ATHENS: A BEACON OF FREEDOM AND PROGRESS IN HELLAS PLANITIA

PETER R. HAGUE PHD

1. Land, Liberty and Latency

Why would anybody want to live on Mars? What does it offer that Earth does not? There are a number of individuals already commited to going to Mars; but for a general population merely looking to improve their own lives, there are three main reaons:

(1) Land. A new settlement on Mars will have almost unlimited land to offer as an incentive to prospective citizens. Unlike presently unused land on Earth, this land would be located close to the major transport infrastructure - the spaceport from which the settlement expands.
(2) Liberty. Every square centimetre of the Earth's surface is under some form of administration - be it that of a nation state or international laws and treaties. None of this exists on Mars and the Outer Space Treaty has no direct means of enforcement there. A Mars settlement can potentially offer a degree of political freedom which is increasingly scarce on Earth.
(3) Latency. The time it takes light to travel between Earth and Mars is on the order of tens of minutes, making much of our networked computing impossible between planets. This natural barrier can liberate Martians from the somewhat overbearing control of Terrestrial tech companies. Without the ability to activate a dopamine response in real time, they will have less hold on people. This provides the opportunity to create a new wave of information technology.

A successful settlement must leverage all of these things to be appealing enough for people to migrate from Earth to in large numbers. Here I will outline a city that can provide living space for all its new arrivals, as well as political and economic freedom. The sheer distance of Mars provides latency. The new city will be located in Hellas Planitia, and thus takes the name of the capital of Greece.

Hellas Planitia has the advantage of low elevation and thus higher pressures than elsewhere on Mars. Radiation shielding is increased a little, mitigating most of the threat from solar flares and a significant part of that from Galactic Cosmic Rays (GCRs), and in addition landing is easier. Geological features in the northwest part of the crater suggest the presence of a subsurface ice layer which can be used as a resource[1]. The site for the city will be in this area, which also has the advantage of being closer to the equator than other parts of Hellas and thus provides more sunlight.

E-mail address: `peterhague@protonmail.com`.

2. Economics

Using the projected interplantary transport infrastructure, materials must be imported from Earth at a cost of \$500/kg. This is based on projected commercial capabilities, and could in principle be lowered if a country were to adopt a mass-based subsisdy as I have suggested elsewhere[2].

Cargo will also only be available once every 26 months due to the occurance of Earth-Mars launch windows. I will divide cargo into low value goods, which can be presumed to have negligible cost on Earth and thus making their cost on Mars \$500/kg, and high value goods with will be assumed to have a per kg cost equal to the shipment cost, and thus their cost on Mars will be \$1000/kg

The economic viability of the city depends on minimising imported goods. If the Martian currency is pegged to imports, i.e. each unit of currency entitles the bearer to import 1g of cargo from Earth, then self interested economic agents trying to maximise their access to imports will be motivated to minimise the fraction of imported goods in the goods and services they sell on Mars. This model is similar to that which was used in the fictional Moon settlement depicted in Andy Weir's *Artemis*. Innovative ways will be found to substitute imports for local materials, and use those materials more efficiently, generating wealth for the city directly and also in some cases through producing intellectual property than can be exported to Earth. The work required to make extra-terrestrial settlement sustainable will be found in the enterprise of the individual settler as they conduct their own economic affairs.

In exchange for the right to settle in Athens and a home, each settler will pay a minimum of \$10,000 into an endowment. Larger contributions will grant larger accomodation, and a higher income once there. A settler is not permitted to remove their principal from the endowment, unless they leave the city to return to Earth. The required contribution to the endowment should also scale with proximity to the most connected hub (see below for how hubs will work) - such pricing will naturally arise if specific locations in the city have to be bid for by potential settlers.

Given that the endowment for a city of a million people will then be at minimum \$10bn, it can be assumed that the management costs are negligible. The returns are taken to be 5% given the long run average growth of the Dow Jones Industrial Average - a conservative assumption given the historical performance of comparably sized endowments for universities. The return on each settlers contribution will be used to ship cargo to them and thus provide an income in terms of the gram-linked currency. The minimum \$10,000 contribution would thus allow the import of 1kg of low value goods or 500g of high value goods per terrestrial year (or 2.17kg of low value goods or 1.08kg of high value goods per synodic cycle). Total import capacity of the city will be greater than 2000 tonnes of low value goods per 26 month synodic cycle, without needed to export in return.

