Habitat design – Mars ex-situ and in-situ resources utilization

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Abstract

This paper is intended to introduce new conceptual architectural designs and engineering proposals developed by the author to: create maximum internal efficiency in a Martian habitat, to provide great interior expansions when ready to be used on Mars surface but able to compact itself in order to be transported, to maximize the interior useful area, to use some of the most abundant materials in Mars with no physical/chemical transformation, and in the process offer the crucial radiation shielding to preserve the life of those living in it. The habitat developed, is composed of three parts, the first part is a metallic structure that will be shipped from Earth with all the materials and equipment that cannot be manufactured in Mars by an initial settlement, the second part will be a pneumatic structure composed of: an inflatable membrane structure to hold the interior atmosphere of 1 bar, embedded to a containment chamber for Mars regolith that will work as radiation shield, and the third part will consist in a conceptual automated gathering system that collects and transport Mars regolith into the deposit chambers mentioned before. The goal is to make the habitat economically and physically viable for possible future missions.

I. Introduction

The word ex-situ means the opposite of in-situ, therefore the systems to be demonstrated in this papers, are concepts of possible ways to efficiently use Earth´s and Mars resources to increase the feasibility of humans living in Mars for long periods of time or even in permanent colonies. The design is based on a conceptual architectural and engineering proposal for a Scientific Mars Station, which includes solutions for the habitat to efficiently grow over time, to expand and compact its modular elements in order to be transported, and to extract, transport and use Mars resources.

On Earth new materials, that goes beyond the physical capabilities of their predecessors, appears from time to time, and an example is the new lightweight steel that was created in 2015 by researchers in Korea that are lighter and cheaper than regular steel, and as strong as some titanium alloys.[8] Materials like this can be very interesting to building habitats, but since they are made ex-situ to Mars, it would be necessary to transport them. In this paper it will be presented a new method of compacting and expanding big habitable structures in order to transport them.

On Mars the surface is covered with regolith, and certain regions like Elysium Planitia, which was chosen to be the initial location of the Station (due to data analyses on temperature, water and elevation), was assessed to have certain areas with a minimum of 5 meters thick of regolith on the surface.[1] This conceptual project uses industrial sand vacuum pump, with proper adaptions in order to work in Mars thin atmosphere to gather regolith and transport them into a containment chamber for Mars regolith to form a 0.50 meters in width of regolith barrier, protecting the interior from the harmful radiation, while anchoring the habitat to the surface due to its weight.

In order to allow natural sunlight to enter the habitat through the opaque radiation shield, ice water tanks (extracted from water ice)[7] will allow light to enter but still block the harmful radiation (see figure 5 and 10).

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II. The Architecture

A. Shape and modulation

The habitat was designed to grow in size overtime by continuously receiving habitable modules to be added into the original habitat complex, making it possible to harbor more and more people. A feature that required that the shape of the habitat modules to be defined in order that they can interconnect and would remain interconnected even when the number of modules increase. Another goal is that the modules shape and dispositions should guarantee simple, short and safe internal routes to easily access all the connected modules. For that, the initial analyses began with two basic variation of module configuration, the first using linear modules and the second radial modules. In the following figure it will exemplified graphically some of the pros and cons among their disposition in a habitat.

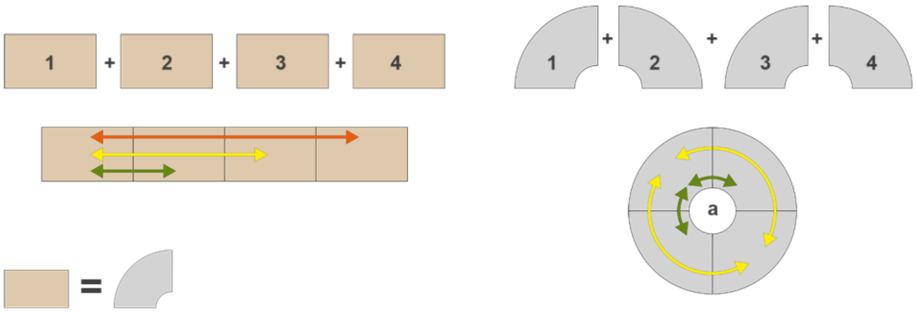

Figure 1 – Comparison between linear and radial modules disposition

For the analyses, were utilized surfaces with the same area, as can be seen in the lower left side of image 1, the only difference were their shape.

To aid in the understanding of how modules interconnect and how that influence the interior functionality, it is being indicated with colored arrows: easy access in green, relatively easy access in yellow and difficult/inconvenient access in orange, based on the distance someone would have to travel.

Adding 4 linear modules together, results in a row of modules that have rather a big length, where the greatest distance lays between the modules located in the extremities, making the process of moving from one extremity to another rather inconvenient, having to go through two additional modules in order to reach the final destination.

The same inconvenience does not happen in a radial module configuration since the extremities are separated by only one module at all times, making the trajectories inside at worst case: relatively easy. The other benefit is that a radial module configuration allows all modules have at least two modules connect to its extremities which would also work as escape routes.

Therefore it was concluded that a radial module configuration would be the best configuration for a Mars habitat, since it would maximize internal functionality and connectivity, and also provide a safer environment. So new dispositions and variations were analyzed next based on the radial modules experiment, and is exemplified in the next figure.

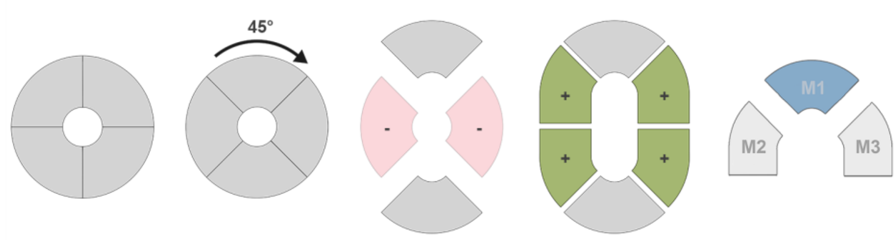

Figure 2 – Process to arrive at the shapes of the habitat´s basic modules

Following the same principle of radial, interconnected and more functional modules, and in order to have a larger area in the central part of the radial habitat labeled as “a” in the Figure 1, it was designed two different type of module that would connect to other modules in a 45° angle (in green) in addition to the 90° angle previously being used. Originating a 3 modules system of the proposed habitat (M1, M2 and M3) shown in the last frame of the figure 2. These modules allow a wider range of variations in the configuration of the habitat as the need grows, as can be seen in figure 4.

Besides the basic configuration demonstrated in figure 2, many other possible configurations can be experimented using only the 3 basic modules demonstrated before. Even more drastic growth can be achieve by adding an additional module, that has three point connection (represented in blue in figure 3) instead of the usual 2 point connection modules, allowing the habitat to have an additional branch of modules as seen in figure 4, in this case expanding into the central open area of the habitat.

