MARS PLANET CONQUEST

TOME II

SECOND RED CATS EDITION
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ABSTRACT

The Mars planet conquest, is part of the human greatest dream. Men has always been an eye pointed to the stars, and now it's possible to touche this dream. In this research work, I put together some useful information that will be required for the red planet colonization. A great conceptualization work, and years of web navigation was required, but like almost every research paper, it will be publicized without it's complete achievement.

Without entering the every details, there are the different phases for the colonization:

1. Preliminary design phase
2. Terrestrial test phases
3. Building and test of colonization vessels
4. Spacecrafts first wave departure
5. Landing of modules
6. Landing of Marsonautes
7. Building of first bases
8. Building and development of colonization infrastructures
9. Beginning of the colonization, by sending Marsonautes every 2 years

All the phases will be treated in this book, and I will add my own fantasy touch for the future of Mars. Mars is not like Earth, the life on this planet will never be the same that on our origin planet. But there is some motivation to establish our self on it:

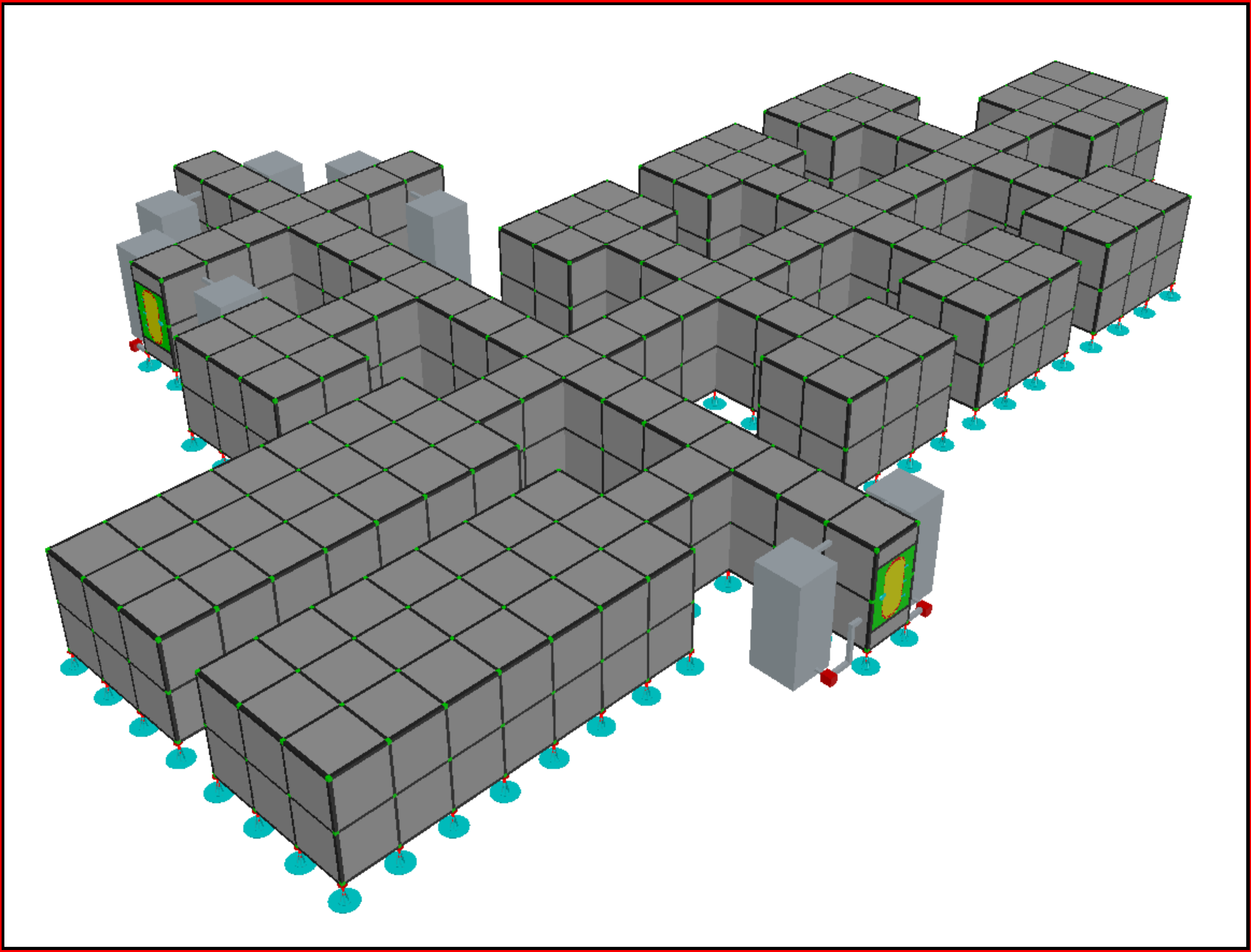
I. Surpassing oneself
II. Security of all the nations and life
III. First step to elsewhere

INDEX

This book is dedicated to my old girlfriends :)

THE MODULES

In this chapter, I'm going to revised the different modules and their respective functions. Like this whole book, this chapter is a resume, and is not intended to describe every engineering drawings that will be produced in subsequent phases. All those images are static and the 3D model are more valuable and precious :)



PHASE-0

The Zero phase, consisting of step to be concluded between the first step landing up to the establishment of the first energy source, to build the modules of the phase-1. It's the most dangerous part of the mission:

- Deviation of the initial landing trajectory
- Bad statistical distribution of surface materials
- No medical infrastructures

SpaceX

LANDING SHELTERS

There is some ways to offer few nights to the Marsonautes before they could have built some more permanent shelters. Honestly, I retained the shelter build with synthetic fibers like "Dyneema" or others like it, like mentioned in the chapter Spacecraft for the crew, with other materials elements to make the correct structural requirement: Air-proof under pressure (the equivalent of a football), heat insulation (-80°C), durability, reduced volume in packed "state".

For a diameter of 4 meters, and a height of about 1 meter, for a volume of 14 m^3, for the inside dimensions, the output requirement will be small, for heating and air regeneration. With this dimensions, five marsonauts could survive there, even more if it's required (emergency situation could happened). This temporary shelter will do great use of the almost no lost SAS opening.

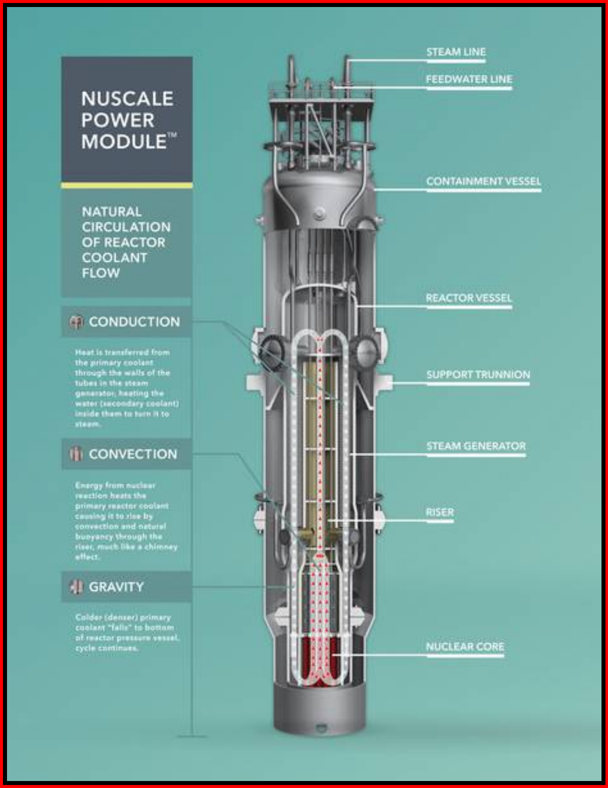
The air regeneration process, will be simplistic for safety and economy reasons, comprising O_2 stocked reserve. The pressure of the bottle (small and medium) will be maintain low, by a small evaporation of the gas. Also there will be the other cans (Oxygen and carbon scrubber) left on the ground by past landing for that purpose...

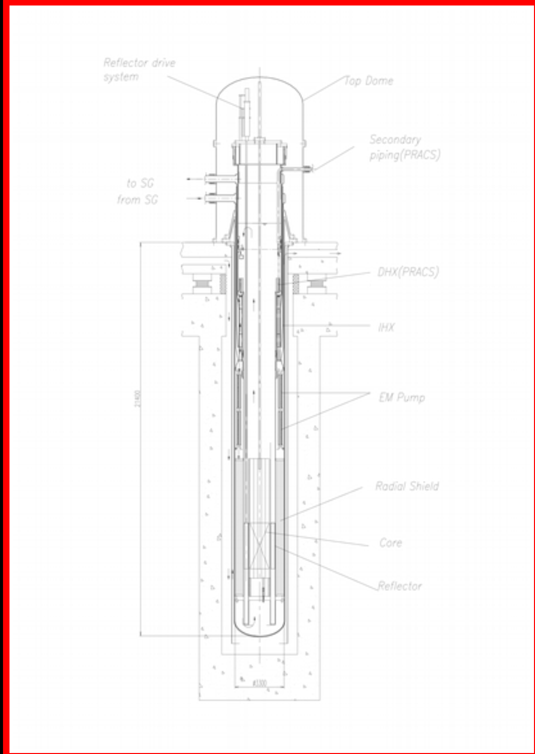
When, finally, the electrical production device, will be ready, the Marsonautes will need to be connected most of the time, for economic purpose. As per example, the battery Lithium-ion, used on Earth, could sustain about 1000 cycles for an energy density of 900 kJ/kg, a power density of 1500 W/kg (reference #12), and a volume density of 1900 J/cm^3. I don't believe that the worst will occurred, but there will be some catalyst and scrubbers in surplus :)

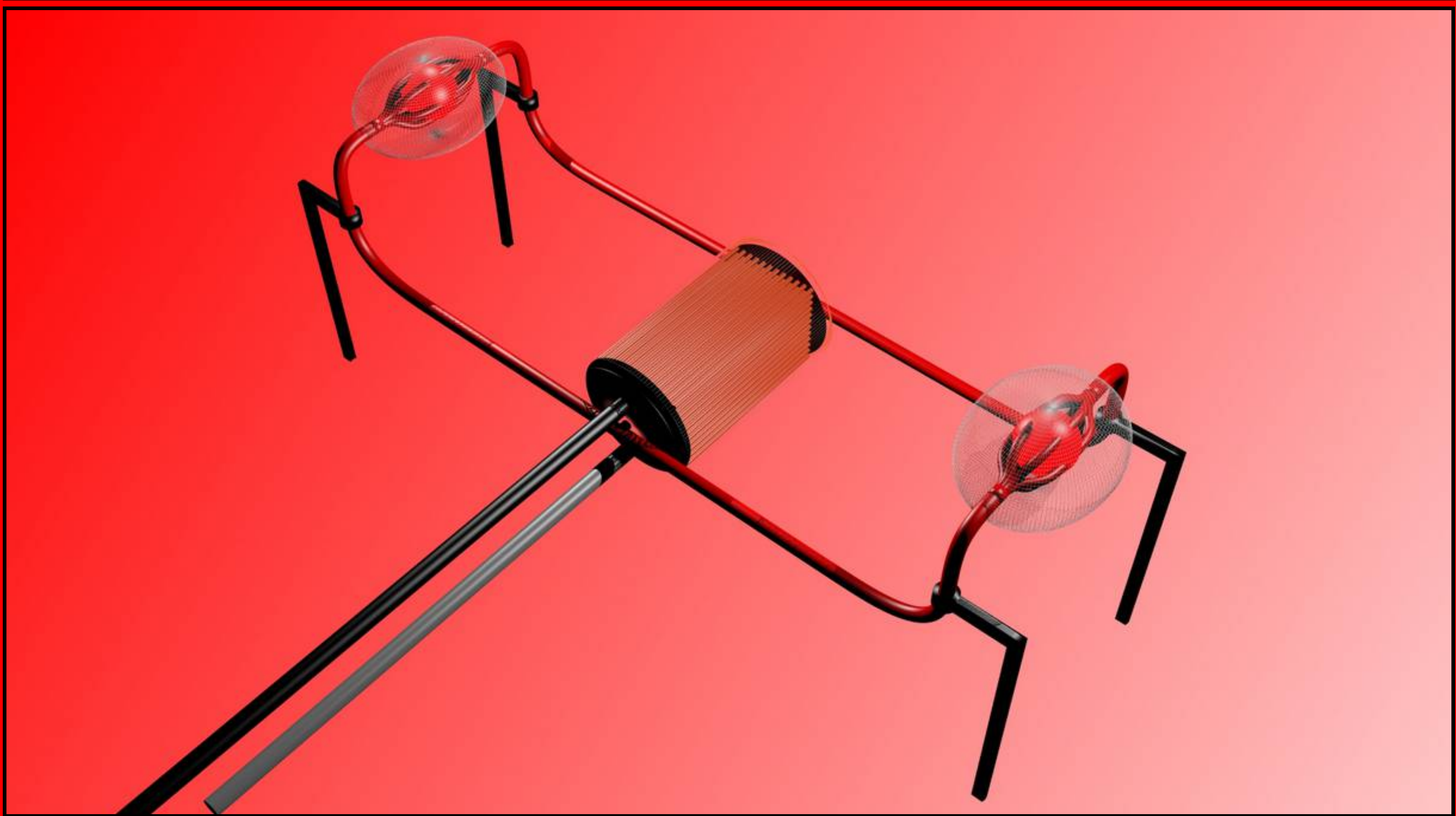
The first objective, will be the make those shelter obsolete before the hour 26. For that, it will be needed to assemble the main complex, and establish a efficient power source (reactor #1), that will be required for the welding. With 24 women and men on the ground within the end of this period. That also mean, a minimum of two or three shelter, in the case of failure to respect this scenario (close enough to the center of the base).