Informational goods, such as patents, that Martians generate and trade back to Earth will yield money their creators will wish to convert into local Athens currency - and such conversion is performed by paying revenues generated on Earth into the endowment and giving the creator the resultant cargo allowance. Both the arrival of new settlers and the trade of informational goods will increase the flow of supplies from Earth.

3. Energy and heating

The city will need electircal power to survive and to grow. Parabolic trough solar concentrators will provide heat to habitats, and also some electricty. They are easier to manufacture than photovoltaic cells and are close to the ground for easier maintenence. Wind power will also be used to provide electricty, as well as biomass generation if available. Worse dust storms in the denser atmosphere at the bottom of Hellas could be offset by the use of wind turbine and artificial light to keep plants alive whilst solar power is unavailable. Nuclear energy may be used, but it is unlikely to be a core energy source as it requires a large industrial base to manufacture locally, so it cannot be scaled without dependence on imports from Earth until Mars is at a substantially large scale and higher state of development.

At apoapsis, Mars has a solar flux of 0.5kW/m^2, compared to 1.37kW/m^2. For an estimate of the heating requirements, I will assume that the shortfall of solar energy must be made up for the area of the dome. For a 5000m^2 domestead, and assuming a 90% efficiency of solar thermal heating, that would require an area of roughly 8800m^2. These heating requirements are a conservative estimate, because good insulation can reduce the requirements somewhat.

In addition, solar thermal energy should be used to generate electricity at a lower efficiency of 5%. Taking a household annual energy use of 13,000kwh/a (the value for a typical US household), which amounts to about 1.5kW continuous power, and a 1/3 duty cycle, this would mean an additional 180m^2 is needed for electricity generation - along with sufficient storage. The total approximately equals a square collecting area 95 metres on each side for each domestead.

4. Habitat design

Habitats in Athens will be designed with three principles in mind:

1. We wish to minimise time averaged cosmic ray doses, whilst providing maximal natural light.
2. Light can be reflected around corners, whereas cosmic radiation will not be. Some secondary radiation from the impacted surface, such as neutrons, will be emitted by surfaces impinged by GCRs, but at a lower quantity.
3. Cosmic ray flux is noticeably more intense from the zenith direction than it is from the horizon, due to path length through the atmosphere.

On Earth, we have 1000g/cm^2 of atmospheric shielding at zenith, and this mass is supported by the pressure of gas at the surface. Martian Architecture will take advantage of the fact that normal atmospheric pressure is strong enough to support sufficient shielding. In fact, the lower gravity of Mars means that air pressure can support 1000g/cm^2 with a 2.5 fold redundancy. A shield 6m thick made of Martian regolith provides this level of protection; if less shielding is found to be needed, a 2m thick shield would provide comprable depth as found at the cruising altitude of civilian aircraft.

The basic residential unit will be a "domestead". This will be a steel framed geodesic dome with a shielded dwelling at its centre. The dome will enclose a family farm, that should be as self sufficient as possible for heat and power, and produce a surplus output of biological matter and other goods. The size of the dome is limited by the strength of

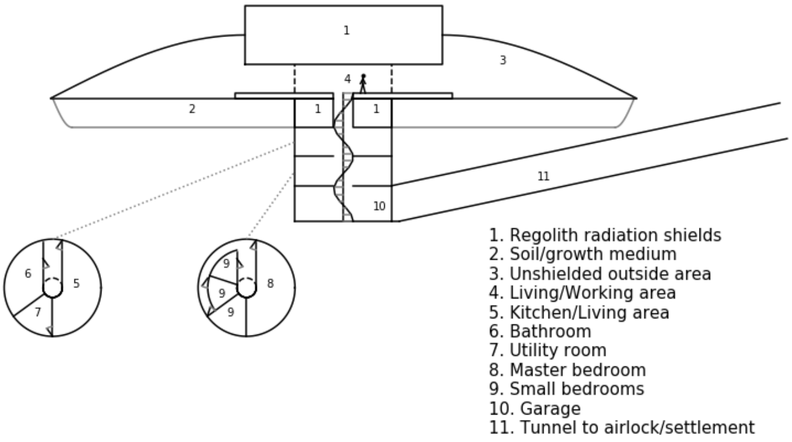

Figure 1. The interior layout of a domestead

material required to keep it anchored to the ground, which increases with area. In this case, it will be held down by a steel frame, with glass, EFTE or acrylic (PMMA) panels (depending on which is easier to manufacture locally).