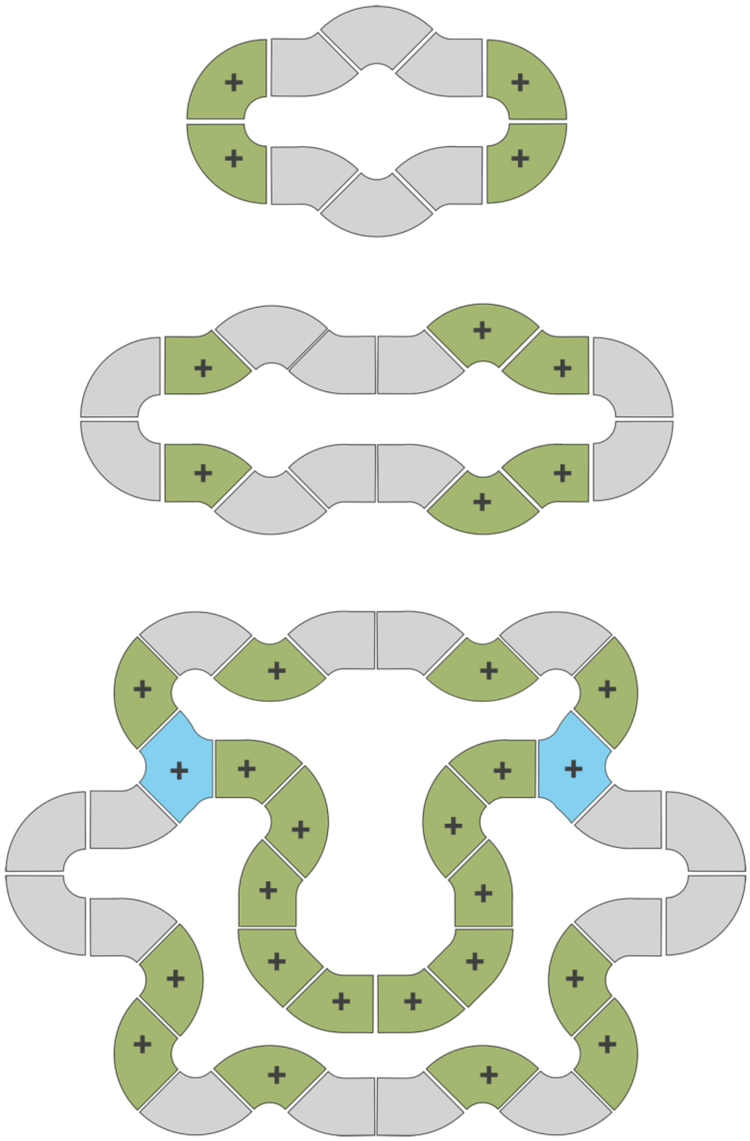

Figure 3 – Possible configuration of the 3 modules in order to have more complex habitats

Figure 3 demonstrates in a time-lapse like order, how the habitat was designed to grow, according to the necessity of habitable space. New modules added to the previous complex are colored green. In the last frame of figure 3, as mentioned before by adding another modular shape (blue) with three possible connections, the habitat would be able to harbor up to 380 persons, all distributed among individual and couple bedrooms, with public bathrooms, kitchens, entertainment areas, etc.. As will be shown later in this chapter in section C – Interior Architecture.

At this level of growth, easy and relatively easy access to all the modules cannot be guaranteed to all modules, but they are still a better solution than linear modules, if imagined the inconvenience that the same amount of linear modules put in a continuous line would create. Using this type of radial configuration, it's possible that in the future if this idea presents itself as feasible, that external connection methods will be developed in order to quickly connect modules too far away from each other. One possibility is to use underground horizontal elevators.

B. Transport and detailed representation of need-base growth

A 3 modules set, was designed to fit into a slightly bigger SLS(Space Launch System) payload bay that is currently being proposed which has 4.2 meters of radius. It would be necessary a payload bay with radius of 5.2 meters to transport 3 modules at time, preferably one of each: M1, M2 and M3.

Because the constructive system compactable characteristic (see chapter II, section A) all the modules: M1, M2 and M3 can be opened/closed separately of each other, according to the necessity of use, varying the station size and amount of people it can sustain. They are also able to be isolated in case of an accident like structural breach or fire.

In the figure 5 it is being demonstrated in detail how the habitat can grow in terms of useful area and habitants. In the first frame of the figure 5 its seen the initial proposed disposition of the Station with only module 1 (M1) opened, which has 750m² of useful area distributed in two floors, capable of harboring up to 10 people. If necessary, the other modules (M2 and M3) can be opened sequentially as show in the frames 2 and 3, the third frame being the maximum expansion the Station can reach with a single launch from Earth, given the previous required payload bay radius are available in the future, which would give the habitat a ‘C’ like shape, harboring up to 26 people. If another launch is made sending another ‘C’ like shaped Station, it can be linked to the already settled Station and form an ‘O’ shape Station, where inside they have a collective of continuous radial corridors that connects the whole station, both in the 1st floor and 2nd floor. (See Chapter I, section C)

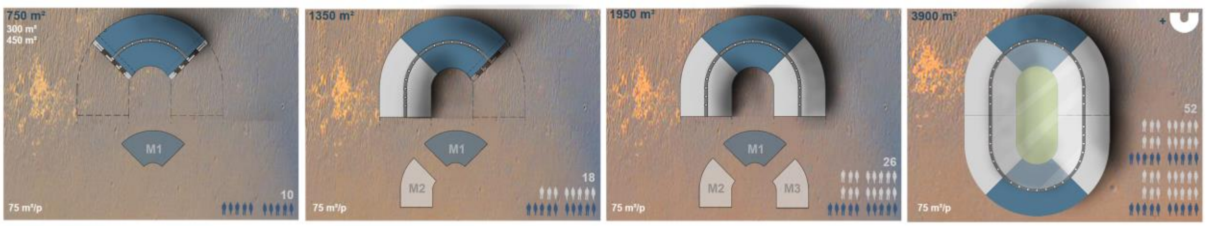

Figure 4 – Time-lapse of the Station modules being used according to the demand

But before connecting into an ‘O’ shape, all the modules: M1, M2 and M3 have the possibility to be used independent of each other if necessary. This concept was introduced thinking on the different kind of research that will be made once the scientists are on the surface, therefore allowing them to go on different directions exploring interesting sites for their specific research field.

And when becomes necessary, the Station can settle in the “O” shape, as seen in the last frame of figure 5. Where the interior of the ‘O’ shape will be an open area that can be sealed with a transparent pneumatic plastic dome with UV protection, for growing plants. Isolated from the outside atmosphere, with abundant sunlight and with direct access to Mars soil, it will be possible to grow crops there, expanding the food production of the already existing green houses on the inside of the station. As seen in figure 6 it could also be used as an ‘outside’ Mars park.

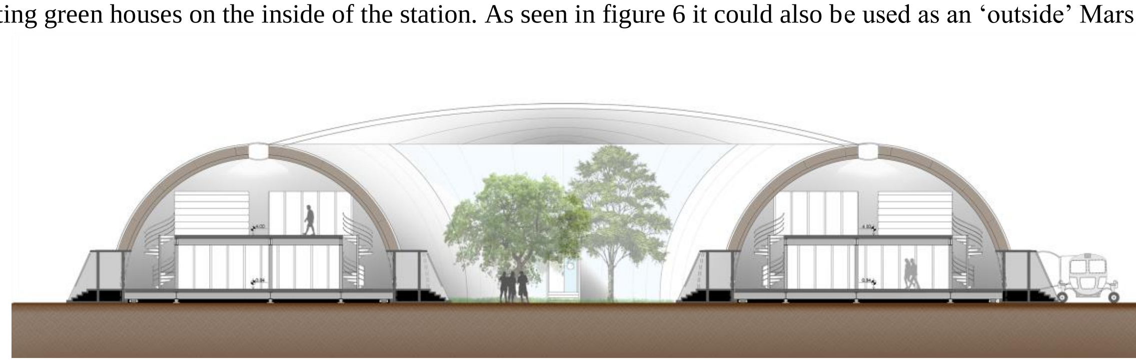

Figure 5 – Section cut of the Station.

In figure 6, besides explaining graphically the use of the interior of the ‘O’ shape, it gives an general understanding of the Station interior logistics, mainly the two floors of the station, where the 1st floor will be used for work and activities with heavier machines that require more of the structure and the 2nd floor which will be used for living, sleeping, relaxing, etc. activities that requires less of the structure, therefore reducing the weight and the overall cost. Around the direct section cut of the Station in figure 6, painted in light brown, it is possible to see the radiation shield with 0.50 meters of width and bellow it in a darker brown is the inflatable structure to hold the interior atmosphere. In the top of the semicircular section it’s possible to see the ice water tanks to provide natural lightening, for better mental health of its habitants and also to aid in the illumination of the interior during daytime.