There is also the possibility to land a full ready module from the Mars-One project (as per example), with some modifications, to make them smaller, by that way allowing us to make them enter the regular rockets that will be used at that time... I must remember the reader that the size of a rocket induced in it's price an exponential factor of the order of just too much :)

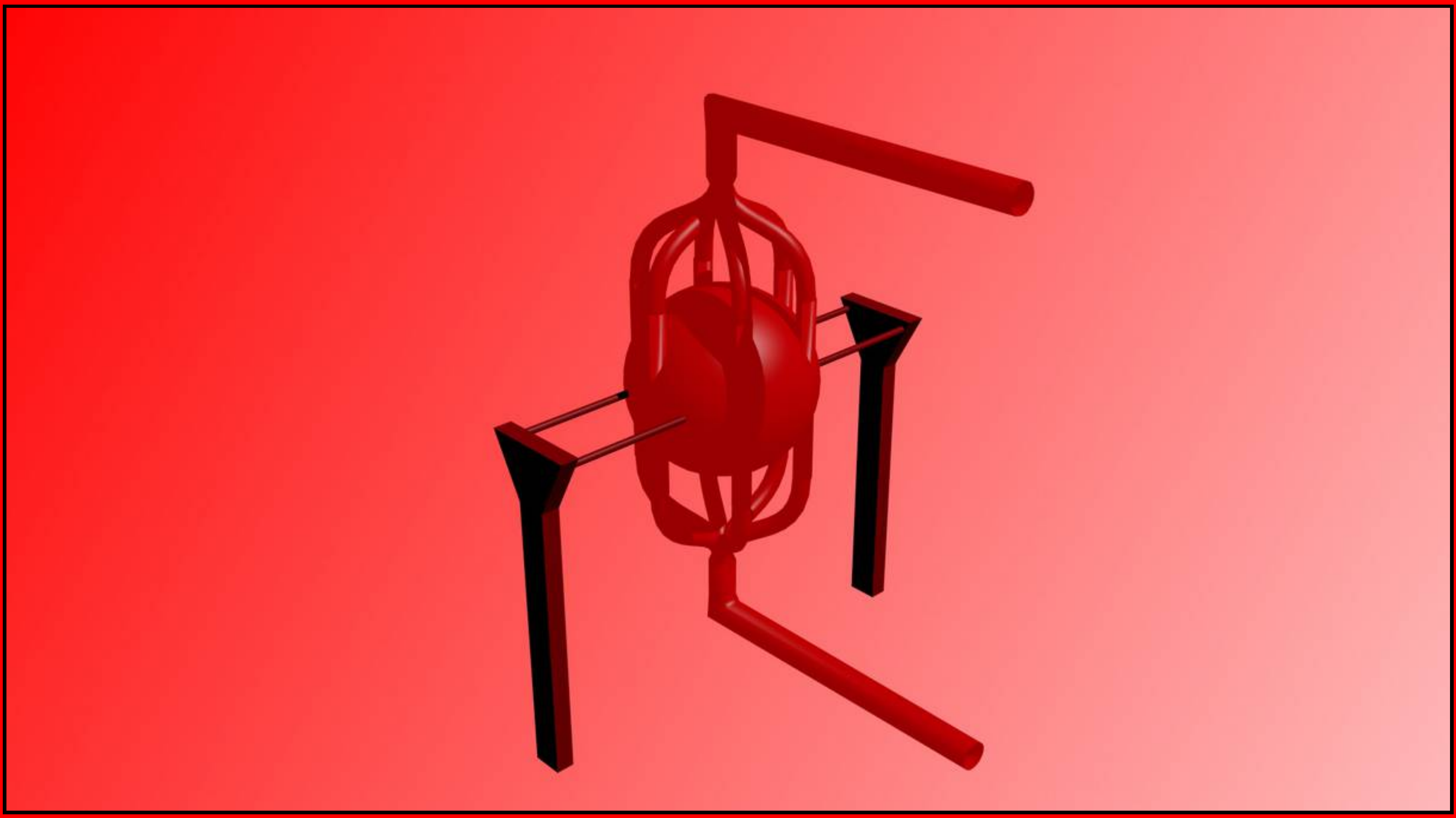
THE ATOMIC REACTORS



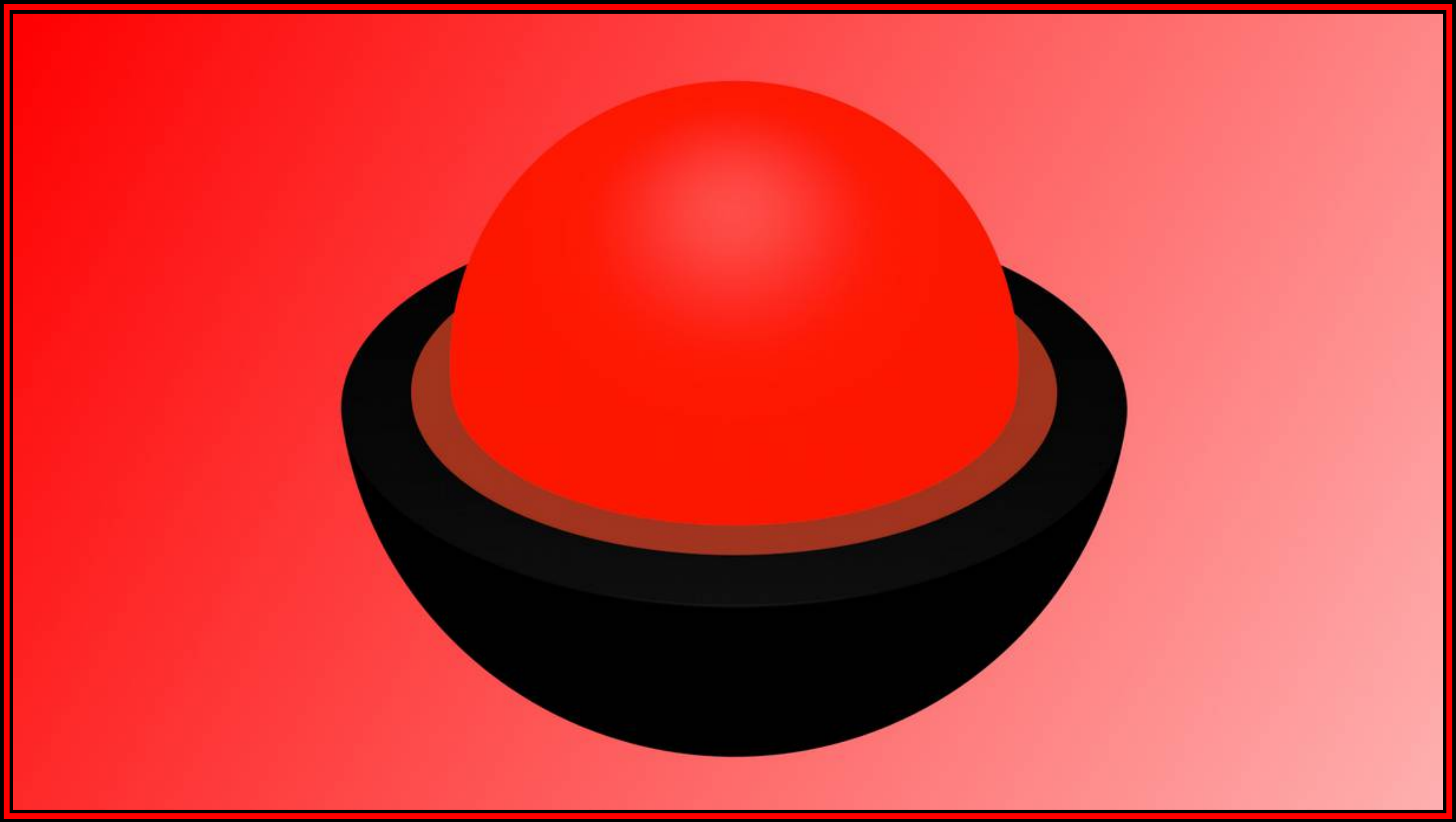




THE EA-PREMIUM-CHAT



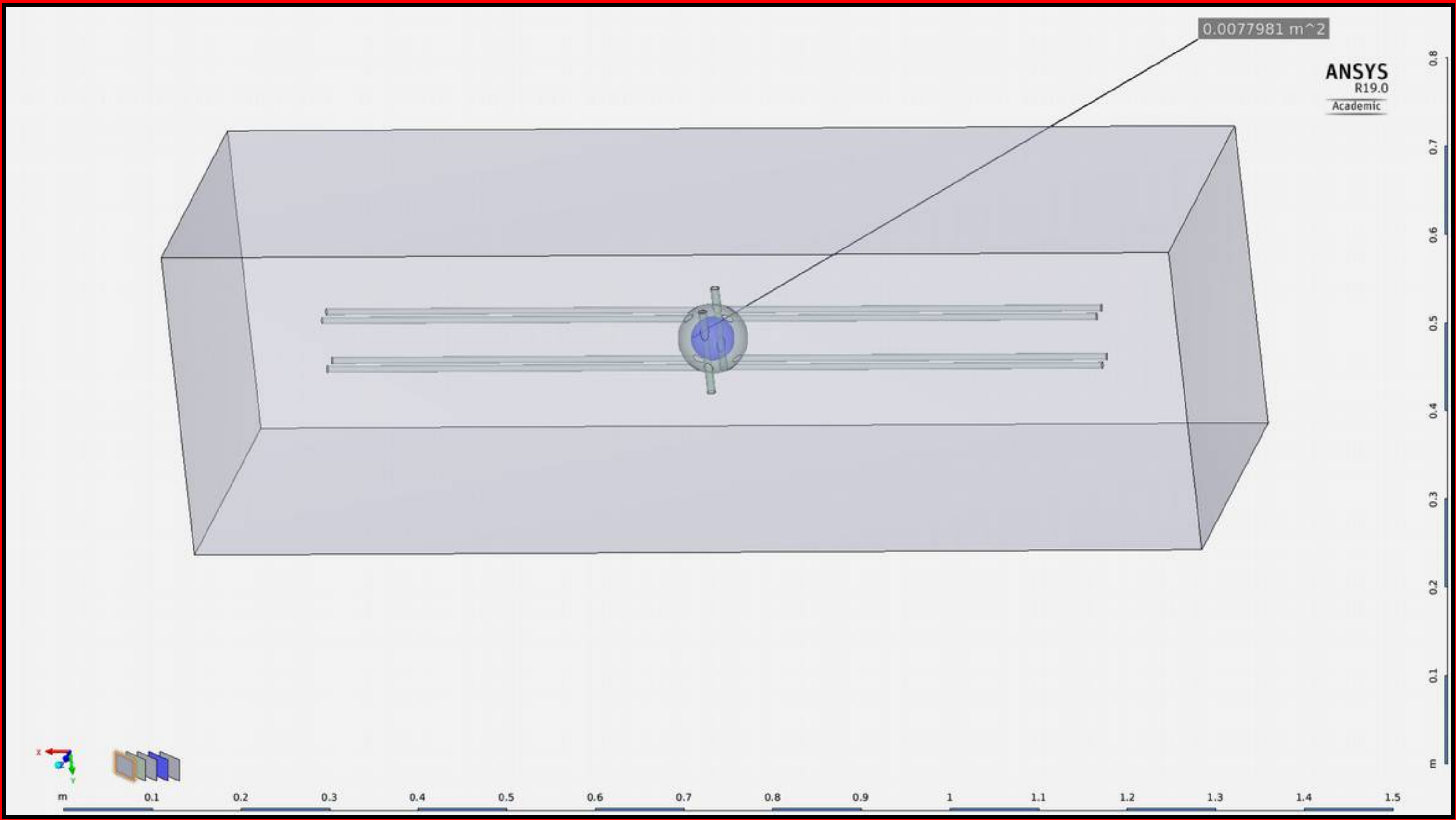
Here is my new generation of nuclear reactor that work mainly with Plutonium-239, and carbine-tungsten reflector and Tin safety layer. After it will be started, only the dead will be able to get close to it :(



To have a good heat transfer, we need a good contact zone between the core and the shell, it could not be solid to solid because of the different dilatation coefficient of the materials. So, I want to use Tin, and fill the hole up to a certain level to take the maximum dilatation volume in count :()

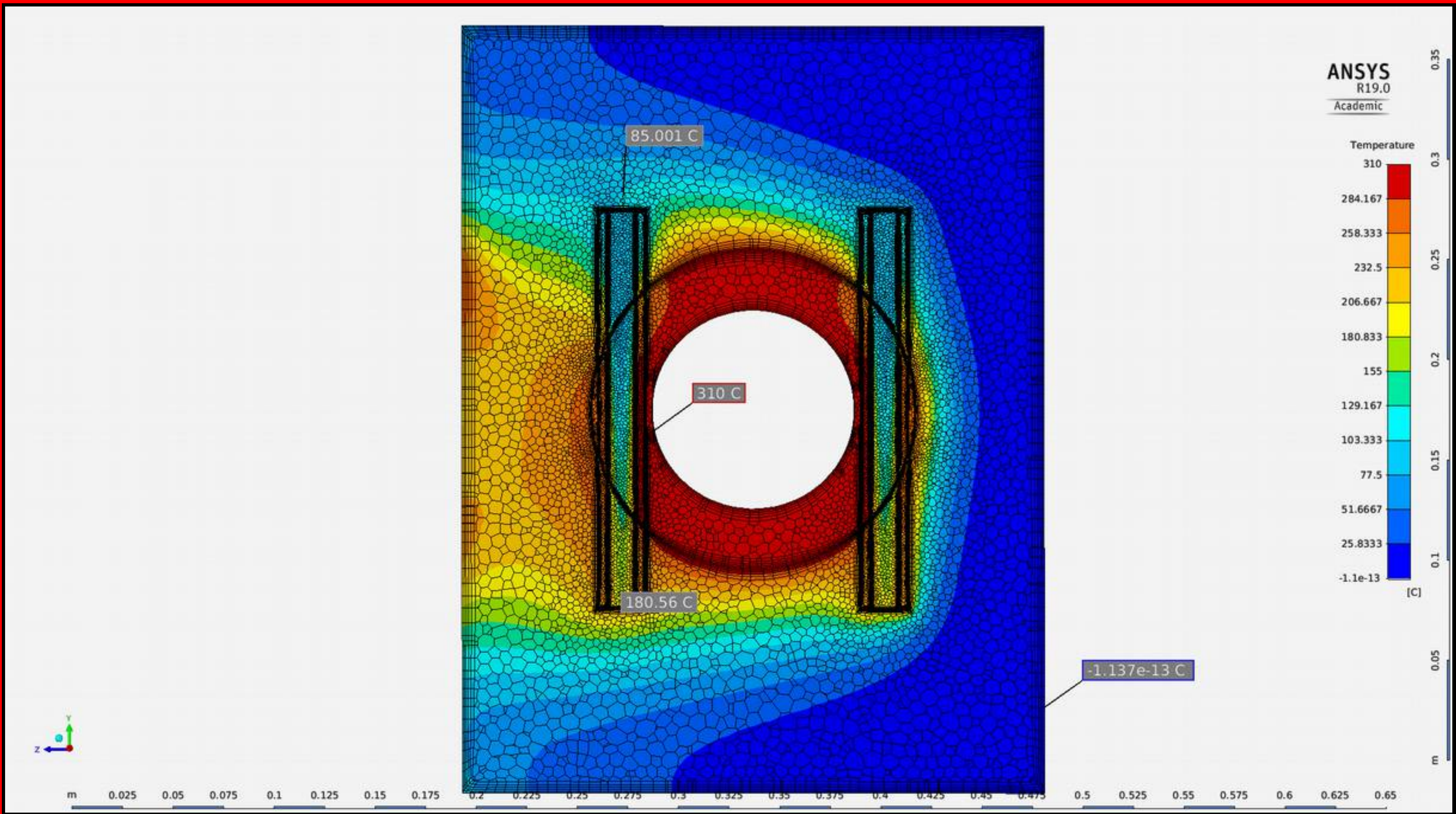
In the heat transfer copper tube up to the evaporator, it will be Mercury (maybe cesium, but it is burning in water), after up to the condenser it will be water vapor because we need a lot of it, and there is a lot on Mars. Close to the reactor the pipes will be in tungsten, to make sure that if something going wrong, it won't melt, the worst case scenario will be vapour ejection in Mars atmosphere (it's almost harmless...).