The stress at the perimeter of the domestead is equal to the area mutlplied by the internal pressure (which will be the same as Earth sea level), which practically limits it's size if it must support itself. The weight of the shield counteracts some of this stress, but still at a 30 metre radius, material that is 2.5cm thick at this point would experience a stress of around 58 MPa. The structure should be able to handle this, but additional anchoring cables inside the dome may be desirable so that the exterior does not have to take all of the stress.

At the centre of the dome is the house, which is a 10 metre diameter cylinder. From top to bottom, there is a 6 metre thick radiation shield, which sits on the top of the dome supported by gas pressure and extends an additional 5m beyond the edge of the house. Below that a living/working area, which is demarked by glass panels at an inset from the edge of the radiation shield. A spiral ramp leads down from here to three subterranian levels; the first level down is a kitchen, bathroom, and extra living space, and then the second level contains bedrooms. Below that is a garage area, from a tunnel is bored to meet up with the pressurised transport infrastructure of the city beyond the edge of the dome. The layout is shown in Figure 1

Houses of similar design, but without the enclosing dome, will be found in all levels of hubs. These will house the industrial workforce, and be available to those making the minimum contribution to the endowment. Such houses will have roof gardens in which they can grow some food, but this is not included in the calculations for the agricultural output of the city.

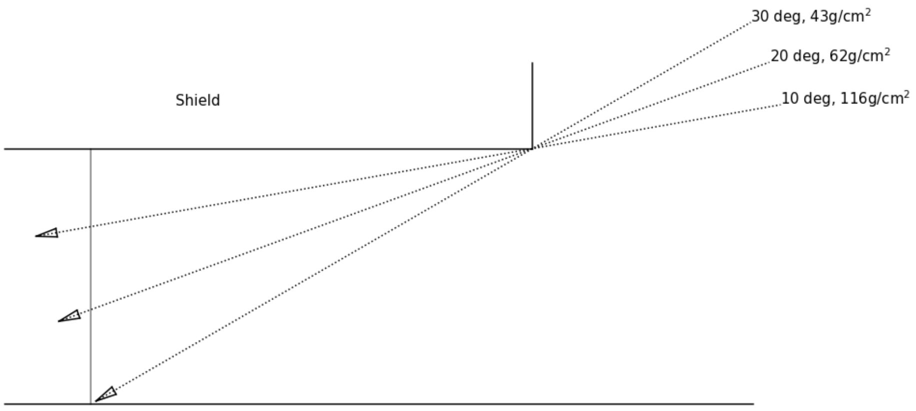

Figure 2. Examples of paths that GCRs can enter the habitat by. Each is labelled with the angle in degrees and the atmospheric depth along that path. No path steeper than 30 degrees can enter through the window.

The food produced by the domestead will be protected from potentially hazardous elements in the Martian regolith, such as perchlorate salts, by a defence in depth. Airlocks, typically located in hubs but can by optionally installed on the dome wall itself, will include facilities for cleaning suits and people entering. On the porch area outside the glass boundary of the living area, there will be a foot washing station as well. In addition, food will be tested for environmental toxins routinely to ensure the first two barriers have not been breached.

For calculating the cosmic ray exposure of residents I use a lookup table for doses at various atmospheric depth, calucated using the EMMREM model[3], to show how to reduce GCR dose whilst maintaining ample natural light. The radiation model is taken from close to a solar minium and thus a time of maximum GCR exposure, and the thickness of atmosphere at zenith is assumed to be 22g/cm^2, which leads to a depth of over 400g/cm^2 in the direction of the horizon. The EMMREM table only extends to 300g/cm^2, and so a linear extrapolation is used for higher values. The depth only exceeds 300g/cm^2 at angles shallower than 2.4 degrees above the horizon, and this extrapolation will not introduce significant error.

Between the shadowing of Mars itself and the atmospheric shielding, the GCR radiation dose in the essentially unprotected areas under the dome is 230mSv/a in this model. This is consistent with the values from other radiation models[4]. The dose in the underground area is close to 0mSv/a, and a dose in the above ground living area, which shields all rays from a higher angle than 30 degrees, will be no more than 100mSv/a at the edge. This is shown in Figure 2. The dose will be lower in the middle of the room, but here we take the most conservative maximum dose.