C. Interior Functionality

Figure 7 will aid in the understanding of how the habitat modules were designed to function internally. First by demonstrating the uses of each floor, it being: 1- 1st floor, greenhouses and laboratories; 2 – 2nd floor, private bedrooms and public areas and finally 3 – which is the inflatable structure. Later it represents some of the methods used in order to increase the habitat´s interior efficiency. First in the 1st floor, each module has two separate access chamber, located in opposite sides in order to improve escape chances in case of an accident and the 2nd floor is accessed by two spiral stairs also located at opposite sides of the module. Both floors have two different types of internal circulation corridors, a transversal one in order to connect the front and back of module and a radial one that connects the module in all its extension.

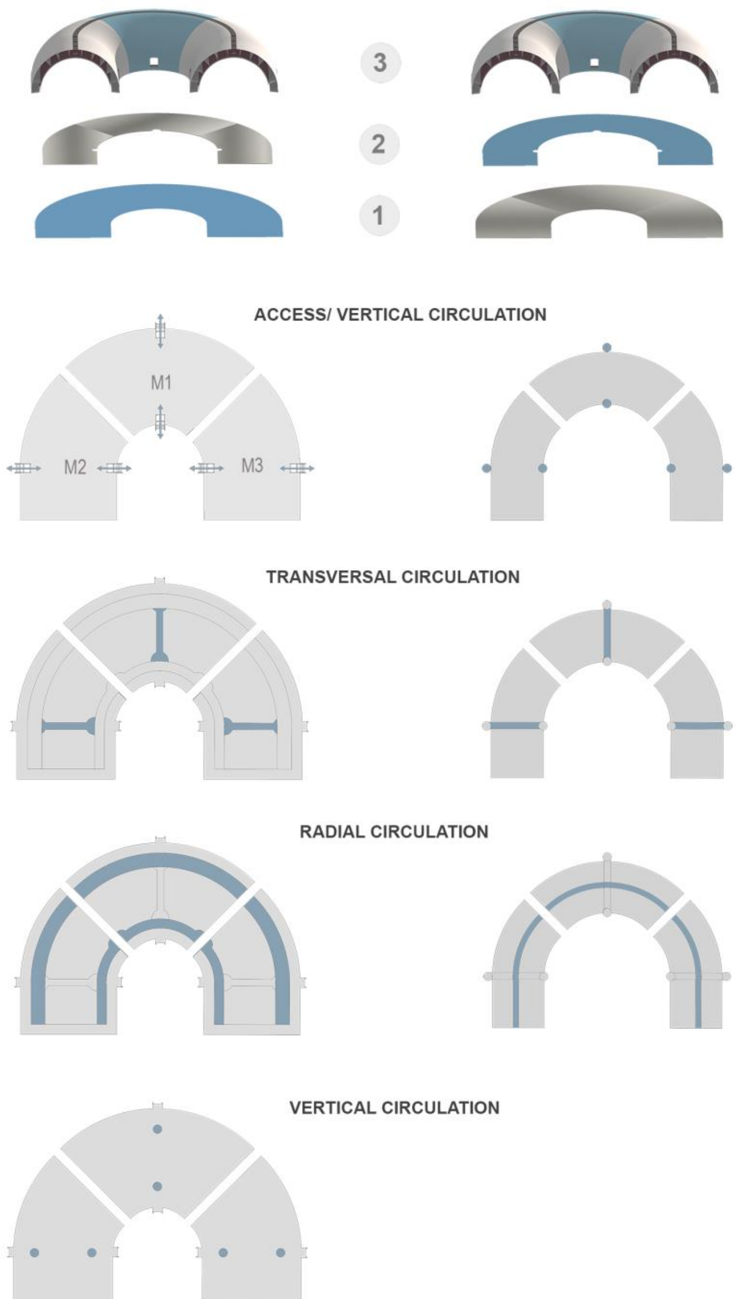

Figure 6 – Interior uses, access and circulation diagram

D. Interior Architecture

Before analyzing the proposed spaces for each floor is necessary to understand the proposed ranking of each module, where the Module 1 (M1) is ranked as the operations control module, from where all missions will be coordinated aided by instructions from Earth when necessary. And the other modules, M2 and M3 will be initially dedicated to scientific explorations missions on the planetary surface. All modules were designed to have its own independency, by having their own laboratories to store and analyze data, and greenhouse to grow food. M1 won´t have a Shop and EVA room due that it will dedicate more to coordinate missions, while M2 and M3 won´t have: command room, conference room and a central (more capable) medical room.

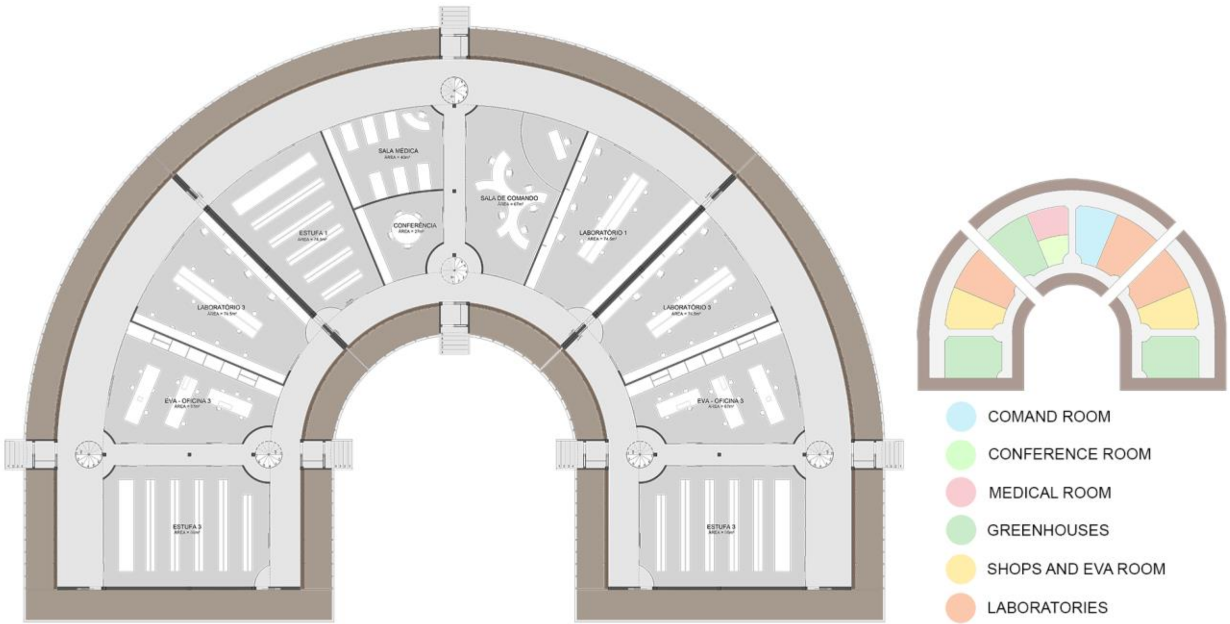

Figure 7 – 1st floor plan, diagram and interior rendering

Figure 8 – 1st floor interior rendering - viewing a transversal corridor

In Figure 9 it´s possible to visualize the expected appearance of the first floor of the habitat, where the majority of walls will be semi-transparent, providing great visibility through the whole floor and promote healthy social interactions.

The 2nd floor of all the modules, serve mainly to provide private quarters, resting and social areas, and health care spaces. It was proposed the use of two bedrooms typology: the single bedrooms and couples bedroom, anticipating that couples will form if a colonization takes place in the planet. But all bedrooms have ability to be modified and transformed best fit the needs of the settlers. Also in each module there is a Gym and a Kitchen, motivating them to exercise and to create positive social interactions. The central radial corridor it's where the modules interconnect, allowing when they are being used together, a continuous central corridor to connect the whole extent of the habitat 2nd floor. Another important element, is the spiral stairs, they are responsible to connect the 1st and 2nd floor and they are located exactly in front of the transversal corridor.