Major problematic, the temperature of the heart won't be able to exceed the Plutonium melting point, and that with the safety consideration, will make the reactor less efficient and costly (to achieve the same power, you will understand later). My first estimation give about 100 kg of Plutonium (without military grade) per base for a power of 500 kilowatt, with a exterior temperature to not goes over 0°C. There is in the world more than 300 000 kg of Plutonium, in storage facility, mainly in England and USA.



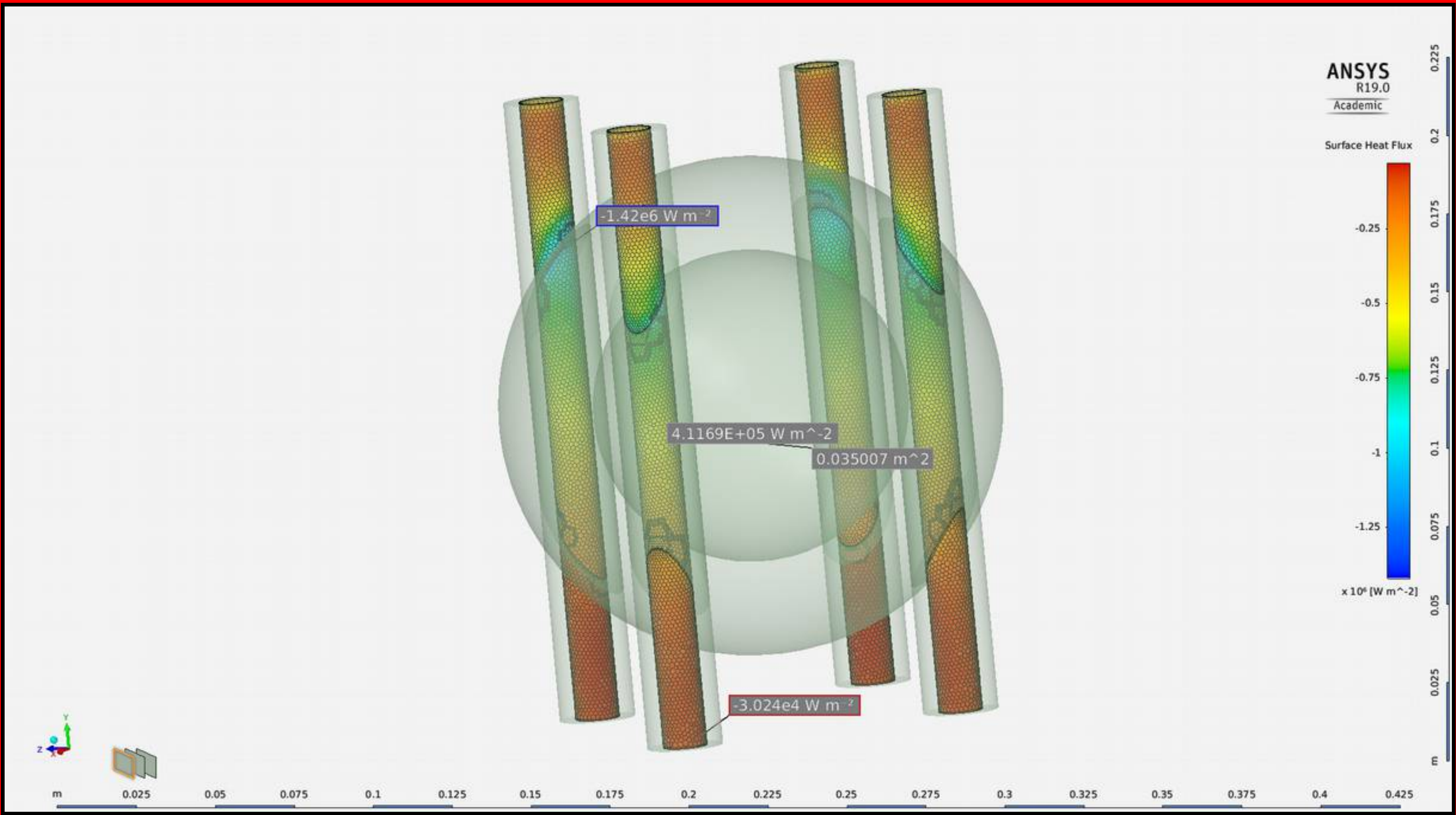
It works like this: The mixture of Plutonium, will produced heat following this reaction:

- One neutron + Pu-239 = 2 neutrons per neutron captured, in critical condition of about 50.01% of producing two others neutrons.
- The Plutonium volume will growth under heat effect, and loosing is criticality. It will stabilized at a density X-Cat :)
- The tungsten-carbine, will reflect a certain quantity of neutron, with the possibility to reduced the critical mass if it's the choice we will make to achieved better efficiency over time.
- Some fail safe devices will be included, the shell itself made of pure tungsten, evaporation of the Plutonium by the top, and the homogenization of the Tin and Plutonium if it melt :(
- Dynamic monitoring of the heat, by captors and passive heat dissipation by heat sink
- Wall to hide the system from the wind and control over this wall, that is not mandatory, but it could improve efficiency.
- Three independent pumping systems for the mercury, to not loosing the reactor (the power production of it)
- Hundred's of this unit for energy security reasons :)
  - Heat dissipation efficiency related to Martian atmosphere saturation.
  - The lost of some units must not influence the overall power productions too much :)



On the image, we could see the reactor at operating temperature, to that fact being possible, the fluid must circulate at a sufficient speed. The Mercury is entering on the top at 85°C and heated up to 180.6°C. Those temperatures are given as is, because I personally can't achieved to optimal delta T for the best heat transfer to the water steam (It's a huge problem, that can only be approximate by expert then experiment for the optimal solution). But we could easily understand that the power transfer is enough to the boiler, we only have to set the good speed for the fluid, and with the good boiler design achieved the best ratio transfer from the core to the turbine, ultimately (I hope for 65-70%).

On the second image, the thermal flux give a power rating of: 4.12E5 W/m² * 0.035 m² = 14 420 W, with the addition of two more pipes, it could be increase to close to 18 000 W :) 350 kW / 18 kW = 20 reactors per bases at 1.75 kg of Plutonium each.



All this computation are relative to the criticality of an atomic Plutonium bomb at a diameter of 9 cm, with the neutron deflector. At that size, we know that the probability of producing 2 neutron by the occurrence of one neutron is close to 50+%. This fact will allow the reactor to produced self-sustain heat. Data:

- Rayon: 0.045 m
- Density of Sigma Phase: 15.85 g/cm^3
- Atomic weight: 239 g/mol
- Contamination (purity): 5%

By the simulation software this configuration gives a barn surface for a probability of 50.079% of about: 2.895 b

- Rayon: 0.04396 m
- Density of Sigma Phase: 17 g/cm^3
- Atomic weight: 239 g/mol
- Contamination (purity): 5%
- barn surface: 2.895 b

By the simulation software, this configuration give a probability of 52.372%. The delta % of two phase = 2.293%, that amount could be lost in further contamination, with a safety margin of 0.293%, it gives 2% net lost.

0.293% gives a radius delta of about 50 micron. The subsequent contamination will need to be in order of 4.25% to fill the 2% probability left. This 4.25% of contamination could gives this amount of energy:

- 83.61E12 J/kg of fissile Pu-239
- 18 000 W of power for the reactor
- 2.153E-7 g/s of Pu-239
- 1 Years = 365 * 24 * 3600 = 3.15E7 s
- The 4.25% give: 0.0425 * 6 kg(Pu-239) = 255 g
- This 255 g could be constituted of 1/3 neutron depletion cycle
- 2.153E-7 g/s * 3.15E7 s = 6.79 g
- 255 g * (1/3) / 6.79 g = 10 years

1% gives a radius delta of about 0.17 mm. The subsequent contamination will need to be in order of 2.75% to fill the 1.293% probability left. This 2.75% of contamination could gives this amount of energy:

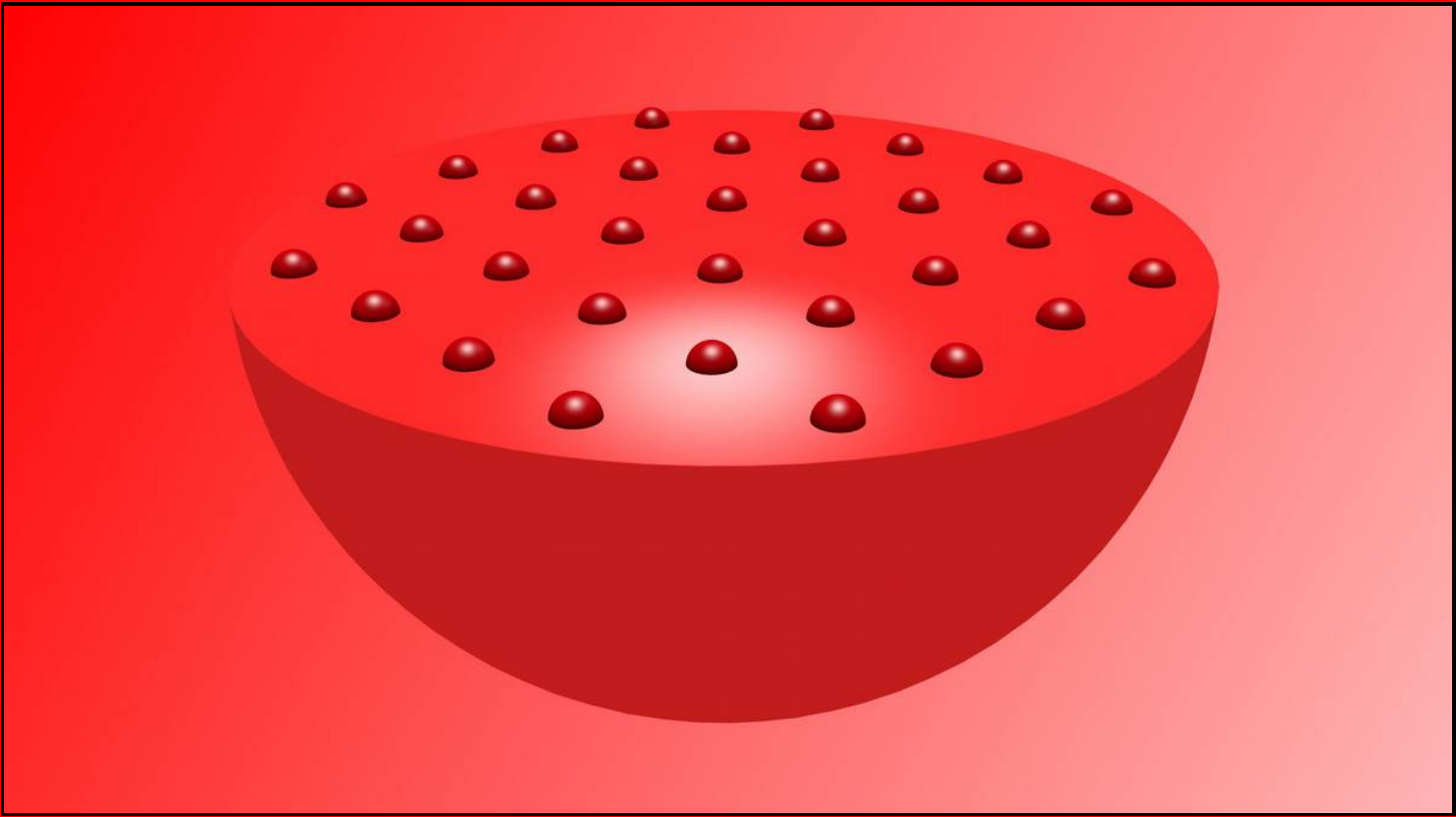
- 83.61E12 J/kg of fissile Pu-239
- 18 000 W of power for the reactor, thermal that gives 15 000 W electric
- 2.153E-7 g/s of Pu-239
- 1 Years = 365 * 24 * 3600 = 3.15E7 s
- The 2.75% give: 0.0275 * 6 kg(Pu-239) = 165 g
- This 165 g could be constituted of 1/3 neutron depletion cycle
- 2.153E-7 g/s * 3.15E7 s = 6.79 g
- 165 g *(1/3) / 6.79 g = 8 years

In the configuration, of 9 cm Diameter, it will need few reflectors to put the mass on over criticality, so we will have to take care of this operation. To achieved a maximum lifetime, it is required to get close to this limit...

The World wide Plutonium stock: (the EA-CAT-PREMIUM-REACTOR has some tolerance to Pu-240 no need to military grade)

Nation	Pu (kg)
Great-Britain	112 000
France	75 000
USA	100 000
Russia	50 000

THE CAT PLUTONIUM COOKIE WITH URANIUM CHIPS



Hummm, it's look great and tasteful :)

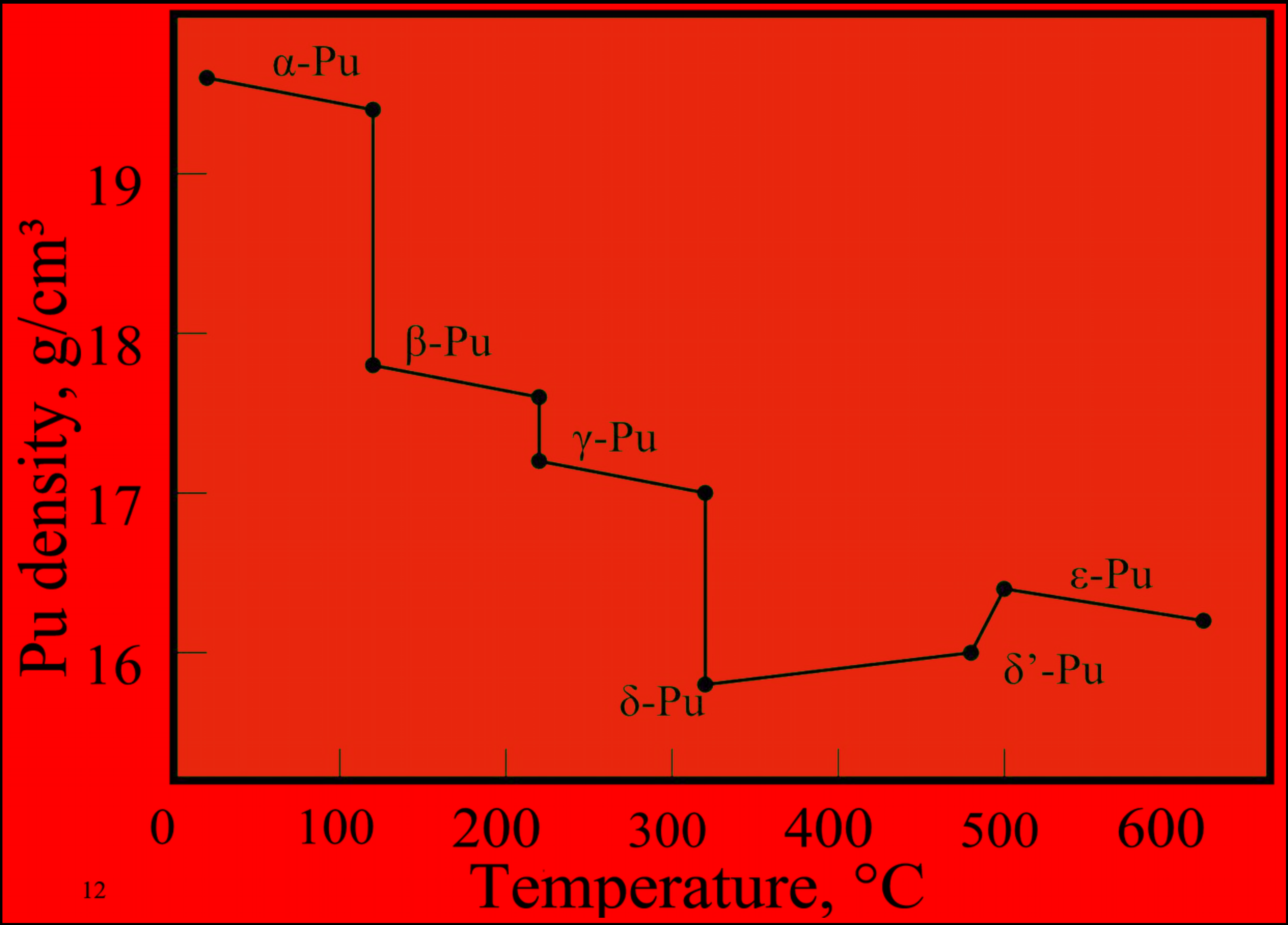
I. Make the Uranium-238 chips
II. Make the Plutonium-239 (not pure) in powder
III. Build layer per layer, the cookie
IV. Compress up to a solid shell, to maintain the shape of the cookie :)