Time between these areas can be balanced to manage radiation exposure. The current occupational limit for US radiation workers of 50mSv/a[5] can be observerd by spending approximately 13.6 hours of each sol underground, 10 hours in the above ground living area, and 1 hour outside shielding. An alternate pattern for achieving this would be 16 hours underground, 5 hours in the living area, and 3.6 hours in the unshielded area. Given that residents will spend 8 hours of their day sleeping underground, this should not leave people unduly deprived of natural light. Furthermore, Sun tunnels with S-bends in them can be used to bring additional natural light through cosmic ray shielding. Radiation doses will be monitored by portable or wearable electronics, in a fashion analogous to how people currently measure their steps or their heart rate. The device will either have a dosimeter in it, or communicate with dosimeters scattered around the settlement to calculate the users dose.

It is easily possible that the 50mSv/a limit is overly conservative, and could be relaxed once the radiation environment and its effects are better understood. If it is safe to exceed it by a factor of 5, then the radiation monitoring described above would not be necceary for most adults. Research will be conducted on Mars into the actual health impacts of radiation; but ultimately exposure levels should be left down to the informed choice of individuals.

Pregnant women have a limit of 5mSv over the length of the entire pregnancy[6]. Annualised to a rate of 6.3mSv/a, this is far below the occupational limits that adults can work to. With the above values, this would allow no more than 1.5 hours in the above ground living area, and no time in the unshielded area. The exit of the domestead is underground, so this level of radiation sensitivity will not confine a woman to one habitat for the duration. The difficulty of detecting early pregnancy may also mean that by the time a woman is aware she is pregnant some radiation may have already been absorbed; the adult radiation limit would deliver about 2mSv in 2 weeks. This is not ideal, but not likely to be catastrophic. Women planning pregnancy may wish to manage their radiation exposure as if already pregnant.

Whilst young children must be protected from cosmic radiation; current dose limits are only 5mSv/a for all minors[7]. It is not realistic for the safe radiation limit to suddenly jump up by a factor of ten the moment someone turns 18; a more gradually changing limit should be figured out for the city, so that as children grow up they gain progressively more freedom.

The domesteads provide food and oxygen production for the settlement, and will operate as self-contained bioregenerative life support systems, even thought they are connected to a larger settlement; a high degree of self sufficiency in life support is necessary for political and economic freedom in as harsh an environment as Mars. To estimate how much mass input is required, I will use the Soviet BIOS-3 experiment as an model for how a domestead might perform, as the more recent Chinese Lunar Palace 1 experiment has less publicly availbale data about the experiment, and the Biosphere 2 experiment suffered from poor design and faced issues that are not generalisable to other bioregenerative life support systems.

Each crewmember during the BIOS-3 experiments required 598g of external inputs per day, of which 208g of which was food, 350g plant nutrients and 28g salt[8]. Given that settlers putting $10,000 into the endowment would be able to receive around 1kg

Mass/day (g)	Mass/launch window (kg)	Endowment per person (USD)
600	474.825	$4,748,250
380	300.7225	$3,007,225
30	23.74125	$237,413
12	9.4965	$94,965
6	4.74825	$47,483
3	2.374125	$23,741
2	1.58275	$15,828
1	0.791375	$7,914

Table 1. Scaling of the endowment contribution needed to sustain indepedent life on Mars versus the mass inputs of the habitat. All values in this table are per person

per terrestrial year from Earth even if the costs there were negligible, this level of closure must be improved upon. Food import should be resolved by having multiple habitats; variation in diet can be provided by having domesteads specialise. Common salt, or a viable substitute, will be extracted or manufactured locally. The large outstanding item here is plant nutrients. Closing the cycle on these will be undertaken in the first level 1 hub deployed, and scaled along with the expansion of the city. This would level 12.2g per day per person as an input requirement; in BIOS-3 this was water purifaction and hygeine products. To import these directly would burn through a 1kg mass allowance in around 80 days, so some improvement on closure, by a factor of 12 or so, would be required here as well to allow the domesteads to remain solvent. Table 1 shows how much extra a settler would have to pay into the endowment at various levels of closure.

These estimates show the importance of advancing bioregenerative life support systems as much as possible before large scale settlement on Mars, and continuously improving it whilst there. Each gram of input no longer required significantly improves the prosperity of the domesteader. Of course, the Martians themselves will know this, and be keenly motivated to perfect the art. The initial settlers who do this will be wealthier ones who can pay a larger share to the endowment; as the city grows the minimum value should then come down to the target of $10,000.

A projection from the BIOS-3 experiment states that, if 100% food closure is achieved, 56 square metres per person of plants will be required. We shall take this as a reasonable estimate for the performance of agriculture in a domestead, even thought the actual plants used will likely differ. Given a domestead of 30m radius with a house of 10m radius in the centre, and 5 occupants, then the population engaged in agriculture will be around 11%, as it is in the present day US. If it turns out that more land is required to support the population, then non-residential domes can be added, based on a similar design to the domestead. Roof gardens of other residents can also supplement food production.