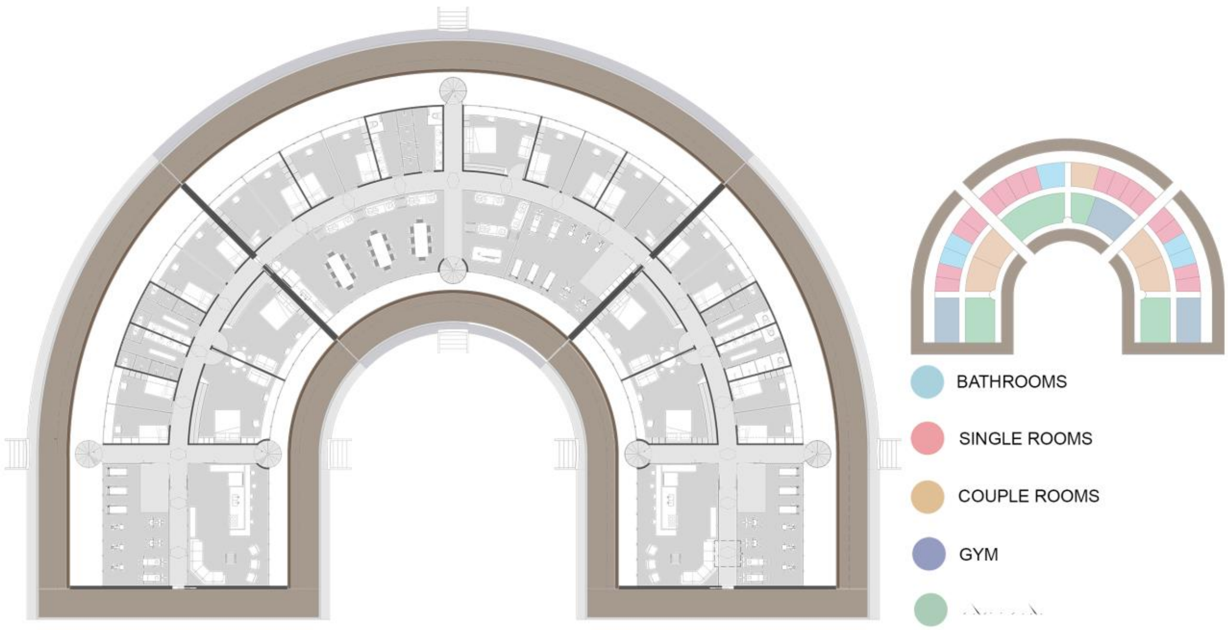

Figure 9 – 2nd floor plan, diagram and interior rendering

Figure 10 – 2nd floor interior rendering - viewing the central radial corridor

Two things were taken into account when choosing the possible interior materials: the capacity of the material to allow open field vision in the public areas and the capacity of materials to provide the necessary privacy in private bedrooms and bathrooms. In a contained space, like extra-terrestrial habitats, it should be better for it not to too claustrophobic, which can be achieve with transparent or semi-transparent lightweight materials in public areas, to allow greater visibility and not work as a barrier (like demonstrated in the left side of figure 8) For private areas, inflatable walls are being considered as the best options, it being opaque and lightweight, acoustic treatment will be needed.

III. The Structural Systems and their Elements

A. The Metallic Structure

The first part of the system consists in modular system of a 2 floor structure of steel frame that can be compressed on itself (figure 1) to fit into the Space Launch System, which dimensions and load capacity were used as initial reference for the transport as mentioned before.

Figure 11. Sequence of opening a modular part of the structure after being transported to Mars.

As mentioned in the introduction the material suggested is a lightweight steel that was created in 2015 by researchers in Korea that are lighter and cheaper than regular steel, and is as strong as some titanium alloys. [8]

It's represented in the figure 1 the expansion process. Image number 1 demonstrates the maximum compactability, ready for transportation and number 5 at maximum expansion, ready to be used for regular activities. Next it's necessary to understand the many components of the system.

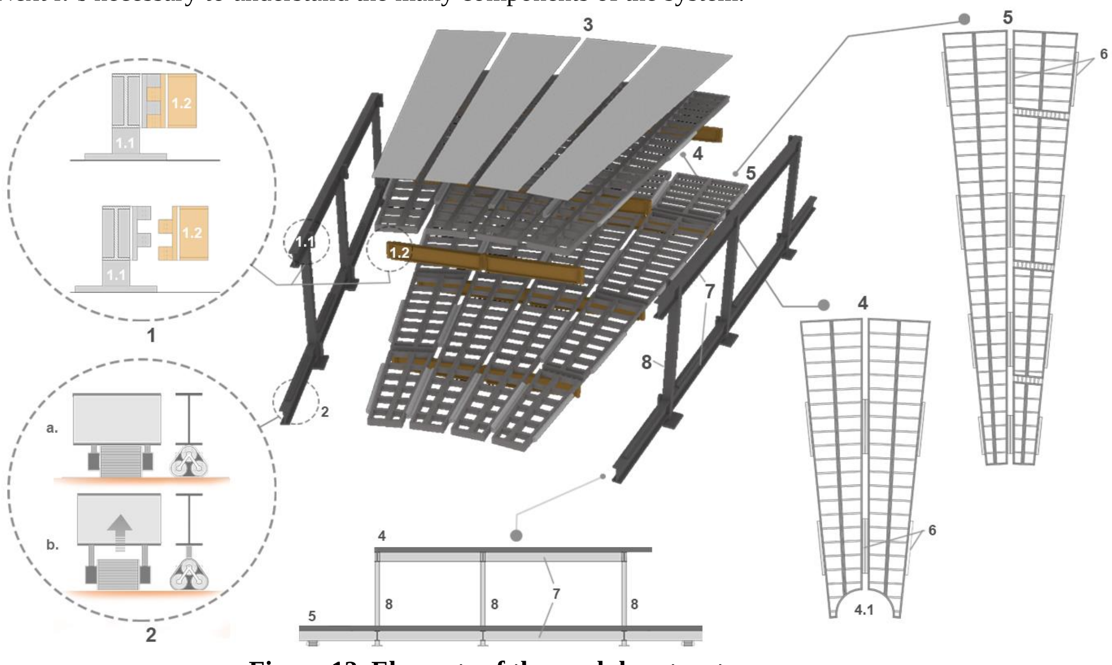

Figure 12. Elements of the modular structure.

In figure 13, it is being represented the components of one part of the modular structure (Module 1 with all its modular structure can be seen in figure 14), where: 1 – Is the connection between pantographic beams(1.2) and metallic columns(1.1); 2 – It is a part of the automated opening and closing system of the Station where in resting mode it assumes the (a) position and when needed to open or close the station it assumes the (b) position; 3 – To cover the steel frame slabs its being proposed structural metallic, OSB or any other type of panels that could sustain long time use; 4 – The 1st floor steel frame slab, can also be seem the openings(4.1) for fixating the spiral staircases in order to access the 2nd floor; 5 – The 2nd floor steel frame slab; 6 – Are the connector among the steel frame slabs and them to the metallic beams, these connectors are what allows the slabs to have the compactable characteristic seen in figure 12; 7 – The metallic beams of the structure; 8 – The metallic columns of the structure;

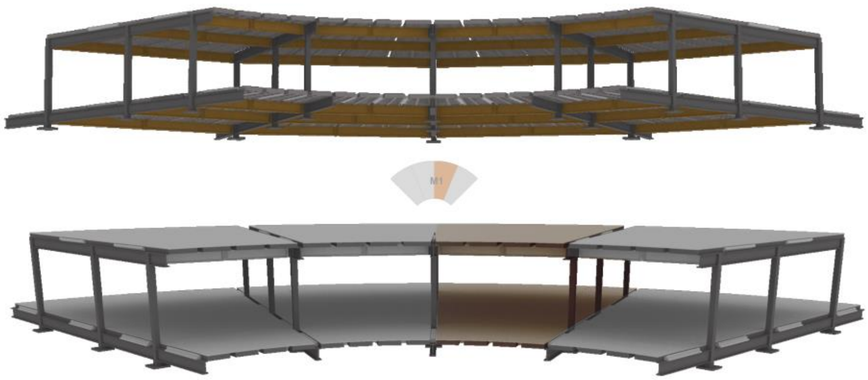

Figure 13. Module 1, made of 4 modular parts that function similar to represented in figure 1

In the figure 2 can be seen that the same compactability technique of the modular part of the figure 1 repeats itself 4 times to form one module. And the same technique repeats on the other 2 modules (see figure 5) So the whole Station can expand in volume a little more than *10 times* its volume while being transported. From a transported volume of 800m³ to expanded and habitable volume of 8140m³.