TABLE 1

Delayed Neutron Fractions for Various Fuels

Group	Half-Life (sec)	Uranium-235	U-235 sec	Uranium-238	U-238 sec	Plutonium-239	Pu-239 sec
1	55.6	0.00021	0.01168	0.00020	0.01112	0.00021	0.01168
2	22.7	0.00141	0.03201	0.00220	0.04994	0.00182	0.04131
3	6.22	0.00127	0.00790	0.00250	0.01555	0.00129	0.00802
4	2.3	0.00255	0.00587	0.00610	0.01403	0.00199	0.00458
5	0.61	0.00074	0.00045	0.00350	0.00214	0.00052	0.00032
6	0.23	0.00027	0.00006	0.00120	0.00028	0.00027	0.00006
TOTAL	87.66	0.00645	0.05796	0.01570	0.09305	0.00610	0.06597

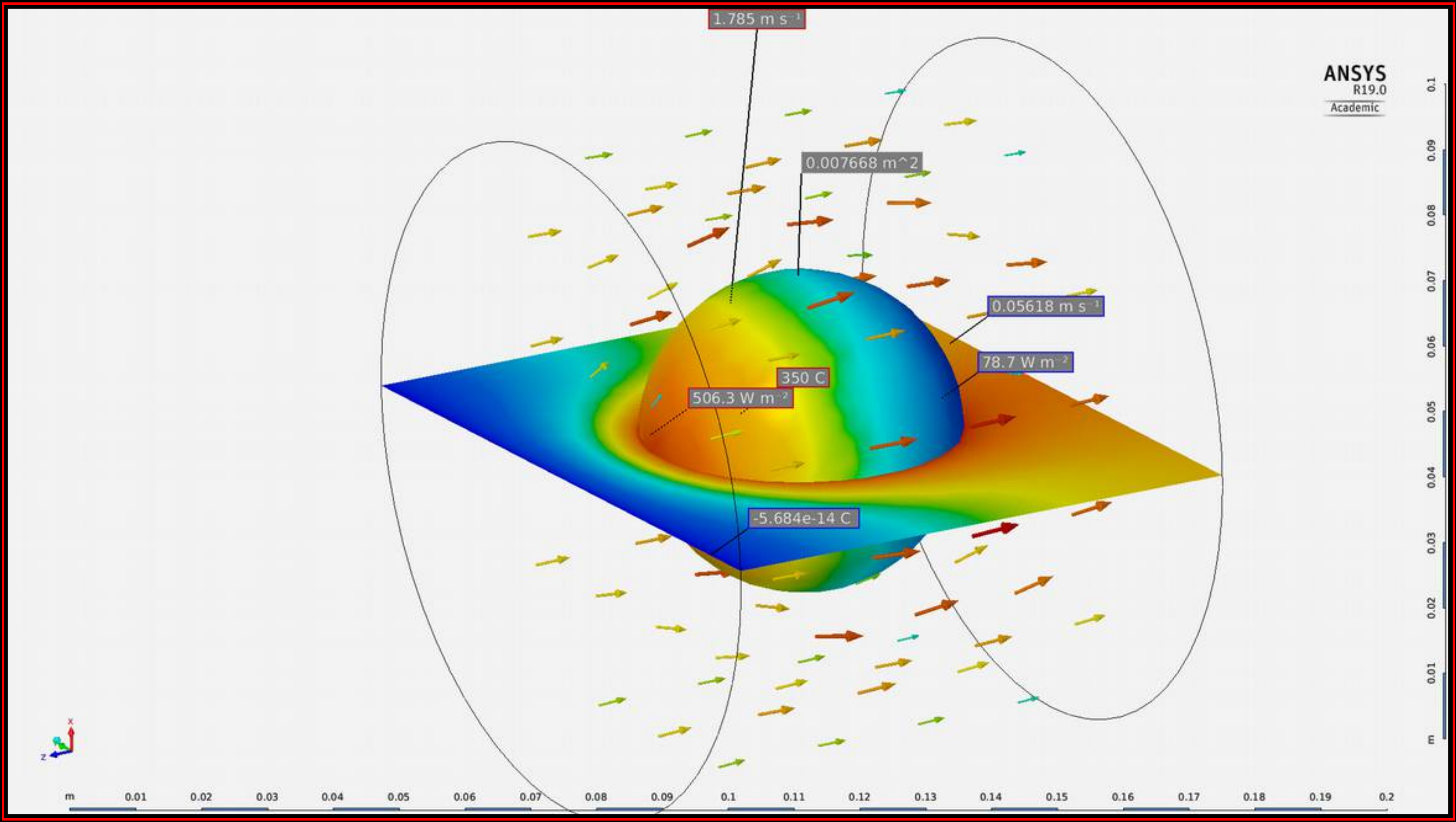
Obsolete and wrong: I will let it there for consideration purpose :)



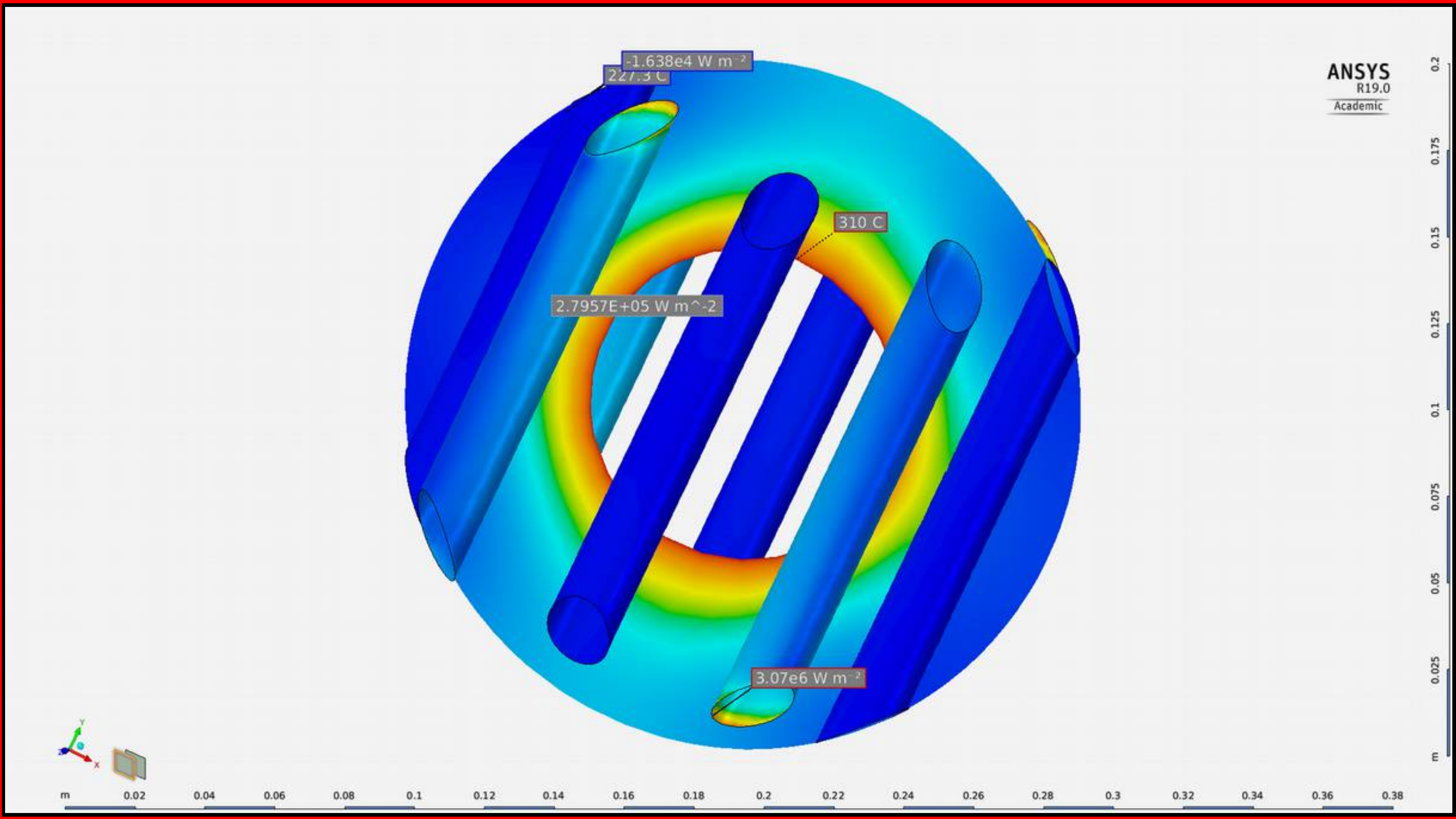
By getting the core at a temperature of 310 or 500°C with a power rate lower than the reaction rate of change of the crystalline network, we will achieve to stay within the limit.

The critical mass of Plutonium is well know, since the appearing of the atomic bomb. Wikipedia: A spherical undamped critical mass is about 11 kg (24.2 lbs), 10.2 cm (4") in diameter. Using appropriate triggers, neutron reflectors, implosion geometry and tampers, this critical mass can be reduced by more than twofold.

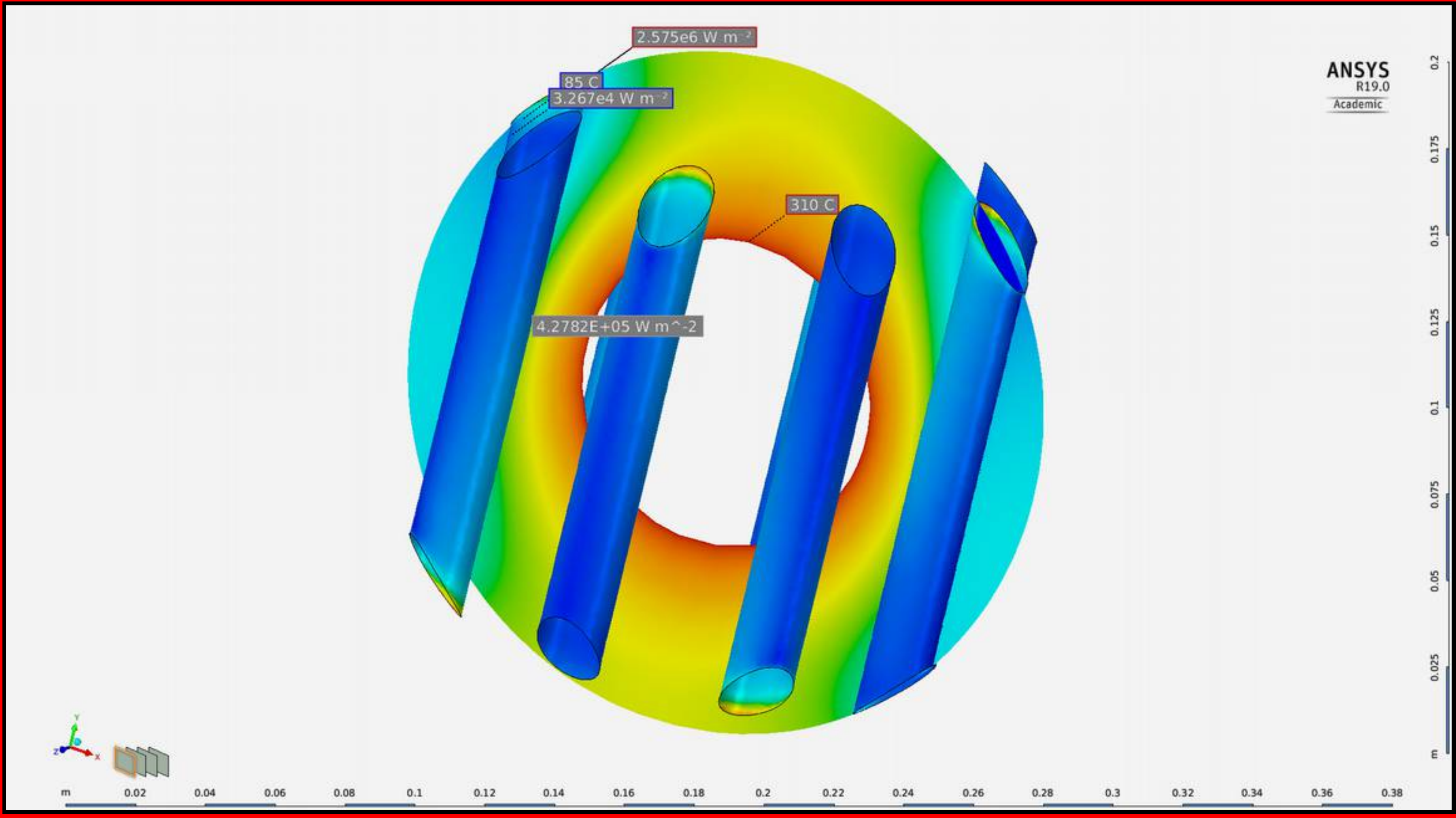
The core will need to be heated to 350°C, and keep at this minimum temperature before being put in the reactor where the deflector will make it under critical by 1-2%. After, it will be need to heat it up to 500°C without being close to it, to start it definitively... At 500°C it will be over critical. **Or let it cool down to 310°C to start it.**