5. Local Materials and Construction

All domesteads and hubs should where possible be constructed of local materials; its purpose is to attract settlers and to add their contributions to the endowment to the settlements capacity to send cargo from Earth.

The initial ISRU setup of a Mars base can provide oxygen, methane and carbon monoxide. The latter can be used with iron (III) oxide to manufacture steel. Ethylene can be manufactured from methane, and from there polymer chemistry can begin. Concrete, bricks, glass and transparent polymers will also be needed. These basic materials will make up the majority of the building materials used in the city. Organic elements such as carbon, oxygen and nitrogen should constantly be bought into the settlement from the environment, to constantly increase the total biomass present. This facilitates the construction of new domesteads for arriving settlers, and it also allows the stockpiling of waste biomass for times of low power availability.

Boring machines will only be used for the short tunnels that connect the base of habitats to the surface tunnel network; which will be construced by excavating, installing the tunnel, and then covering it over again with the same material. The same method of digging and covring will be used for construction of hubs and domesteads.

6. City design

The city will be a network of habitats connected by tunnels. Tunnels will be bored into the ground to meet the base of each habitat, but will run nearer the surface most of their distance to save on the use of boring machines. Surface tunnels will be created by scooping out a semicircular cross section from the ground, and then adding an inflatable tunnal and pushing the excavated material back over the top of it.

The basic domestead described above will be connected to a level 1 hub, along with five other domesteads. This can be the initial settlement which will lead to the construction of the city. The level 1 hub connects to a level 2 hub when more space is needed, and so on up to a level 5 hub. There will be 3 level 5 hubs in the completed city, linking to each other in a ring. Each hub is built with 8 connections, 6 of which are used for subunits in the initial construction, one connects to the parent hub, and one is available to interconnect to hubs on the same level. For the level 5 hub, the extra connections are used for connections to the two other level 5 hubs.

Each hub contains accomodation for non-agricultural workers, and the populations are calculated so as to reduce the fraction of the workforce employed in agriculture to 11% (the current level in the United States) by the time the city is complete. This is shown in Table 6

A connection tax will be levied inversely proportional to the number of steps to the most connected current hub; analagous to a land value tax on Earth

Hubs are cylindrical areas dug out of the ground and then covered with 6 metres of regolith once constructed. Their size and layout is shown in Figure3. The interior height of each hub is 15 metres, with the street level being 3 metres above the base. The area in the centre of each hub is free for whatever purpose that particular hub might serve; it might house a factory, commercial area, or perhaps a park or a small lake. Schools and childcare facilities will be common in the lower level hubs, where more people live, and large scale industrial facilities common in higher level hubs.