Another benefit of the Station building techniques is that since the structural shell (see figure 3) will work as the 'roof' of the habitat, carrying its own weight and the weight of the radiation shield, the metallic structure will use less material on itself, has to carry less load from the 2nd level structure and no load at all from the 'roof'.

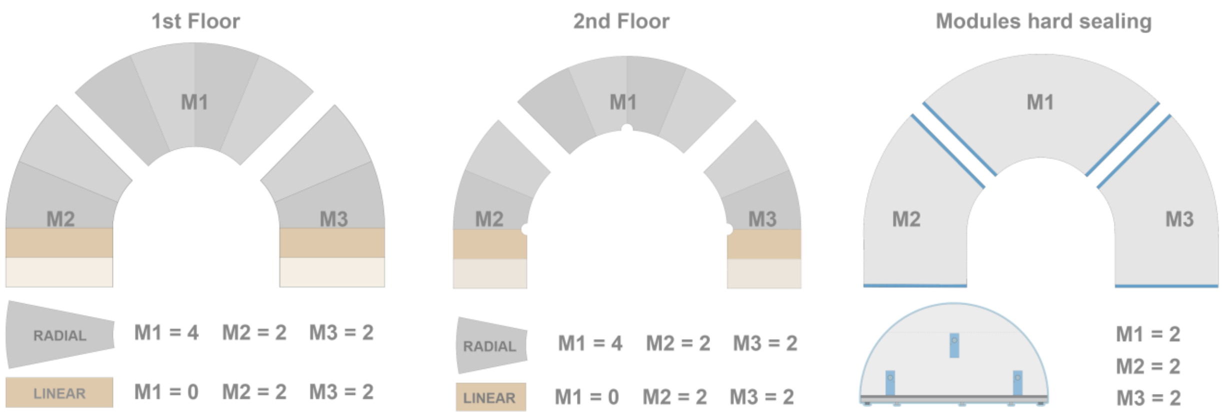

Figure 14. Modular components of the Station and their individual amount

After the stage 5 demonstrated in the figure 1, different types of interior walls can be set as needed: walls with embedded hydraulic components for: bathrooms, laboratories, shops, greenhouses, etc. acoustic isolation walls for: bedrooms, study rooms, etc. and finally regular walls, that can be opaque or semitransparent either for public areas or to semiprivate areas where illumination is needed and could aid in perceiving the habitat as opened and larger. The floors would already have the necessary docking parts for the walls as the interior design plan, maintaining the work needed from human at minimum. This makes possible and facilitates the transportation of solid and safer habitats with generous internal volume when at its maximum expansion state, but able to fit into the space vehicle payload bay. Once on surface it diminish the Human/Robotic effort to mount it, since it work as one element having little separated parts to be set up manually.

B. The pneumatic Structures

The habitat outer layer have two components embedded in it, as can be seen in the figure 16. The first component is the inflatable structural shell and the second component is the regolith containment structure, each one having their specific materiality and function.

The first component, the inflatable structural shell will serve the function of holding and maintaining the internal pressure of 14.7 psi inside the station, for structural and material reference, it is being used the well tested, documented and proven feasible inflatable shell of the TransHab module, that owe its strength to a Kevlar restraint layer and is air sealed by Combitherm bladders[9] The internal pressure produced by the atmosphere is a bit over 10,000 kg/m², which means that, that amount of force is being constantly applied on the inflatable wall in outwards direction, therefore if an external force could deform the inflatable membrane or breach its perimeter it would have to exert a force stronger than 10,000 kg/m². For the habitat proposed in this paper it is been considered the possibility to use that internal pressure as a structural solution to sustain the weight of the radiation shield that is located on top of it. Since an internal pressure so strong has to exist in order to allow Humans to live in it, given the right safety measures are taken into account, it should be possible to use it as an extra structural component of the habitat, holding externally applied loads as will be initially and simplistically demonstrated in the figure 17.

The second component, the regolith containment structure is a simple pneumatic structure, that using the Regolith Gathering and Transporting Facility (RGTF, which will be demonstrated next) can be filled with Martian regolith with 0.5 meters in width, that will serve to protect the habitants from radiation as demonstrated by Simonsen and Nealy (1991)[5] and also possibly use its weight as an anchor for the habitat.

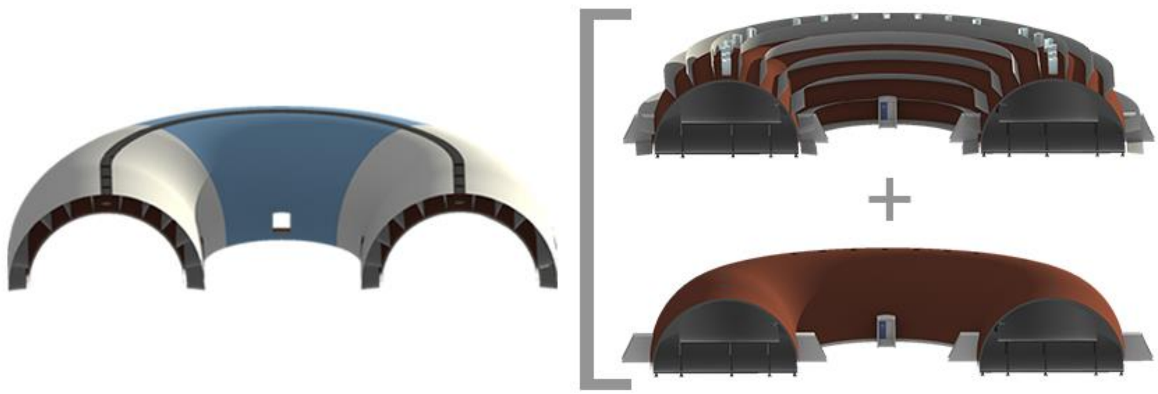

Figure 15. The pneumatic structures will aid in the use of in-situ resources

The following figure demonstrates the load transfers for a system that only internal air pressure works as a structure. It also indicates some special areas where more attention shall be given, mainly to prevent accidents in case of pressure loss, like the green area indicated with the letter 'e', which should be set to rapidly discharge the regolith in it, in the case that internal pressure is lost, which otherwise would fall inside the habitat. The area represented by the letter 'd' indicates where the weight of the regolith would have the less influence over the inflatable membrane, since the regolith would start to transfer part of its weight directly to the soil.