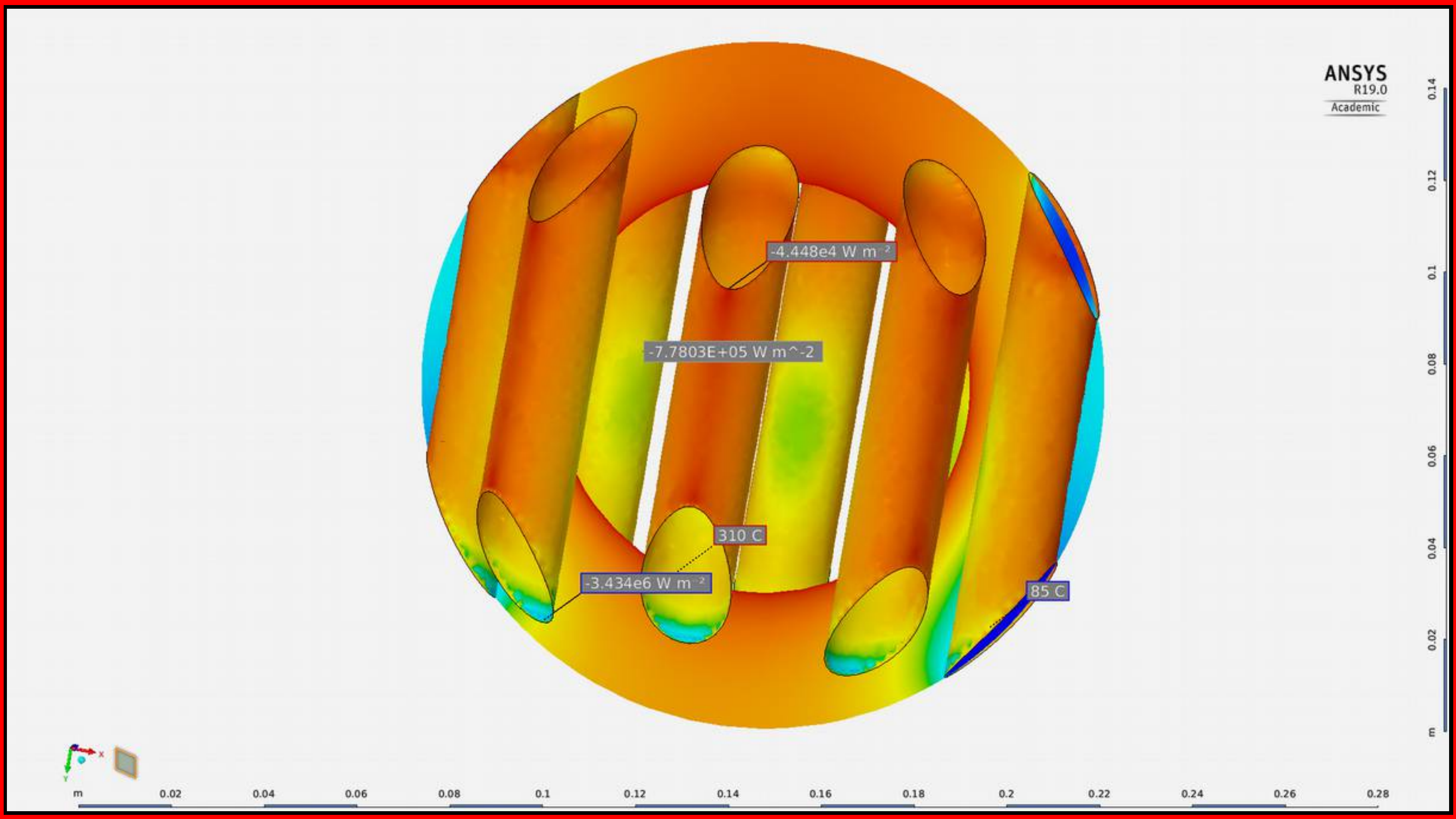
In this image, we could see the Pyrex sphere that contain the heated Plutonium. At a rate of 2 Watts of heat loosing, we will have more than 2602 J / 2 W = 1301 s = 20 minutes (Plutonium mass not taken into account) to insert it in the reactor, if it's not enough we could use a thicker container :) :() :(



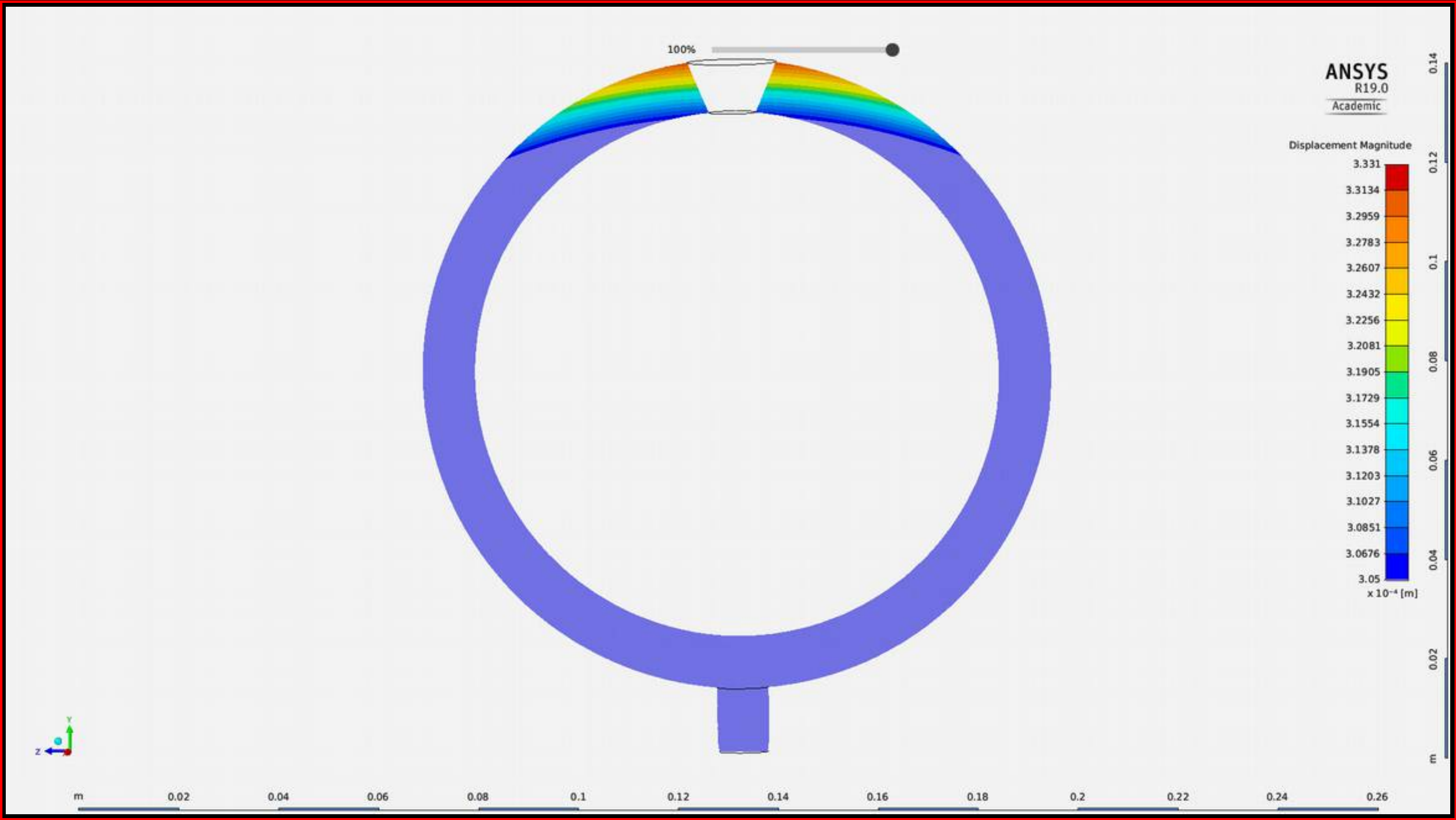
In the first image, only four tubes are in use, and in the second there is 8 tubes: the ratio is 1.53X heat flux

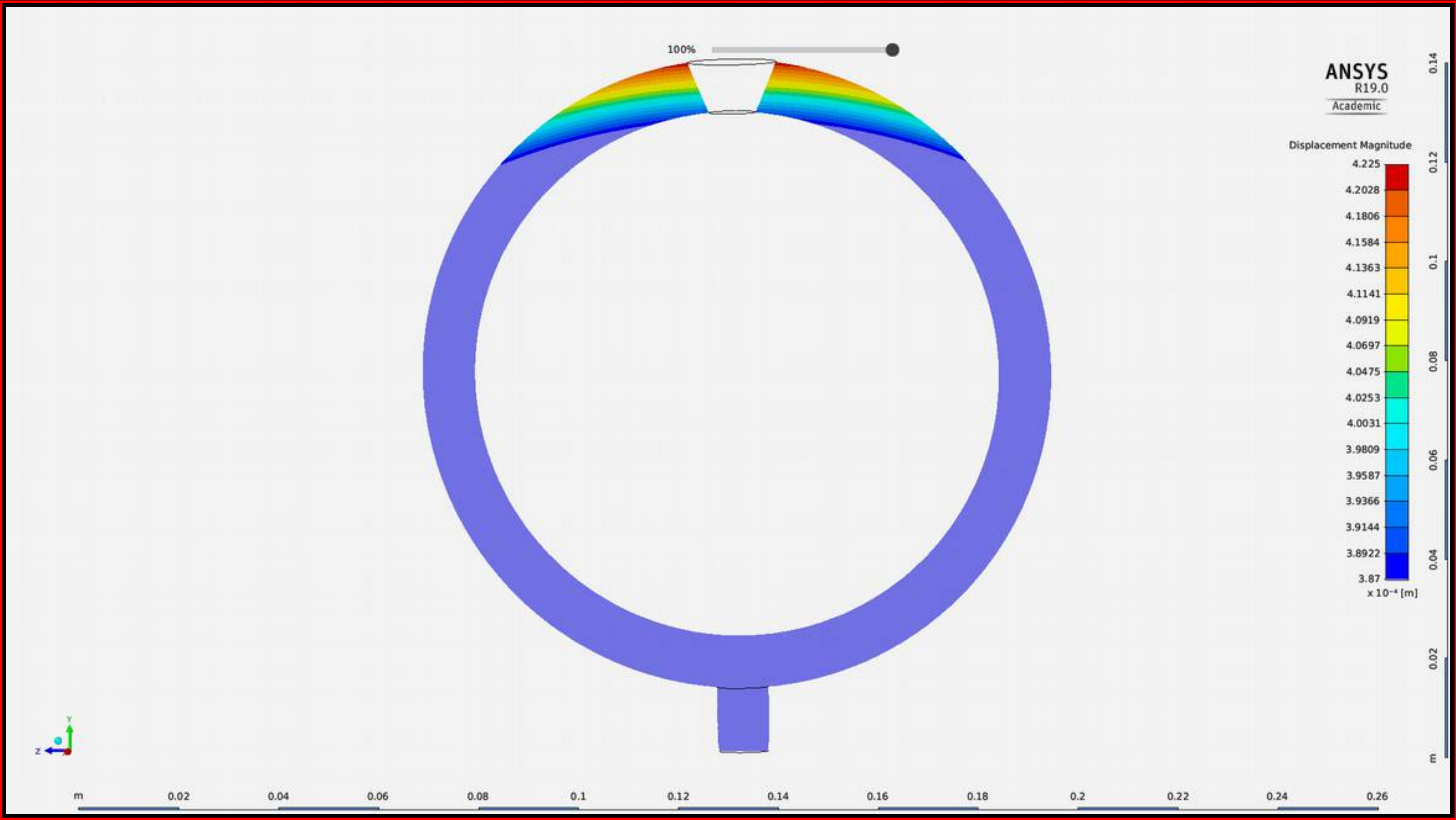


in the second. 28 678 W in the second reactor in tungsten.



In this image, the shell is half the thickness of those on the previous page: 33 246 W, a factor of 1.16X better.

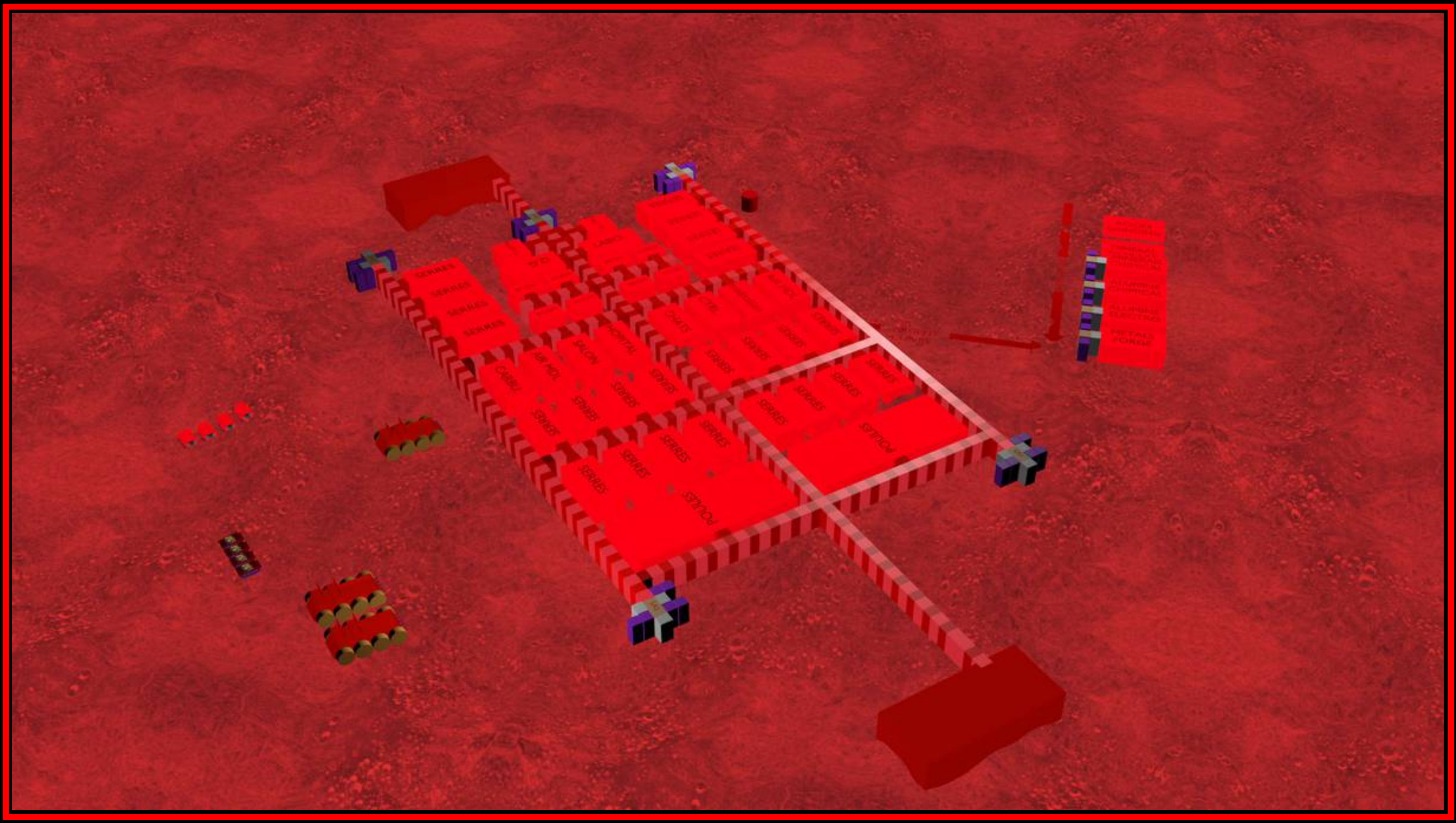




Difference between 480°C and 600°C, by a point of view of dilatation. The delta is about 0.15 mm, that will do... but it's now obsolete, for consideration only :)