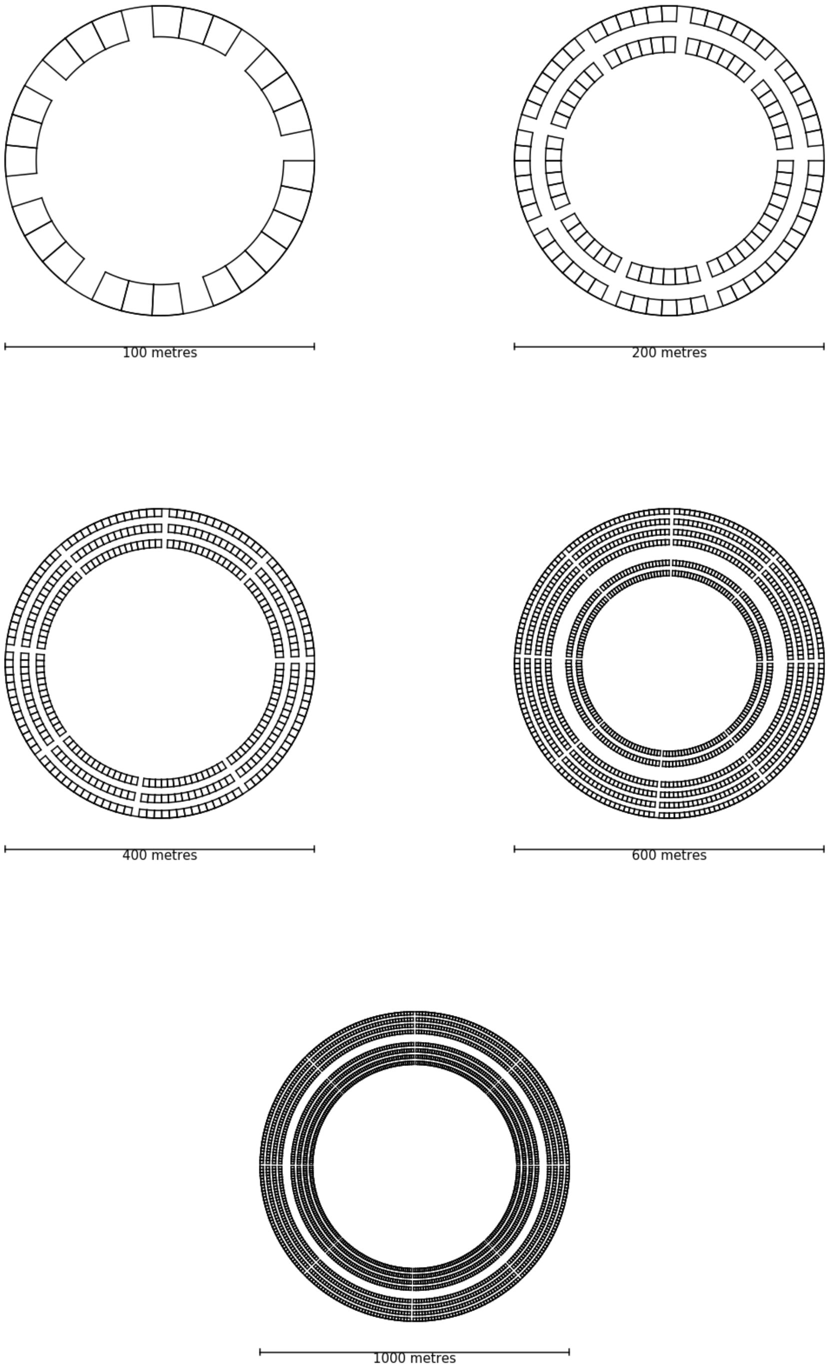

Figure 3. Layout of housing in each level hub from 1 to 5

	Unit population	Subunits	Total population	Agriculture %
Domestead	5	0	5	100.0%
Hub 1	100	6	130	23.1%
Hub 2	500	6	1280	14.1%
Hub 3	1000	6	8680	12.4%
Hub 4	5000	6	57080	11.4%
Hub 5	10000	6	352480	11.0%
City	0	3	1057440	11.0%

Table 2. The population of each component of the city,

Each house within a hub is roughly 10m x 10m, with two stories above the street and one below, and offers comparable space to the houses in domesteads. Their roofs are not flush to the ceiling of the hub; this both allows a roof garden for each resident, and helps give a sense of their being an ‘outside’. Construction of these houses will not be vastly different from the construction of terrestrial homes.

The hub will be brightly lit from its ceiling, using a combination of artifical light and reflected natural light transported through s-shaped light tunnels in the radiation shield. As with the domestead houses, the bottom level of each hub house is a garage, and is located below the street level. This sub-street level is the only place large wheeled vehicles are allowed - roads connecting to exit tunnels are here as well as visitor parking.

The market-driven construction of the city might cause transportation issues compared with a more top-down planned approach; this should not be a problem given the availability of tunnel boring machines. When additional transport networks are required, they can be added below the city.

Figure 4 shows an example of part of the layout of the city.

7. Robotics and Information Technology

The city will make extensive use of robots for labour saving reasons and to reduce the need for EVA on the surface. For many applications robots can be autonomous, but in some cases human operators will be required. Teleoperating robots will allow those who must or who choose to reduce their radiation exposure, such as pregnant women or teenagers, to contribute to surface activities.

Drones for use within domes will undertake agricultural work, as well as repairing leaks. Within the pressurised environment, the same design of quadcopter drones that are found on Earth will be used - and will have a larger payload due to the lower gravity. Given that domes and hubs are supported by internal pressure, repairing leaks quickly is a high priority. Sensors situated around the habitat will determine from air currents where the leak is - this may require the application of machine learning as the data are likely to be noisy - and then drones will autonmatically fly to the spot in question and patch it, pending a more thorough repair. To extend the time allowed for this to happen, each habitat will have a supply of compressed air to maintain pressure for longer.

