of Martian origin, for example, could live on Earth or wherever with no further interests on the red planet, but having citizen´s rights, which is unreasonable.

Besides, a foreigner is allowed to apply for Martian citizenship by marriage, investment or whichever as long as he/she has attained legal adulthood according to local patterns. Given that naturalization is a concession, eventual requests are evaluated by the Ministry of Justice: they cannot be simply taken for granted. Concession rules consider if the candidate has not committed any crime in both Martian and alien jurisdiction, as well as his/her intrinsic worth as a citizen. Once citizenship is granted, it implies for the person and his/her descendants (provided they are at a minor age when the ancestor is naturalized) the same rights and duties of any Martian. Multiple citizenships are allowed, but in case of war between extraplanetary states, a choice must be made.

Social welfare and Martian lifestyle: policies for euthenics: From the Greek verb εὐθηνέω, formed by εὐ (*eu* = good) + τίθημι (*tithemi* = to cause), euthenics is the set of policies intending to enhance human welfare through the improvement of our living conditions in a planned, controllable environment. As Demosthenes once said about euthenics: *to be in a flourishing state, to abound in, to prosper.* From the start, Koemitan-Nahootsoii pursued euthenics, for, in the long run, living on Mars is justifiable only if such an experience means better welfare than we have on Earth. Since a Martian City State demands more scientific planning to be built, such a challenge offers the perfect opportunity to implement euthenics policies. In a nutshell, the mature Martian society invests in prevention more than in remediation: we invest deeply in flourishing lives, which is much wiser than correcting problems after they appear. Such a motto applies to both health and education, as following:

Euthenics in Health Services: instead of either prioritizing the cure of diseases, or seeking to achieve an ideal doctor-patient ratio, Martian euthenics policies focus on periodic individual exams executed by super-efficient domestic gadgets ruled by a central AI in order to prevent diseases. Improving prevention reduces the individual workload thereby giving physicians and nurses plenty of time and space to deal with patients who do need special care. In early 21st century Earth, even when a given therapy was effective, it tended to be applied far too late. [note: Italian experience demonstrates that by favoring family doctors and annual exams, such prevention policies decrease the number of surgeries and increase life expectancy by two years above the average of richer countries]. The Mars City State drives this prevention policy to a higher level: daily imperceptible exams instead of annual ones. [note: e.g., scientist and professor Sanjiv Gambhir (Stanford) proposes a smart toilet that routinely checks for users´ diseases] Adding a super accurate AI to future gadgets - smart toilets, smart watches, as well as many other wearable artifacts etc. - offers a great level of prevention; therefore [note: as predicted by Yuval Harari] nurses are more important than physicians, since a super AI perfectly substitutes human beings when it comes to diagnostic proceedings, but not concerning direct human care. A rate of one physician per 1,000 patients is perfectly enough to meet the needs of the Martian City given the high standards of prevention policies [note: current WHO statistics [22] report as much from 45% of Member States]. Such policies also include human reproduction advice and genetic counseling to avoid unnecessary suffering caused by malformation. This is a public service even if people are under no obligation to use it. Positive eugenics, which intends to select embryos according to racist theories, is deemed intrinsically immoral; however, negative eugenics seeks to correct conditions and diseases in embryos by using preventive genetic therapies.

Martian Education: as demonstrated by the Nobel Prize winning economist James Heckman [23], when it comes to education, the earlier the investment the greater the return. Heckman shows that a high IQ improves human success only by 2%, but teachable values as discipline, diligence and perseverance do lead to self-realization and benefits the whole society. That is, eugenics to enhance human intelligence by selecting gifted people to reproduce is not the best way to create a better society, but rather euthenics improving the environment up to an optimum level to make a real difference. After tracing a huge number of dysfunctional adults, Heckman identified how levels of social abilities were less encouraged at early age and how malnourished they were between ages 0-5 (in Earth years). His research demonstrates that the most efficient people are those who have received more early care; therefore, Martian society invests a lot in early nurturing, learning experiences and physical health from ages zero to three (in Martian years). Martian basic education and high school are totally public. Despite being also public, college and post-graduation are based on merit, demanding counterpart services to society. The University of Mars is an asset to Earthling universities in several fields, and several agreements were made possible (like dual-title graduation and post-graduation). Exchange programs based on Earth offer scholarships to the intellectual development of Earthling students on Mars. Additionally, fully online education systems provide vibrant opportunities of learning for both Earthlings and Martians. Among all fields of study, there are some which particularly make the University of Mars a great place to be enrolled, given unique Martian specificities: Astronomy, above all, given the absence of light pollution, the near absence of atmospheric interference, and top-notch, cutting-edge observational facilities. Also, Geology and Comparative Planetology, given the opportunities afforded for by the vast environment; Space Engineering and all branches of Engineering; new techniques in Agriculture. Considering the biotechnology involved to cultivate Martian soil as well the genetic modification of seeds, agriculture on Mars is quite useful in Earthling contexts; and also Medicine: Martian medicine, focusing on prevention through artificial intelligence, sets an example; and lastly, Arts and Architecture, as we comment below. On Metaphysics, Aristotle says “it is owing to their wonder that men both now begin and at first began to philosophize”. Not only does Martian lifestyle driven by automation favors contemplation, but the planet also evokes that original wonder that drives humanity to philosophical thinking.