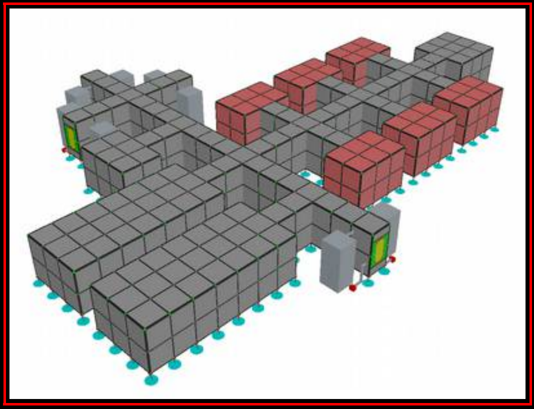
PHASE-1

The assembly of the principal complex:



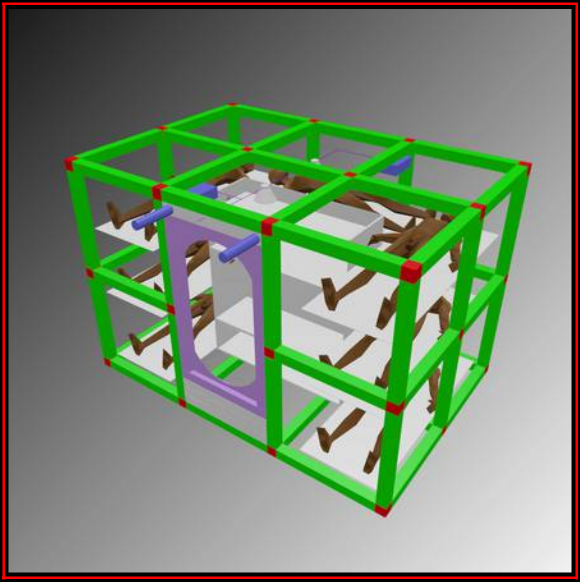
Complex Principal EA-CHAT-ETERNAL

THE DORMITORIES



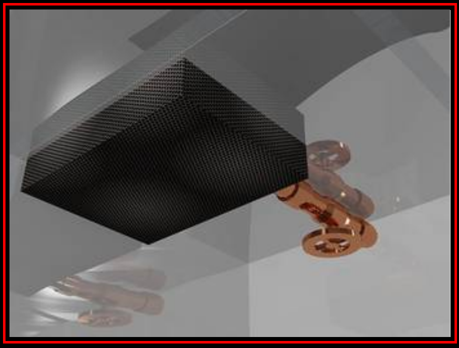
The regular surface dormitories, of the first phase, will be more comfortable than the temporary shelter of the initial landing phase. The typical day, at the beginning of the colonization, will be constituted of three shifts of height hours. The marsonaut will have a bed for a duration of 12 hours, enough to sleep and rest.

As you can see on the drawing, there is 6 dormitory module, link together, in this version, by a 1.4 meter width “tube”. Each module must be close when no one entering it. With this kind of door, in this version, we can unlock it only from inside. Because the mass of each module is low, they could be assemble and weld separately, and connected together subsequently. This method will allowed assembly by more marsonauts and shorter time. The interior will be finished once pressurized.

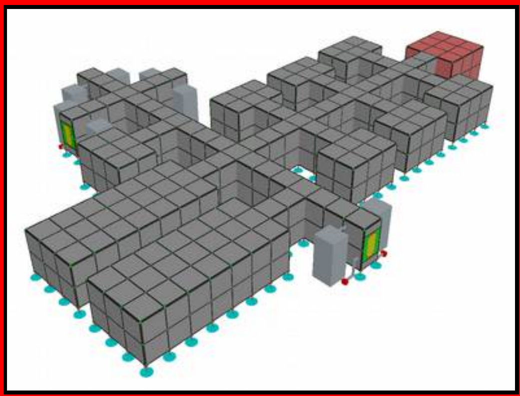


Like others exterior modules, the structures will hold on isolated spring with adjustable height. All this to prevent the modules to fall in the ice with the lost of precious heat. And more, the modules are connected together, and must stay at the same level for structural integrity. There won't be any source of water in those module, because the time required to some in place will be prohibitive during the first phase. Also, water is a precious resource and can't be waste.

The dormitory will be provided with independent ventilation, and two closing valve, just in case of... Some protection mechanisms, like sensor, and automatic pressure drop valve. Marsonautes will be allowed to put their suit in some kind of lockers. The others stuff will be provided when the marsonauts will have time to go back on the field to search for them :)

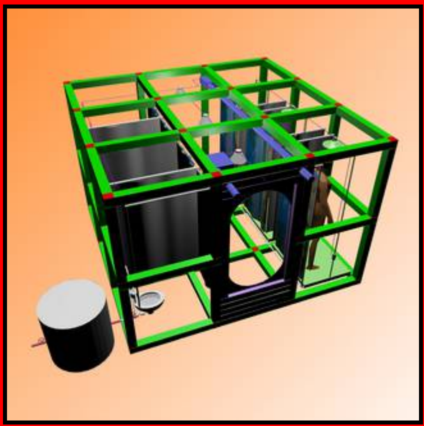


THE SHOWER AND TOILET



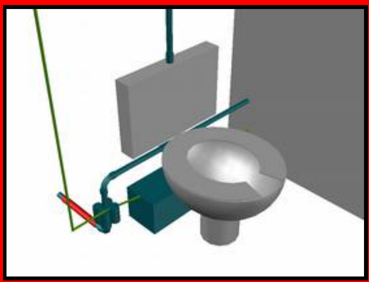
Located close to the dormitory, the restroom was a great source interrogation. With three showers, 4 toilets, this module will make everyone happy :) With an individual using time of about 58 minutes per marsonauts per day, it should not be overcharge :() The toilet itself, will possess two modes: one for solid and one for liquid, for a greater efficiency.

The water economy system of the shower is very interesting. It is consisting in pumping water from the bottom of the shower up to the top ! We could make the water quantity present in the system varying, during good situations I would set this value to 10.5 l. The ventilation system could be use to share moisture between this module and the rest of the base, because their will be ultimate dry condition elsewhere.

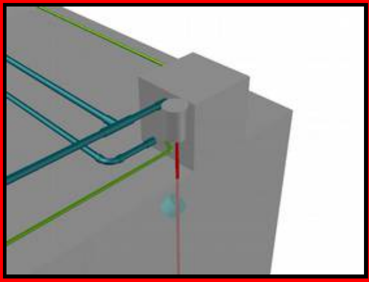


The using time of the showers should be fixed to 43.2 minutes per marsonaut per day, in this configuration of 100 men per base. It could look strange, but they could wash their cloth directly under the shower, because the cloth itself will be made of very thin tissue that will dry rapidly. During the next phase of development, it will be possible to install a better process for doing the laundry.

The interior of the module will be built in plastic, for at least the shower compartment, the poles and separator. The toilet will be made of aluminum. The toilet mechanism will be active suction, because we won't have sufficient height drop for regular system. The pumps could be replace by spare parts (they will most probably fail before a long time).



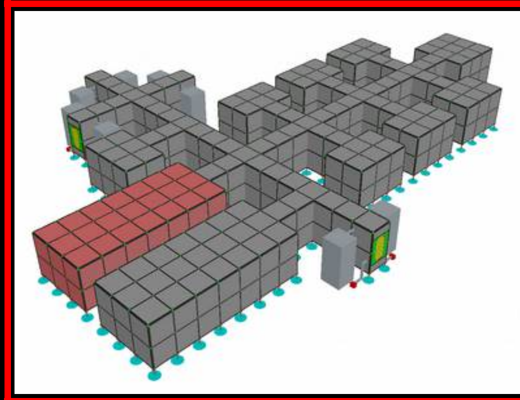
The water of the shower, will be heated a minimum , because in this case it is going to came from the reactor (not for the first hours). All the water used by the shower will be recycled in the toilet, and be rejected outside to be used as building material for radiation wall or road.



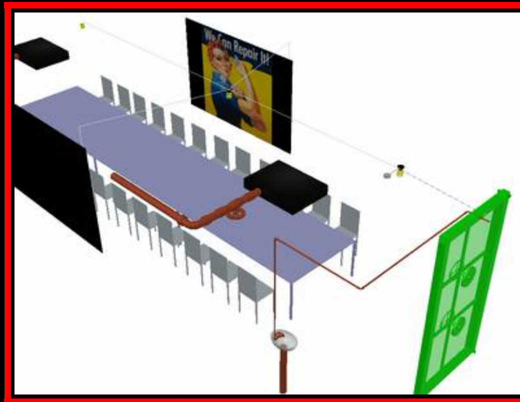
Consommation d'eau par jour sur une base

	Marsonautes	Nombre / jr	Eau requise: Litres	Total:	Total par groupe
Selles	150	1	6	900	
Urines	150	5	1	750	
				réutilisation:	1650
Lavabo	150	3	0,25	112,5	
Douches	150	1	10,5	1575	
Netoyage	2	1	2	4	
				première utilisation:	1691,5
Eau potable	150	6	0,75	675	
Eau de cuisine	150	3	0,25	112,5	
				dépense nette:	787,5
				Total eau fraiche:	2479

THE COMMAND ROOM

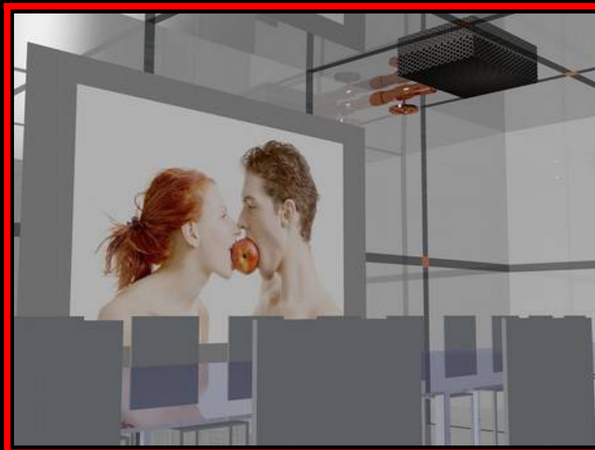


Convergence point of the surface complex, the great room or the command room, will be great asset. For eating or meeting, during the 4 hours break, it will be love by all. Of equal dimension of the laboratory room, and 3.5 time bigger than the dormitory, such 9.2 X 2.7 X 4 meters in this configuration, it will allow 24 Marsonauts to sit and some standing beside. With two big screen made with OLED, we could watch movies like 1984, revising strategy or receiving message from Earth...



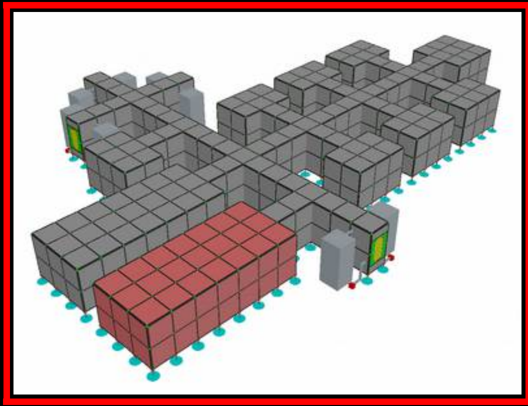
One of the two water source of the base will be in this room, available to the conqueror. The water itself will be distilled, so we will need to add some minerals in it, for drinking. The matter constituting the chair could be in some rare material for future need. It could be easy to melt those chair to build conductor from copper. They could after be replaced by the same model but built with local resources.

The whole base, could be control from this room and the marsonauts too, with only one laptop plug on the network and of course the password for it :) The network should be decentralized, some boxes in every corner of the complex will made its power of calculation. The helmet of the marsonauts will deserve this function too, and adding some exterior sensor to the system. Each room will be equipped with those sensors:



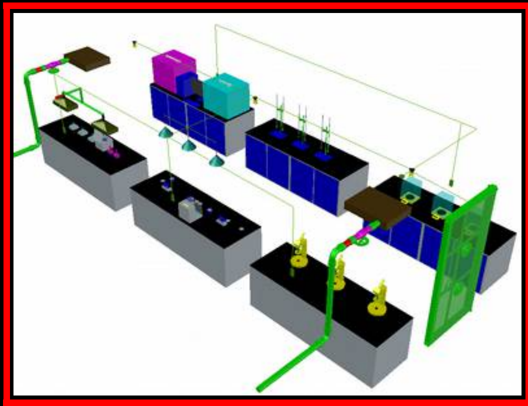
1. Barometers
2. Detectors of CO_2 level
3. Detectors of O_2 level
4. Detectors of CO level
5. Thermometer
6. Smoke Detectors
7. Hydrometer
8. Voltmeter for electrical network
9. Water pressure
10. Door status
11. Ventilation level

All those systems, won't be installed the first hour, but as soon as possible. Wires will be to proscribed as we could, see car electrical system :()

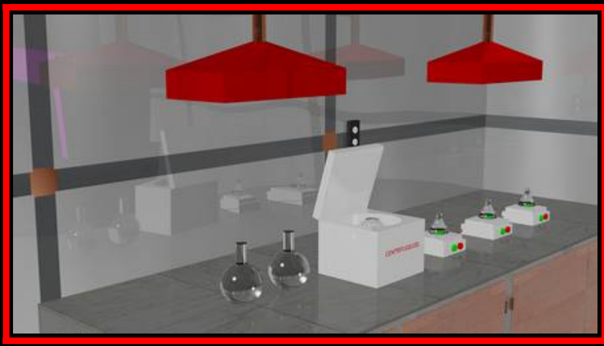


LABORATORY

This structure will be operational on the next day. The systems inside it will need to be in place as soon as possible, for possible medical emergency, because number of essential tools required for it, are in there. From the radiography, to more intensive scanning device, physicist and surgeon will make great use of those technology. The medical database, for scientific officers, will be located physically in the laboratory. During the third phase, when we will go underground, the tools will be transferred to the new module, the old one will became an emergency station for outside workers.