To clean dust from outside surfaces such as solar collects, drones will be used to reduce the requirements for EVA. They will be helicopter designs, scaled up from the *Ingenuity*

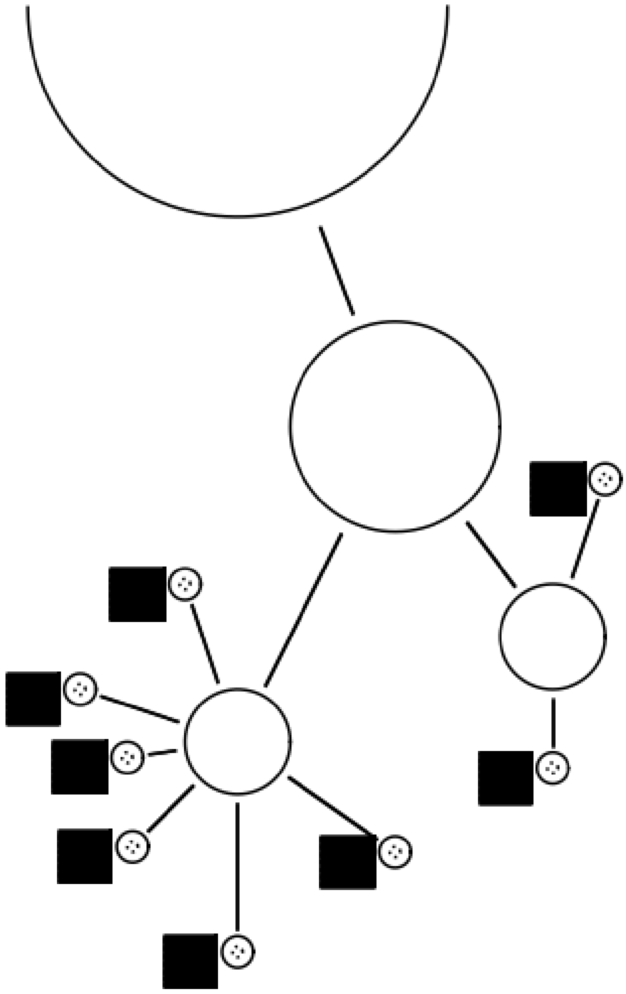

FIGURE 4. Layout of part of the city. Domesteads along with level 1, 2, and 3 hubs are shown. The connecting tunnels are buried near the surface for the distance shown, and then connect with bored tunnels near each dome or hub, which connect to the base of that component.

drone currently scheduled to fly to Mars, and will carry a gas canister to blow away dust[1]. The helicopter will be based at a small charging station near to whatever it must clean, to reduce the flight time and thus the battery requirements. Cameras overlooking the collectors will determine when they need cleaning through image classification software, and drones will be guided by comparing these images with their own on board cameras. Outside work that can be conducted closer to the ground will be done by quadrapedal robots such as Boston Dynamics' Spot[9]; these will be better on rough terrain than wheeled robots.

Tunnel boring is minimised in the city design, but in order to allow underground access each dome will require at least one tunnel; to reduce labour costs it makes sense to automate these devices as much as possible. The excavators used to dig out surface tunnels and habitats should also be automated for the same reason.

Residents will make use of portable electronic devices similar to smartphones. Such devices will be used to monitor radiation exposure, and will also function as a fob to open doors and to access vehicles, which will make it harder to forget to carry them. In addition, they will perform similar functions to our current devices, but be smaller and less designed for distraction - we do not need to recapitulate that particular problem on Mars. An example of a current design that attempts to rethink smartphones in this way is the Light Phone[10]. It may be the case that wearable devices entirely displace carryable devices; the fact that smart watches came to market after smart phones means we can't know if people would have bothered with smart phones if watches had become popular first. Being severed from established information technologies on Earth will give the opportunity to explore the space of possible systems as a society.

The city should be careful from the outset not to allow the vast harvesting of personal data by businesses. Data protection laws must be strict, especially for export of personal data back to Earth. This should be easy to enforce; the difficulty of communicating across interplanetary distances with significant bandwith means that the city government will likely operate the only facility capable of doing this, and it will be expensive to operate. This and the latency of tens of minutes will make the terrestrial Internet largely useless to Martians; emails without attachments will be sent, but not much else.

Ubiquitous wireless networking will be needed throughout the city. Wired networking will still be used - given the increasing fraction of things which use electrical power from sockets also needing a network connection, a data connection will be included in the standard plugs used.

The manufacture of paper is intensive both in terms of power and in terms of consumption of biomatter. Given this, Athens should strive to ensure all buereaucratic systems and offices are truly paperless. The modes of work that enable this may also inform Earth on how to achieve this.