Religion: despite following secular principles when it comes to politics and government, Koemitan-Nahootsoii is quite liberal with regard to the right of worshiping. All religions are allowed, as well as the right of not having any, given that beliefs are part of the set of individual choices, provided that no one tries to interfere with others' individual freedom. Thanks to AR/VR tech, people build virtual temples in which services and rituals are held. Besides, the government provides a physical Pantheon (from Greek πᾰν = all, θεον = gods), a neutral temple that offers space to physical celebrations for every soliciting group. When it comes to funerals, the Martian government provides a service inspired in Capsula Mundi, an Italian broad-based project that reformulates our ideas about death. Instead of putting corpses within a protected coffin to be buried in a field sown with cold grey tombstones, Capsula Mundi offers an egg-shaped pod made of biodegradable material in which a whole body (or its ashes) can be inserted. After sowing the egg, a tree is planted on, thus offering the Sacred Forest of Memory and Love instead of a cemetery. Families become caregivers of the trees as they grow: such a forest respects the principles of all ancient religions. Additionally, the forest if of great educational value: it reformulates the way we deal with death and integrates perfectly within the ecosystem.

The Martian Basic Income: a policy for human euthenics. Koemitan-Nahootsoii acknowledges the fact that the colonial first stage was characterized by hard work executed by people who aimed at an ambitious goal: to build a new society in a barren, but resource-rich, new world. From the start, both colonies, outposts, and the City itself sought to have all its basic functions ruled by automation. Such an automation demanded a high initial cost and labor as an investment for the human species. Whilst in early 21st century Earthling societies experienced relative anxiety about automation due to their fear of becoming obsolete and losing jobs, in Martian culture they do not. Since Koemitan-Nahootsoii is ruled by labor-saving technology, minimal human assistance is required, representing personal freedom for getting involved with more intellectual activities. As is well known, automation deters people from doing monotonous tasks; therefore, it represents freedom instead of danger. On the other hand, for security reasons, technical education is granted to all Martian citizens from childhood. So, in the case of failure of automation systems, every single citizen will be able to handle basic life support machines, with the help of redundant automation, self-diagnostics and backup hardware.

For a wide range of reasons, automation is linked to a policy in which every citizen receives a living wage after reaching adulthood. As pointed by the philosopher Phillipe van Parijs, in the wealthiest nations [24] productivity, wealth, and national income have advanced sufficiently far to support an adequate universal basic income. Thus, a Martian Basic Income (MBI) is sufficient to meet basic needs, allowing time and efforts to be invested in education, research, leisure, and well-paid activities that ultimately provide more income. Universal and unconditional by nature, MBI does not vary with an eventual increase or decrease of individual earnings. On Mars, one can be richer than the others through his/her own efforts, but poverty is a primitive state to be totally overcome by technology. Earthling objections to MBI usually appeal to the risk of laziness; however, the traditional differentiation between "work" and "leisure" does not make any sense in the context of our developed high-tech Martian culture, since human leisure is a way to improve the AI that executes any monotonous task in the City State. Even a person who spends his/her time by playing the whole day is actually feeding the AI with information and making it smarter, which promotes the common-good. Considering that current AIs are capable of replacing human agents in so many situations, in Martian society complex diagnostics procedures, as well as repetitive tasks, are fully taken care of by smart, but controllable, AIs. Having achieved the automation stage, Martians are free to dedicate their time and energy to scientific research, art, philosophy, education, leisure, relationships, cosmic adventures, space exploration and all kinds of endeavor that fulfill our search for a meaningful life. Above all, having no worries about monotonous and basic tasks, Martians have time to spare to take care of each other. The MBI policy follows liberal and democratic principles in a deep sense. According to Brazilian philosopher Renato Janine Ribeiro [25], equality must be in the starting point, not in the end result. Social inequality is justified, according to liberals, by individual efforts and talent. A truly liberal motto is expressed as: absolute equality of opportunities, incentives to difference, rewards for individual efforts and performance. Therefore, any previous unequal condition at the entrance of people in the world of work should be as little as possible [25]. MBI consequently ensures equality in the starting point as much as possible.