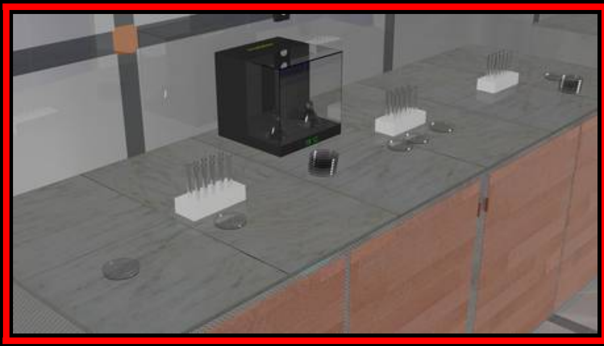


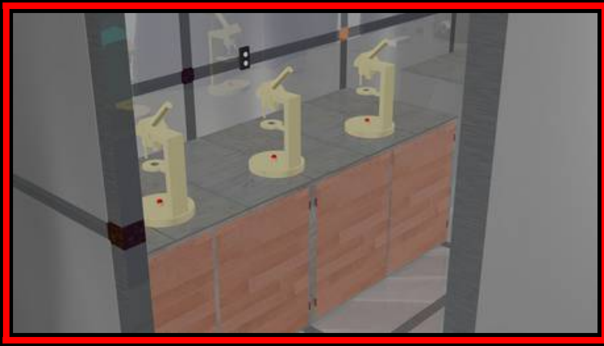
If everything going fine, the first task will be to analyzed the minerals that will be found under the ice or on the border of the site. You have to find a source of aluminum. Ice analysis is essential, but preliminary analyzes following the probes sent will probably have answered the main question: Is there NaCl in quantity in or under this ice? Aluminum production will start as soon as possible, after these two questions have been answered. Details of aluminum production will be discussed later.



Also, monitoring of plant growth is essential, and will need to start in the lab and in greenhouses from the end of phase-2. Vegetable consumption should begin with radishes 30 days after starting germination. Extensive analyzes, in a multitude of fields, will begin, to write a big chapter on Martian biology.

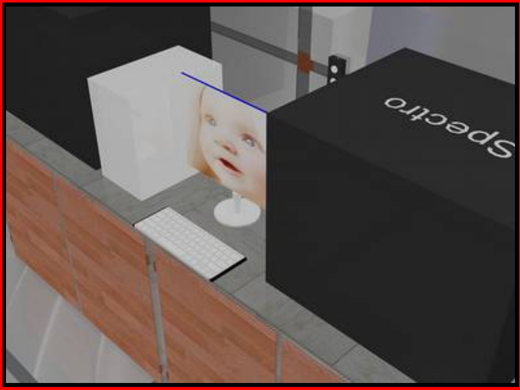
We can see, in the drawings beside, one of the possible configurations for the laboratory. Divided into 6 workstations, the laboratory will evolve as needed. It should be noted that full size images are available in a directory provided with the Open Office document and PDF. At station # 1, equipped with two hoods that open directly to the outside, may be performed more risky experiments or requiring a small evacuation of gas. Because having hoods does not mean justification for anything. Really risky procedures will be done outside of the main complex. In the drawing, a centrifuge, hot plates and glassware.



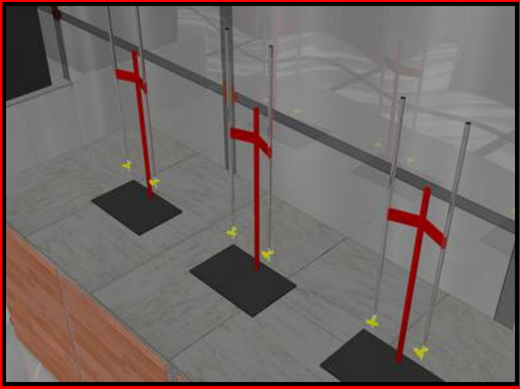


Station # 2, showing on the drawing an incubator and test tubes. With maximum illumination, this station could serve as an operating table when needed. The related material in the cabinets.

Station # 3, the photon microscope, will serve very early. The biology of plants, with a gravitational force of 1/3 of g, will not be complete when departing towards March. Analysis and refinement will be on the agenda. What a challenge for young scientists who will be recruited around the age of 13 or 14 and will be in their twenties once on Mars. For that, it will be necessary that the project is salesman and planned in the extreme. Specific educational guidance will have to be implemented.



Station # 4, that of the database computer, the mass spectrometer and the chromatography. For the analysis of Martian rocks, this post will be of great help. Probably busy full-time, scientists will have to prepare in advance, to minimize their time of use. The collected data will be classified by the chief scientist in a right of access system. The high authorities of the Earth, will be informed in the shortest time of the discoveries made on Mars, to develop improved strategies. Thousands of scientists and technicians will surely work faster than the few marsonauts busy with collecting data.



Item # 5 contains on the image, burette that will be used for several tasks. Essential element of any laboratory, they are often used to carry out a manual titration or to mix a mixture with precision. For example, in the case of Mars, the study of the process of extracting aluminum from Kaolin, introduces the need for their use to add sulfuric acid in an exothermic mixture. The burette could be stored on the shelves, to make room for other instruments.

Item # 6 contains on the image 3 electronic scales. To be moved with care, the electronic scale can be classified as (Reference # 13):

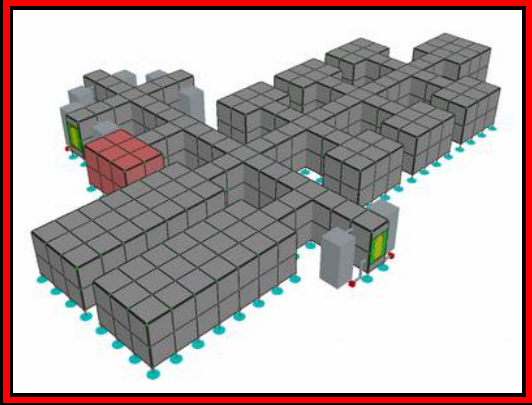
Analytical balance:

- Ultramicroanalytical (0.1 µg / 3 g)
- Microanalytical (0.001 mg / 3 g)
- Semimicroanalytical (0.01 mg / 30 g)
- Macroanalytic (0.1 mg / 160g)
- Precision balance (1 mg / 160 g - 60 kg)

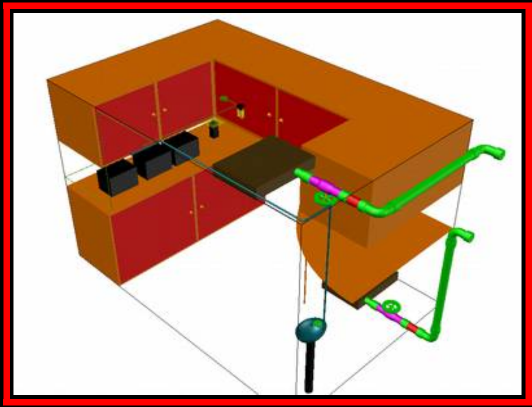
Each type of balance has a weight range, for the Martian scales, it will be necessary to adjust the weight to the gravity :)

Here is what could happen if the washing is not done, because the manager would have fallen sick and had to be operated on. In conclusion, this represents a good summary of the possibilities that the laboratory will have on the red planet. The complete list of instruments and glassware is very long and is not limited to this configuration. In addition, we will have to add a list of chemicals that we will send up there. I started working on such lists, but this is beyond the scope of this chapter.

KITCHEN



The kitchen will start with limited functions, since the marsonauts will be on food rations, imported from the Earth, for 2 months. The transfer between the imported rations and the food produced on Mars, it will do gradually. With local production, it will feel the need for a room dedicated to the preparation and cooking of food. Even with the improvement of the quality of the rations, during the opening of the kitchen, the explorers will be satisfied only during the appearance on the menu of vegetables and chicken (fish farming remains an option little analyzed). One of the negative points is that cooking techniques will be limited because the air will be a resource to preserve (not too much smoke).

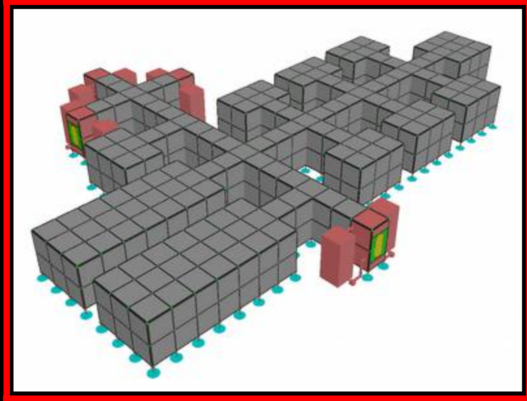


We can see on the drawing that the kitchen is good size: 4.5 X 3 X 3 m. The storage space is more than sufficient, given the directive to consume food as soon as possible after harvesting. The storage volume is estimated at more than 9 cubic meters. In order not to throw anything away, it will be possible to build a certain stock of food anyway. This only for products that can be frozen and stored outdoors. Food such as tomato sauce and some vegetables. Lactose-fermented products and dehydrated vegetables may be partially stored in cabinets. I propose to introduce a system of voting to select products that would import the base from the Earth periodically. The spices would meet several selection criteria and give a lot for the mass and volume allowed. The marsonauts would see their morals increased following this type of initiative. Each new Martian would be entitled to an individualized sending every two years, bet that in many cases, it will be edible food. The kitchen will have a water point without drain, but which will be accessible only for the needs of this one. The sewage will have to be conveyed to the outside by the toilets, a seal will allow this work.

A single person will do almost all the work and will be replaced at least at all working shift. There could be 18 services during the day, so 6 per shift. Since the first days on Mars will require a lot of logistics, the lunches will be brief, because the work in the great hall will take up more time. The order in which the workers will be served, will be determined by their daily efforts.

It can be noticed that the drawing includes 3 small owen. One of these is a microwave, the other two are roasters for chicken. Other adapted devices will be available such as a pressure cooker, a kettle ... The quality of the food will be a priority because it has a great influence on the morale of the troops. For security reasons, the knives will have a transponder that will prevent their exits from this room. A complete section of the sabotage guide will be devoted to cooking and food (see Sabotage Consideration chapter).

SAS



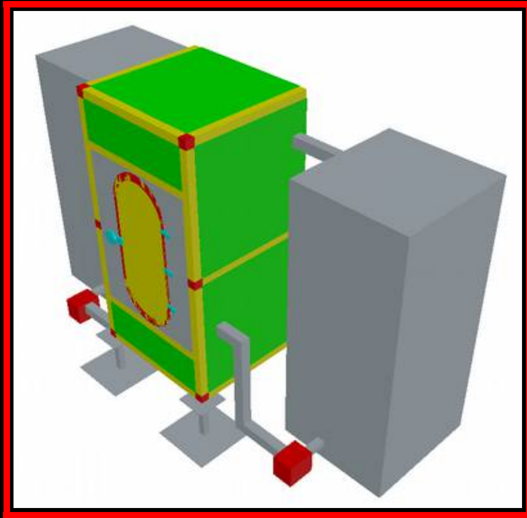
The SAS is one of the most important system, an unprecedented technology allowing a minimal loss of atmosphere and time will be put in place. I named this one: SAS without loss. Of course, there will be losses, but it will be minimal thanks to two tanks that will act as a buffer.

The principle is simple, to go out, the one or two marsonauts will open the first door, and once inside will ask for an exit using the interface of their helmets. The air in the SAS will empty to both tanks and when the pressure balance is reached, a pump will empty the rest. When the air has been expelled the door will be unlocked automatically. At this point the ideal would be for someone to want to enter the complex to avoid a pumping cycle. So, by synchronizing the inputs and outputs, the work of the pumps will be minimized and their lifetimes increased. To enter the marsonauts, there is absolutely no CO_2 in the complex, we could clean the SAS with oxygen to further reduce the presence of this gas. It is possible to transport and store a small amount of gaseous oxygen.

There will be four SAS for the main complex. In the case of an absolute emergency we could depressurize the complex and open the doors of the SAS for a smooth exit of the staff. But, the value of Nitrogen leaves me to think that this type of intervention is better not to happen. Nitrogen production will be by distillation of liquid air in a module provided for this purpose, at a cost of 250 kW of electricity for a production of 20 cubic meters of nitrogen gas at TPN per day. This startling cost is mainly due to the composition of the Martian atmosphere:

Composition de l'atmosphère de Mars	
Dioxyde de carbone	95.32%
Diazote	2,70%
Argon	1,60%
Dioxygène	0,13%

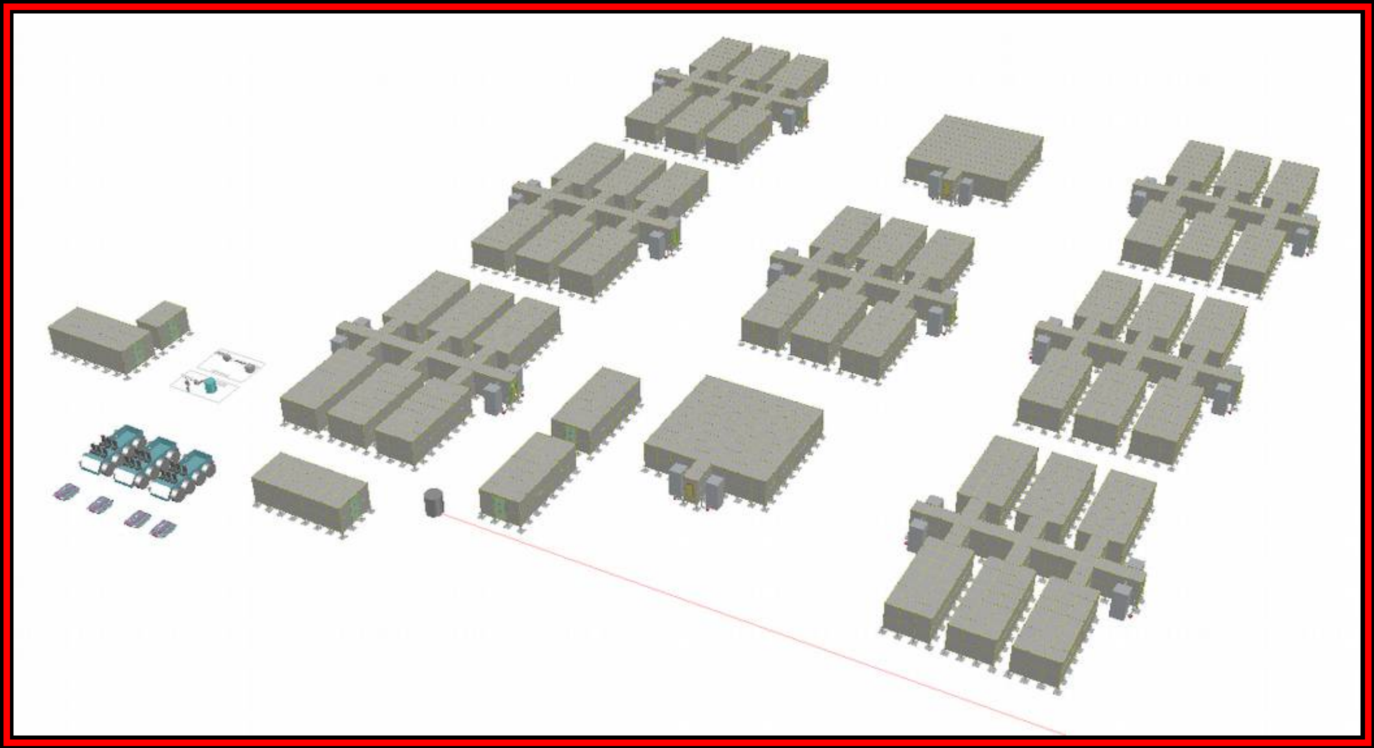
The entire main complex contains more than 250 cubic meters, so 17 days at 250 kW of power to fill it with nitrogen TPN. It is possible to convert the atmosphere into oxygen only but for comfort and plants the nitrogen is essential. The initial reserves will be about 5 l total required for all modules, plus a reserve of 50 l at the landing which will evaporate at a rate of 2% per day. That is to say that without cooling there will remain a reserve of 6 l after 100 days on Mars. However, the nitrogen production module will include a refrigeration system that can support this reserve.