8. Social Organisation

The administration of the colony will take a small portion of the imported goods - essentially levying a tariff - and this will be its primary revenue source. This money will be spent locally on manufacturing new domesteads for settlers, and for support for

---

[1] Sadly, it is not possible to fly a drone using the gas for thrust; the tank to hold sufficiently pressurised cold gas to produce thrust would be too heavy for the vehicle to leave the ground, even in Martian gravity.

families. The government shall be democratic, with separate branches of government, modelled on the best traditions of liberal democracies on Earth. A supermajority will be required to take a larger segment of the endowment, or perform any other modification to it, as this will be considered a constitutional issue. There will be a small unicameral legislature - the city is too small to justify a larger bicameral system - and the voting system shall be mixed member proportional. This system is proven in several places on Earth and tends to avoid producing rigid two party systems. A Mayor shall be elected through a multi round system.

A written constitution for the city shall forbid the government from infringing free speech, privacy, free association and freedom of worship. These shall be closely modelled on already accepted liberal principles, and in addition there will be special notice paid to protecting the citizens from digital surveillance and abuse of private data.

Areas of the city must be provided where natural light is reflected around radiation shields to allow children and pregnant women to get enough natural light. Childbearing and child rearing must be made as comfortable as possible for all concerned if the city is to flourish; there is to be a basic income granted to all parents based on the number of children they have. Given that children born in the city will not have a stake in the endowment as new settlers will, each birth will mean that the per capita mass of imports from Earth will go down. To avoid a plunge into poverty, the wealth generated per kg of imported goods must increase at the same rate as natal population increase - or preferably, at a higher rate. Matching birth rates to economic development will be a major task of the government.

If Mars, and the wider solar system, are to be populated then natalist policies must be pursued. Developed terrestrial nations have thus far largely avoided the question of how to reconcile a progressive, egalitarian society with the need to produce enough children to propagate society. This question must be tackled head on by the Martians. How can a society grow in number without rolling back the emancipation of women?

The young, educated and forward thinking settlers that Athens should attract will be unlikely to accept a return to strict traditional gender roles. We must look forward to solve this problem, not backwards. Our present technological level necessitates that mothers and not fathers be subject to 9 months of radiological purdah, but beyond that burdens of childcare should be shared equitably. Ample childcare facilities should be provided so that parents are able to work. Given the importance of natalism to the city, those employed in childcare should be the largest portion of the government workforce.

9. Summary

The goal of Athens is to support a population of 1 million settlers such that they can both prosper personally, and they can continue to expand and build civilisation on Mars by continuously producing more with fewer inputs from Earth.

The story of Athens does not stop at a million people. It is designed to produce surplus material and to continue attracting new settlers. It can grow as a city, or it can support the creation of other cities elsewhere on Mars. From such cities a nation can be built, and that nation will have a space program. Technically adept and burdened by much less gravity than any nation on Earth, the Martian nation can then spearhead the humanisation of the solar system and beyond. Any future in space we imagine can be created from the first city on Mars, and the engine of this creation will be the everyday labour of the people who live there, working to better their own lives and improve their own community, and seeking land, liberty, and latency.

References

[1] Bernhardt, H., Reiss, D., Hiesinger, H. & Ivanov, M. A. The honeycomb terrain on the hellas basin floor, mars: A case for salt or ice diapirism. *Journal of Geophysical Research: Planets* **121**, 714–738 (2016). URL `https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2016JE005007`. `https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016JE005007`.

[2] Hague, P. R. A metric of solar system development. *New Space* (2020).

[3] L. W. Townsend, M. PourArsalan, F. A. Cucinotta, M. Y. Kim & N. A. Schwadron. Transmission of galactic cosmic rays through mars atmosphere. *Space Weather* **9** (2011).

[4] Tony C. Slaba, Christopher J. Mertens & Steve R. Blattnig. Radiation shielding optimization on mars (2013).

[5] Nrc regulations title 10, code of federal regulations part 20.1201 .

[6] Nrc regulations title 10, code of federal regulations part 20.1208 .

[7] Nrc regulations title 10, code of federal regulations part 20.1207 .

[8] Salisbury, Frank B., Gitelson, Josef I. & Genry M. Lisovsky. Bios-3: Siberian experiments in bioregenerative life support (1997).

[9] `https://www.bostondynamics.com/spot` .

[10] `https://www.thelightphone.com/` .