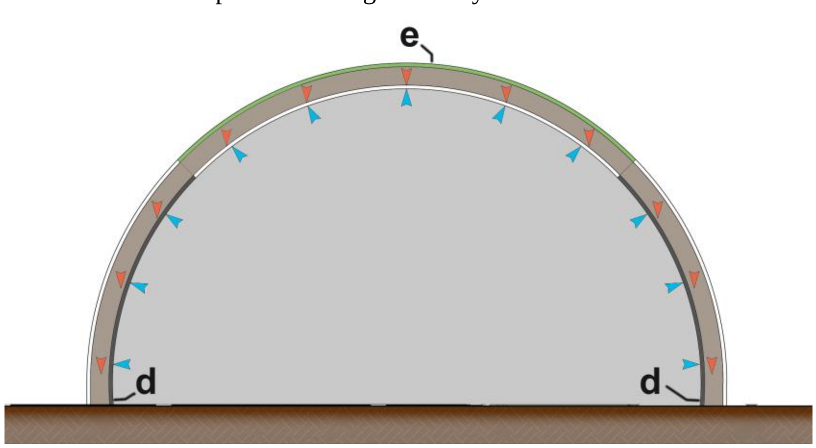

Figure 16. Initial study of load distribution and safety mechanism

IV. Protecting/building with In-Situ Resources

Like on Earth, the most sustainable and cost efficient way to build on Mars, would be trough utilization of local resources. Mars regolith is a planetary level resource wildly available, covering extensive surface area, varying in thickness from region to region, which in specific locations (of Elysium Planitia and Arabia Terra, the ones analyzed in depth so far) can have a minimum of 5 to 10 meters and up to 60 meters maximum in thickness.[1,2.3] They can also be found deposited planet wide in crater basins and dunes fields.[4]

So instead of transporting a radiation shield from Earth, adding more weight to the space vehicle, Martian regolith can be used as radiation shield, diminishing the weight to be transported and providing protection to the inhabitants of the Station. Accordingly to Simonsen and Nealy (1991)[5] the ideal width of radiation protection for Mars, using Mars regolith, would be 0.50 meters. Which will be used for this project. The question on how it will be structurally sustained was answered in the previous section, the question that remains is how the regolith can be gathered and used efficiently in order to provide a safe and economically viable habitat.

Although many habitats that have been proposed were underground to facilitate the process of covering them with regolith, that strategy was not chosen for this project, for it seemed disadvantageous, since it results in the habitat loosing its mobility and will require large and heavy machinery to dig where the habitat would be placed, adding even more weight to be transported by the space vehicle. So that's the reason the science station presented in this paper was designed to be above ground, therefore able to move to another location if necessary by removing the radiation shield, which does not require heavy labor or complex equipment as will be shown next.

C. Regolith Gathering and Transporting Method

Each year, industrial vacuum pumps are able to accomplish more and more complicated tasks, like moving rocks, sludge, gravel and sand. They are becoming a very reliable way to gather industrial material and transport them kilometers away if necessary in a much easier and energy saving way than has been done so far, it works in a batteries of 12 Volt D.C which are can operate continuously before need to be recharged with 110 or 220 volt A.C.[b] The IVAC´s industrial Vacuum PV500 model, is powered with compressed air which could be CO_2, which would be used to create suction and gather Mars regolith at a rate of 60 cubic meter per hour.[c] To avoid sucking in rocks and boulders, a filter can be installed at the nozzle of vacuum. For future missions a similarly potent vacuum could be developed, adapted for the Mars mission and the planet environment. But for this project its being presumed that PV500 will be transported to Mars with the Station.

The real challenge appears when assessed the necessary conditions for an efficient vacuum to function, which includes an environment with an atmospheric pressure that Mars doesn´t have, at least not at the moment and neither will have naturally, since its atmosphere is too thin compared with Earth´s. As will be shown later in this paper, one of the premises for choosing the station initial location, are low altitudes areas, around 4000 meters below Mars altitude zero. Which might prove useful in this case, slightly increasing atmospheric pressure but not remotely enough since that at that altitude (-4000 meters) the atmospheric pressure would be only 0.13 psi,[d] compared to Earth at sea level which is 14.7 psi.[e]

So besides the Station itself a lightweight facility is being proposed and designed, the Regolith Gathering and Transporting Facility (RGTF) where the vacuum pump will be able to function on the pressurized interior of a pneumatic dome fixated to the surface. It is being initially conceptualized as automated, able to carry itself folded to the chosen extraction site and then inflate the dome to start operations. The holes resulting from regolith extraction can later be used to bury small emergencies facilities if necessary.

In order not to destabilize the surrounding area of the Station or individual modules, the RGTFs should be stationed a minimum of 10 meters from any habitat. But it could be much more if necessary, since the PV500 vacuum specs suggest it can discharge the regolith 2 kilometers away,[f] increasing significantly the area around the Station that regolith can be gathered.

That discharge capacity that will be used to transport the regolith from the RGTF to the Station pneumatic structures, as will be demonstrated in the figure 7, and the actual utilization by the pneumatic structures will be demonstrated in the figure 8.

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b http://www.ott-as.no/ivac – IVAC´s PV500 specifications.

c http://www.industrialvacuumunit.com/documents/IVAC_OTT.pdf - Detailed specifications

d http://www.mide.com/pages/interplanetary-air-pressure-at-altitude-calculator - Mars atmospheric pressure by altitude calculator

e http://www.mide.com/pages/air-pressure-at-altitude-calculator - Earth Atmospheric pressure at diferent altitude

f http://www.industrialvacuumunit.com/documents/IVAC_OTT.pdf - Detailed specifications

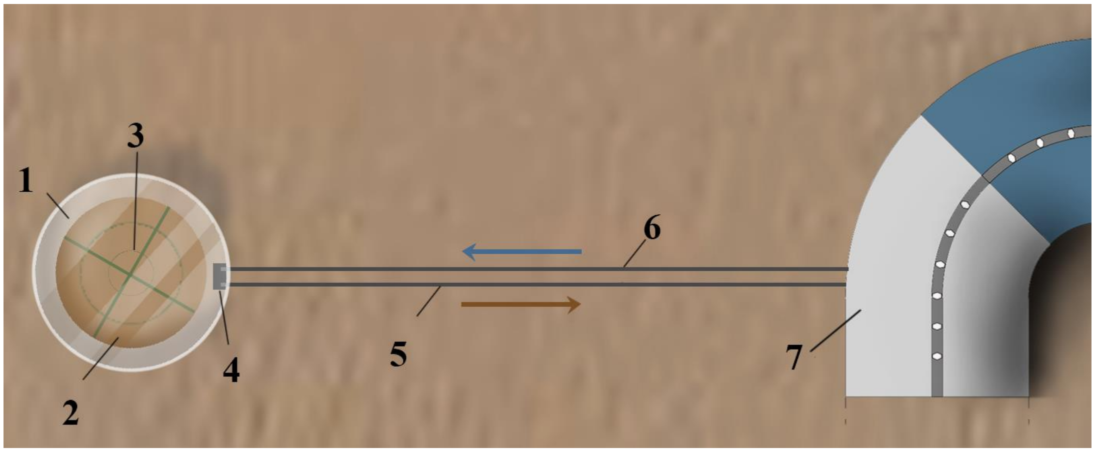

Figure 17. Top view of RGTF system components

In the top view of the Station seen in figure 7, it's possible to identify the general main stages of in-situ resource utilization, from regolith extraction to deposit, in the following order: *(1)* The pneumatic dome to create artificial atmospheric pressure *(2)* The regolith extraction area *(3)* The equipment used to move the vacuum nozzle in order to extract regolith and the trench shield to be proposed *(4)* The vacuum pump located at the border of the dome *(5)* The regolith being transported to the station *(6)* The air used to transport the regolith being transported back into the RGTF in order to have it used again by the vacuum. *(7)* See figure 8.

After being transported to the Station the regolith is then distributed to be deposited as radiation shield as can be seen in the following schematic figure.