Aesthetics in the Martian society makes itself felt, on a very first level, in the immediate environment and the way it integrates with day-to-day activities, like work, rest, feeding, leisure, sleeping, the basis of which is architecture. Designs and layouts of living, recreational and working quarters reflect a preoccupation with functionality but acknowledge aesthetic pleasure, promoting comfort for body and mind. The designs favor low cost and rely exclusively on locally available material and expertise. Living on Mars has created new and spontaneous artistic expressions well connected to the Martian environment and way of life.

As the principal style for public spaces, we take inspiration from the highly ornamental Solarpunk aesthetics (figure 8), a kind of futuristic art nouveau architecture whose curving lines and shapes import their artistry from natural forms like trees, mountains, snowflakes and galaxies. The style mixes glass and wrought iron to build sculptural environments that are not only places to stay in, but also pieces of art that invite people to be absorbed in contemplation of sublime beauty. Architects were called for to plan unique spaces to the city, ambiences that offer an immersive experience, overcoming the monotonous simplicity of the Bauhaus style (which was the main aesthetic style during the colonial stage, given its practicality). After achieving the City stage, society became solid enough to invest time and energy in more complex ornaments. Getting inspiration from cities like Prague and Paris, the Martian City State is known to cause Stendhal syndrome in Earthling tourists and students, such is its radiance!

The City design prioritizes an active commute for health reasons. Walking commuting in cities like London, for instance, is common ground when distances do not surpass 1 km, but on Mars this limit can be augmented to 3 km due to the weaker gravity.

FIGURE 8 – (top row, left to right) *Solarpunk/Art Nouveau interiors, curving lines inspired from natural forms, giving the impression of an organic scenario that inspires artistic contemplation: Hotel Hannon in Brussels; Victorian Style sunroom, by Virtual Studio Innovations; proposed underground street with solarpunk style, favoring the walkaround, in Jerez, Spain, picture by Mark Richard Beaulieu;* **(bottom row)** *Gothic Conservatory, by Adale Rene.*

CONCLUDING REMARKS

In this article, our team summarized the possibilities of a City State in which humankind can live not only as if we were on Earth, but in a better place. We have drawn upon imagination and solid science alike, and we strove for practicality but allowed ourselves to dream and to seek a better future. After all, wherever humans are found, the impulse of moving forward is the main constant. Our expansionist tendencies are not in opposition to nature. As human beings, we have been enduring discomfort in inhospitable places and have tamed them at will, and by doing so we are perhaps following nature's plan. Since the beginning, philosophers have been asking whether the universe has a *telos*, a finality, a goal. If it has, we are executing the mysterious plan of existence, spreading life across the cosmos, as sustained by the philosopher Teilhard de Chardin and the biologist Julian Huxley. If it has not, as sustained by some existentialists, so we are creating finalities through our imagination. It does not matter who is right, in both cases **wondering is the keyword**.

Lastly, we would like to liken our design to an excerpt written by Foucault [17] in which he emphasizes the importance of ships crossing the sea and talks about colonies. After all, spaceships are ships that cross the sky, and who will deny that the Martian City State is an augmented, super-efficient colony? The Martian City is an extreme type of heterotopia, and as we consider, after all, that the spaceship is a floating piece of space, a place without a place, that exists by itself, that is closed in on itself and at the same time is given over to the infinity of the sky and that, from world to world, it goes as far as the colonies in search of the most precious treasures they conceal in their gardens, we can all understand why the ship has not only been for our civilization, from the 16th century up to the present, the great instrument of economic development, but has been simultaneously the greatest reserve of the imagination. The ship is the heterotopia par excellence. In civilizations without ships, dreams dry up, espionage takes the place of adventure, and the police take the place of pirates.

Get aboard your spaceship. Do not let dreams dry up. Be a pirate. Onward, Martians!

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