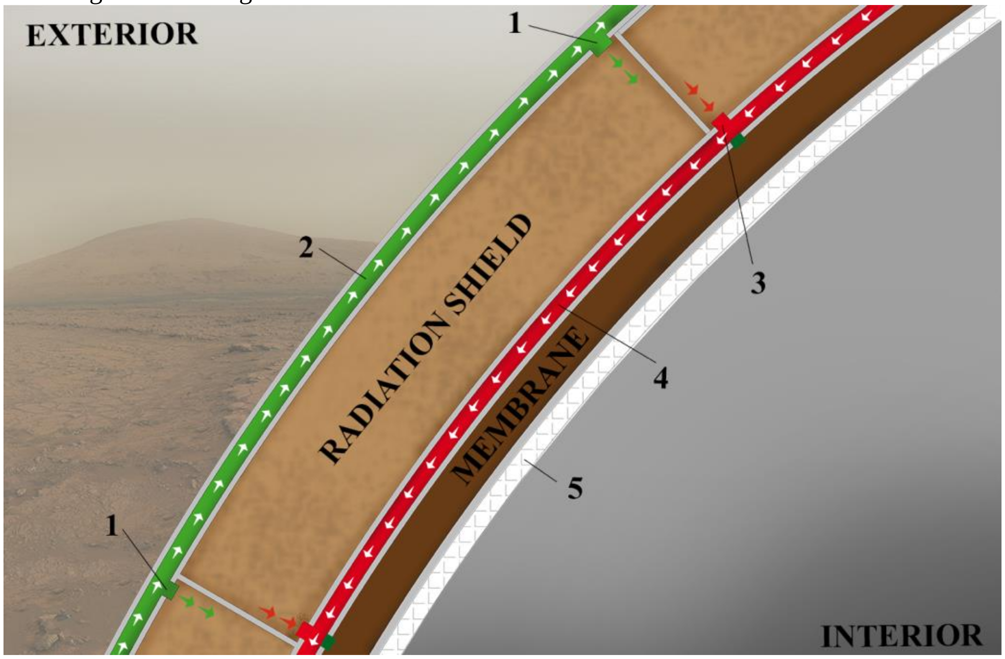

Figure 18. Pneumatic structure embedded ISR distribution system

Into the Pneumatic structure there are the following elements and stages: *(1)* unmodified regolith deliver nozzle, where the regolith gets delivered and deposited into the radiation chamber *(2)* The regolith distribution line, made of malleable tubes *(3)* Regolith removal nozzle, uses the gravity and suction to remove the regolith from the radiation chambers *(4)* Regolith removal line *(5)* Thermal insulation on the inner side of the pneumatic structure, and also where additional lightening can be embedded.

Figure 9 presents the estimated volume of unmodified regolith that will have to be transported from the RGTF to the chambers to each module.

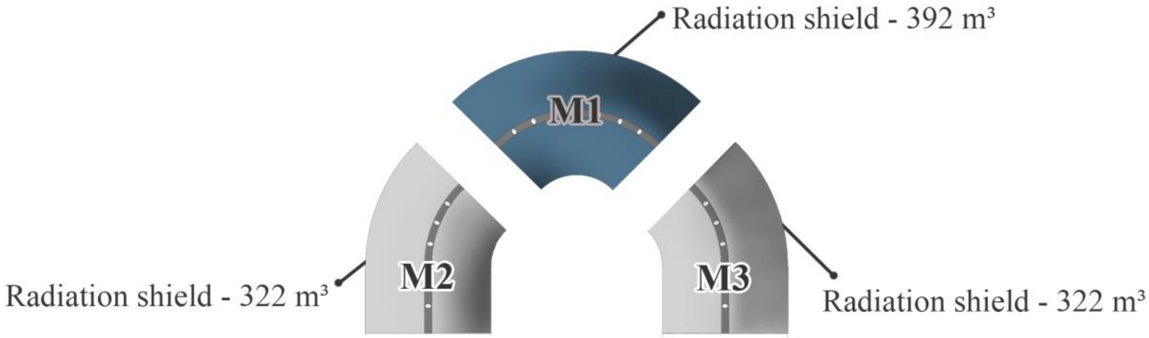

Figure 19. Amount of unmodified regolith required for each Module

Since, as mentioned PV500 has the capacity to transfer materials at rate of 60 m³ per hour, it would take the RGTFs around 6.5 hours for Module 1 and the Modules 2 and 3 around 5.4 hours, to fill their radiation shield. And since it doesn´t require any modification on it, they would be deposited directly into the pneumatic deposit chambers.

D. The Structural Systems Working Together

When put together, the systems developed will work together to provide two basic benefits: protection and habitability. The protection is provided by the radiation shield and its other components that protect those inside from the outside: low temperatures and radiation, and the habitability is provided by the metallic structure and the inflatable membrane and all its many components that creates a space with areas to: live, grow food, rest, relax, socialize, etc.

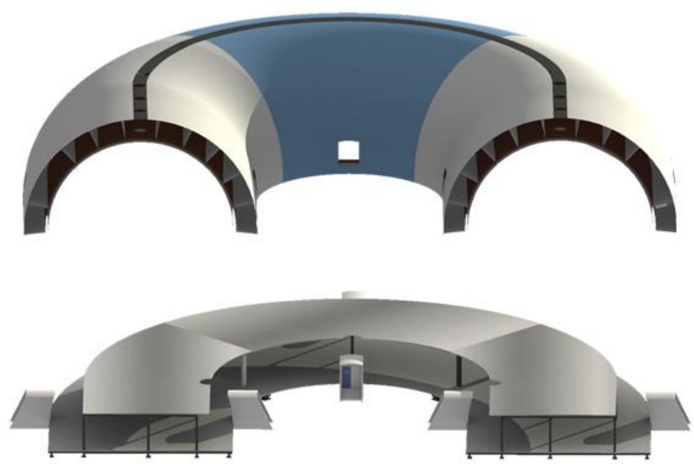

Figure 20. The pneumatic plus the rigid elements to be transported

These are the elements that will be taken from Earth and they were designed to: reduce in size to fit the Space Launch Vehicle to later expand and be used with a much larger useful area and volume, to weight the less possible in order to reduce the cost of sending them into orbit and along the interplanetary trip, to will aid in the utilization of Mars abundant resources like the surface regolith, to allow multiple and various modular configuration, to allow continuous growth.

V. Parameters for Station initial location

The parameters for choosing the possible location for the Station were: highest annual daytime temperature, highest indication of water ice, low altitudes (for atmospheric radiation protection).

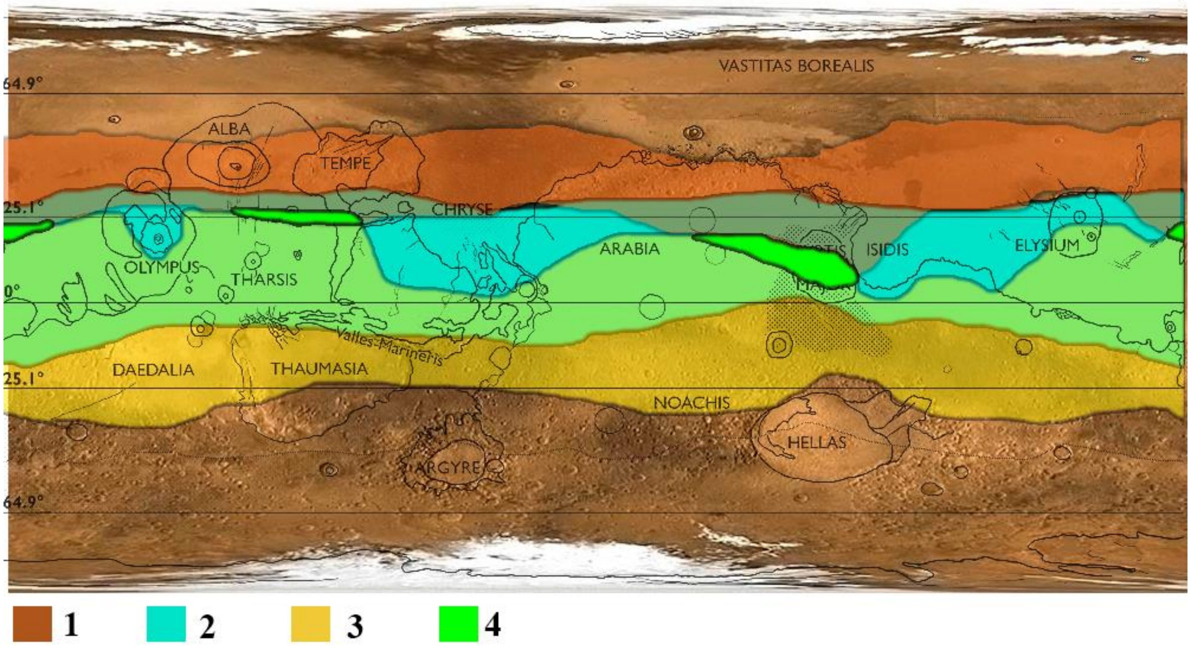

Figure 21. Planetary temperature analyses and overlaid areas.[9]

In figure 13 it´s presented the daytime maximum temperature on Mars surface all year with the following values: *(1)* 1.65°C during Summer Solstice: (2) 6.85°C during Winter Solstice *(3)* 16.85°C during Equinox *(4)*By overlaying them, small patches of land can be found that share the same daytime maximum temperature in all year.

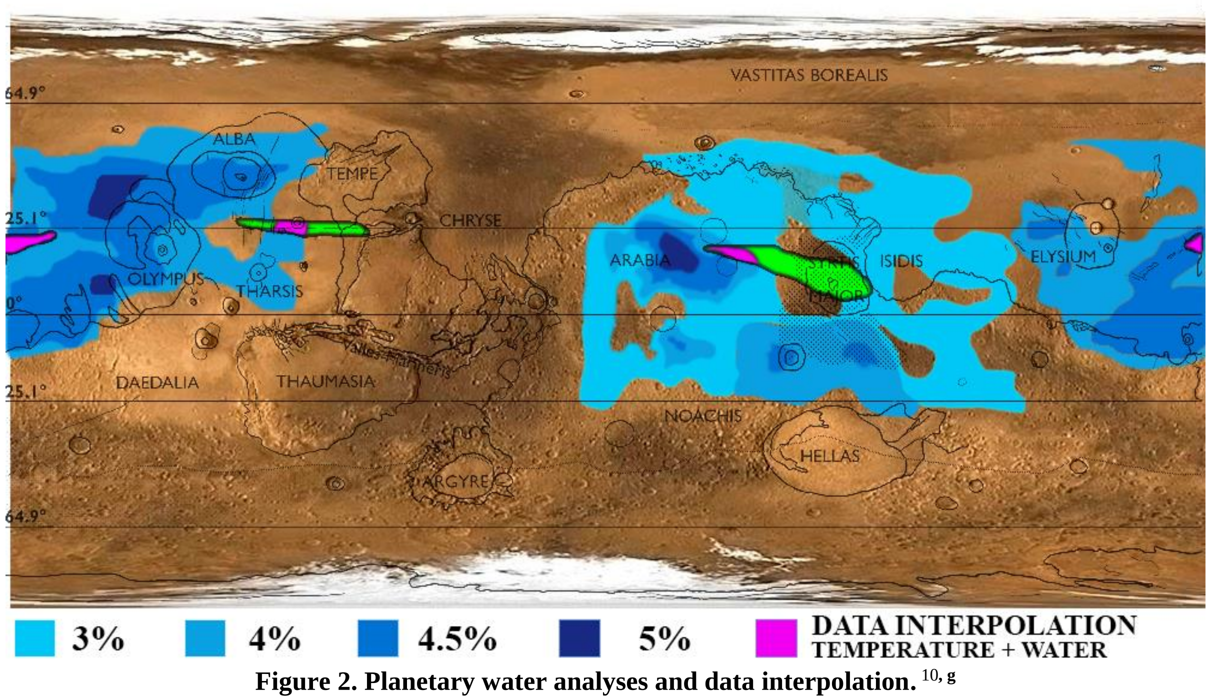

Figure 2. Planetary water analyses and data interpolation. [10, g]

g http://www.universetoday.com/93059/large-amounts-of-water-ice-found-underground-on-mars/ - Water in Mars

Besides for Human survival, water is an attractive element for scientific research, so interpolating the data from the temperature map + regions that could have water, can be found locations that has the two proprieties.

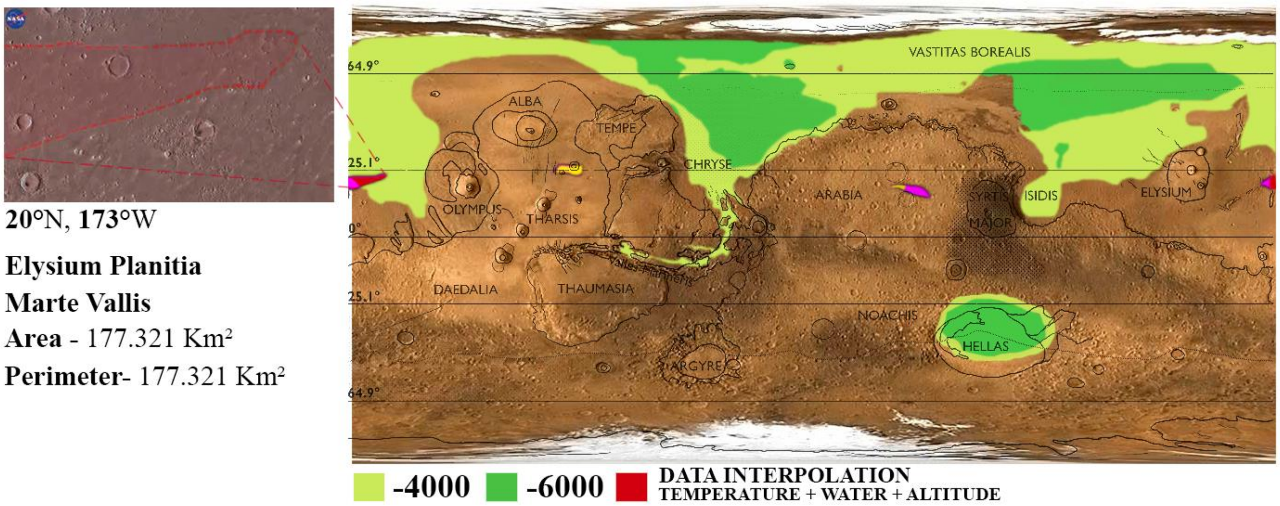

Figure 3. Planetary altitude analyses and data interpolation to locate final location[h]

Low altitudes can aid in the protection against radiation. The area marked in red located in Elysium Planitia, possess all the characteristics chosen as initial parameters for setting a first Human habitat on the planet Mars.

VI. Conclusion

Initially named: Mars International Research Station (MIRS) the habitat was designed based on the understating that there is a limited amount of cargo that can be taken to Mars, therefore one must value: lightweight and compactable structures.

So a lightweight structure was developed which is able to expand itself a little more than 10 times in volume, to provide more useful area, comfort and freedom than the usual extraterrestrial habitat. And knowing the importance of mobility in an exploration mission and thinking on different scientist with their different scientific interest independent mobile modules were developed. (Figure 5)

Recurring to Mars in-situ resources as a way to reduce payload weight, reduce the dependency on Earth and to create efficient protection against radiation and climate. Besides identifying the resources, it was defined, even though in a superficial level, conceptual methods that those resources could be extracted, transported and used as the mission requires.

In order to improve the habitat chances of success, a study on the planet environment and physical conditions was elaborated, and certain parameters was set in order to guarantee that the future location will provide the best possible conditions for both Human survival and comfort, and the necessary resources that would facilitate a the creation of a radiation shield.

More research and tests is required in order to assure that the proposed construction methods and techniques for this Station can be used in a real Mars mission situation.

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