The conceptual drawing opposite, shows us the tanks and the two pumps. The tightness of the doors is ensured by a plastic strip of little deform-ability and a screwed handle which requires a reasonable force. The handle passes from edge to edge of the plate and must be an exemplary built and sealed with carbon-60 type lubricant. Spare parts, mainly seals, will be sent on the first trip. This concludes the summary of phase-1.

PHASE-2

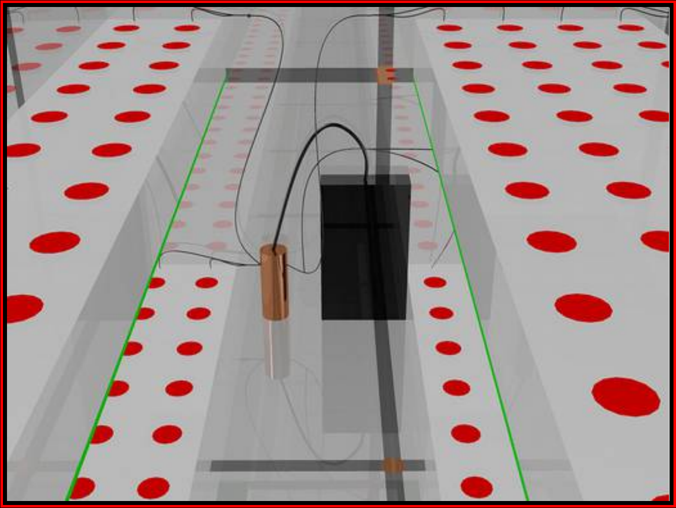
All marsonauts having landed, the beginning of phase-2 can begin. During this phase, we will build the greenhouses, chicken modules, air-survival modules, nitrogen extraction module, aluminum and steel processes, trucks and an energy distributor. The motto for this phase is safety, because who knows if we should assemble trucks first to rescue marsonauts who have landed too far from the base. The stabilization of electricity resources and air regeneration will do the greatest good. The beginning of agriculture will mark a milestone that will precede the raising of chickens, which will be the first reputable meal since the departure of the Earth, about a year ago. The end of the stress and the beginning of the pleasure with the exploration of the site in truck. The recovery of the remaining material will be done during this phase. However, a sword of Damocles will float over their heads, radiation. The travelers will have to bury themselves as soon as possible, it will be the beginning of phase-3.



THE GREENHOUSES

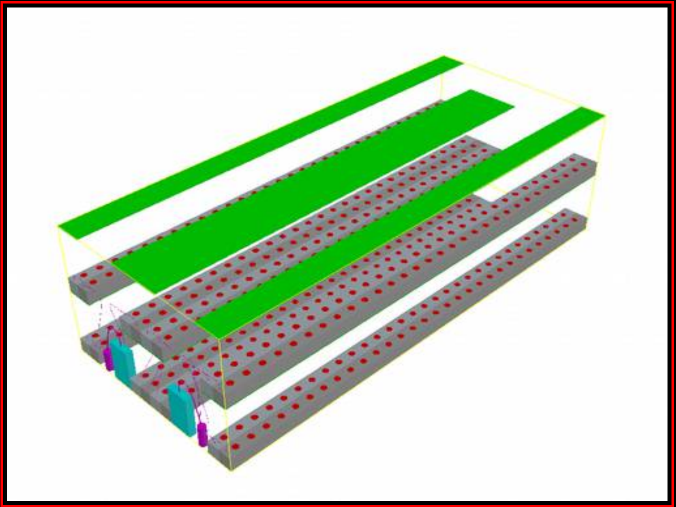
Like every modules, the greenhouses are of capital importance. They will be the first source of food for our Marsonautes. The dimensions will be the same that those of laboratory and command room: 3 X 6 X 2. This volume, 114 m³ (base on 1.4 m tube length), will be use optimally. Depending on the vegetables the number of level could be up to five floor.

species	exterior average (kg/m²)	En serres	Étages de haut	Densité (kg/m²)	récolte par année	kg/(jour*m²)	Protéines (g/kg)	Énergie (kJ/kg)	rentabilité (kJ/(jour*m²)	indice qualité (g/J)	consommation (kg/jour)	Protéines (g/jour)	énergie (kJ/jour)	square meters / marsonaute
patates	4.4	14.0	4.0	56.0	3.3	0.506	20	3550	1797.4	5.6	0.650	13	2307.5	1.28
tomates	6.5	32.0	2.0	64.0	2.0	0.351	9.5	730	256.0	13.0	0.025	0.2375	18.25	0.07
concombres	2.0	13.1	3.0	39.3	6.3	0.679	6.5	650	441.3	10.0	0.350	2.275	227.5	0.52
fraises	3.4	12.0	4.0	48.0	3.0	0.395	6.7	1360	536.5	4.9	0.100	0.67	136	0.25
piments	3.5	11.0	2.0	22.0	1.2	0.072	19	1660	120.1	11.4	0.013	0.2375	20.75	0.17
champignons	-	10.0	1.0	10.0	3.0	0.082	25	1130	92.9	22.1	0.013	0.3125	14.125	0.15
salade	3.5	9.7	5.0	48.5	8.0	1.063	13.5	550	584.7	24.5	0.500	6.75	275	0.47
pois	0.8	9.3	2.0	18.5	4.3	0.218	54.2	3390	737.8	16.0	0.013	0.6775	42.375	0.06
radis	1.3	10.0	5.0	50.0	6.1	0.833	6.8	660	550.0	10.3	0.013	0.085	8.25	0.02
fèves	0.8	10.0	2.0	20.0	4.3	0.236	54.2	3390	798.7	16.0	0.013	0.6775	42.375	0.05
asperge	1.5	2.6	2.0	5.2	0.3	0.004	22	850	3.6	25.9	0.000	0	0	0.00
betterave	4.4	14.7	3.0	44.1	1.8	0.221	16.1	1800	396.9	8.9	0.050	0.805	90	0.23
brocolis	1.5	3.3	3.0	9.9	3.0	0.081	28.2	1410	114.7	20.0	0.013	0.3525	17.625	0.15
choux	16.0	9.8	3.0	29.4	5.0	0.403	12.8	1030	414.8	12.4	0.225	2.88	231.75	0.56
carotte	6.0	22.1	3.0	66.3	3.0	0.553	9.3	1730	955.8	5.4	0.025	0.2325	43.25	0.05
cantaloups	19.2	25.0	3.0	75.0	4.0	0.822	8.4	1410	1158.9	6.0	0.750	6.3	1057.5	0.91
soya	0.4	1.2	2.0	2.4	4.6	0.030	364.9	18660	559.8	19.6	0.075	27.3675	1399.5	2.50
blé	0.7	2.1	2.0	4.2	3.3	0.038	126.1	13680	522.3	9.2	0.075	9.4575	1026	1.96
œufs	-	-	-	-	-	-	126	6470	-	19.5	0.025	3.15	161.75	-
poulet	-	-	-	-	-	-	247	9160	-	27.0	0.200	49.4	1832	-
Moyennes	4.5	11.8	2.8	34.0	3.7	0.4	58.81	3663.5	557.9	14.4	-	-	-	0.52
Totaux	-	-	-	-	-	-	-	-	-	-	**3.125**	**124.9**	**8951.5**	9.41



This preliminary data analysis is very interesting. The most important result, is certainly the square meters per Marsonautes require for good health, around 10 m² ± 3 m², for an average contingent height of 1.65 m. It look a bit barbarian, but we could insert some flexibility. The basis is: women breath less and the same for smaller person.

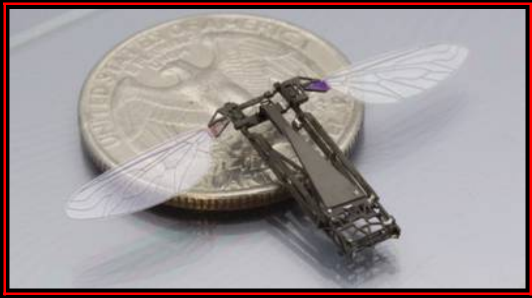
The image on right, is showing a concept of tomatoes greenhouse, in green the light system. DEL system, is energy saver, for the soil, about 1000 m³ will be need for the complex.



We will need to use aeroponic system for plant growing, for the beginning, at least. The management of an entire ecosystem is far beyond our actual skills.

The chemical need, will be about a liter per hectare. About 25 ml per single greenhouse per week, for the vitamin. For every 2 years (1 cycle) we will need for 100 Marsonautes 26 l of nutrients. For security reasons, let's send 10 time the amount, so 50 shipments of 5 liters, for a total cost of 250 X 25,000 USD = 6.25 M USD. Almost nothing :) (Reference #19).

Some species will need pollination, manual or with those small robots :)



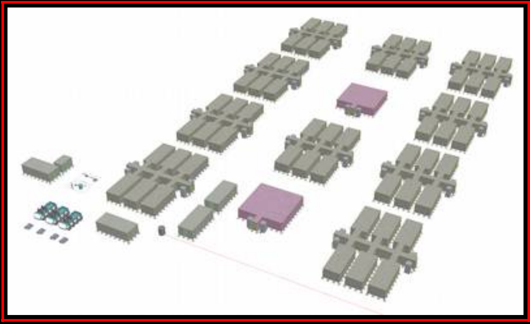
The two most controversial species are the wheat and soy bean. On Earth, there are everywhere, but they are not intensive growth. I mean, with a lot of space those are the best economically, but not when the space is limited like it will be on Mars. Culturally, some nationality eat a lot of bread (wheat), this will have to be modified for purpose of space colonization (at the beginning at least). *Triticum compactum is an annual plant growing to heights of approximately 0.6 meters in the summer and dying in the winter.*

We are talking about 1.96 and 2.5 square meters per marsonaut for a ration of 75g of wheat and 75g of soybeans a day respectively. With this amount of products we could make bread and oil for salad. With manual devices, it would be possible to produce these goods with little means. The straws could be used for chicken manure, which would increase the value of these productions. But, the data relating to these hydroponic productions are non-existent, which increases the controversy.

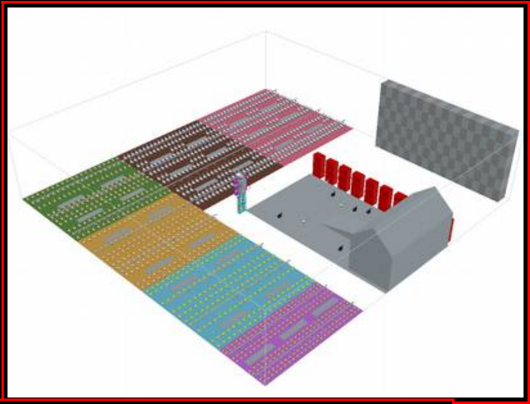
A first superficial analysis allows me to estimate that the production of chicken and eggs would require three farming complexes. Potato, soybean, and cabbage crops seem to me to be good candidates for chickens, if they want them... One of the problems will be the supply of calcium for laying hens. As with most problems, the search for mineral resources will pose great expectations.

In summary, the agri-food sector is the most likely to generate costly research. Each species we want to implement on Mars will have to undergo a battery of long-term tests to measure its adaptability to Martian conditions. But with a research budget of around $ 25 billion ...

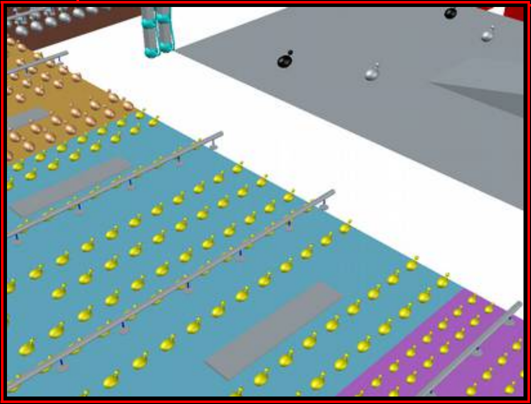
CHICKEN MODULES



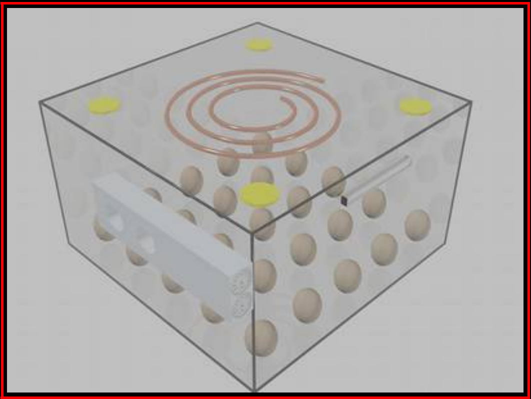
I believe that chicken will be the easiest meat to export to Mars. With two hen houses, our marsonauts will have access to meat, so good quality protein. A first evaluation gives me a quantity of 200g of meat per marsonaut per day, with the support of two complexes of complete agriculture. We can notice on the drawing opposite the respectable dimensions of these infrastructures. We are talking about 3 X 13 X 13 meters, which is relatively impressive. The time required to weld a structure will be approximately 6 hours.



The inside of the hen house will be divided into six sections as in the drawing. Each section has 200 chicks or chickens. The change of section takes place at 10 days. In gray, with the little hut, roosters and breeding hens and their place to lay. Since they need about twenty fertilized eggs per day, the breeding hens can nest in a quieter place, either in their shelter. Incubators can be noted in red, at numbers 30, they will give heat during the 21 days necessary for eggs to hatch. At the top right this is the laying hens, to provide a respectable number of eggs of 75 units per day.



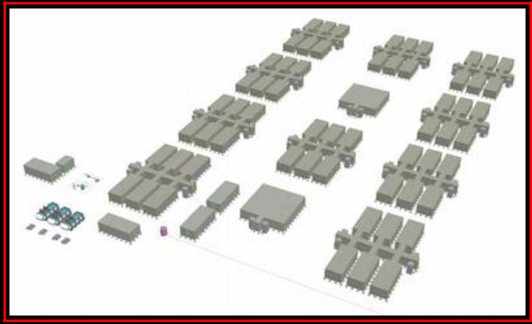
There are three densities of sections, 0.045, 0.085 and 0.125 m2 per chickens. The temperature varies from 34 to 18 degrees Celsius (Reference # 18). The water will be piped to pipettes which will be hung with small saucers to collect the water so as not to wet the floor. Given the circumstances, our chickens will not have the privilege of having a litter, only the breeding hens will have to make their nest. This litter will consist of wheat straw and soybeans. The cleanliness of the premises will be essential and we will have to shovel, scrape and clean the chicken manure every 5 days. The feeders will be in sufficient numbers and contain a judicious mix of grains and vegetables. Vegetables are practically not used on Earth, because the cost is higher, but on Mars it will be the opposite. Cabbages, soybean residues and potatoes will be the least expensive food on the red planet. In addition, we will need to add some extra amino acid to balance the chickens' diet.



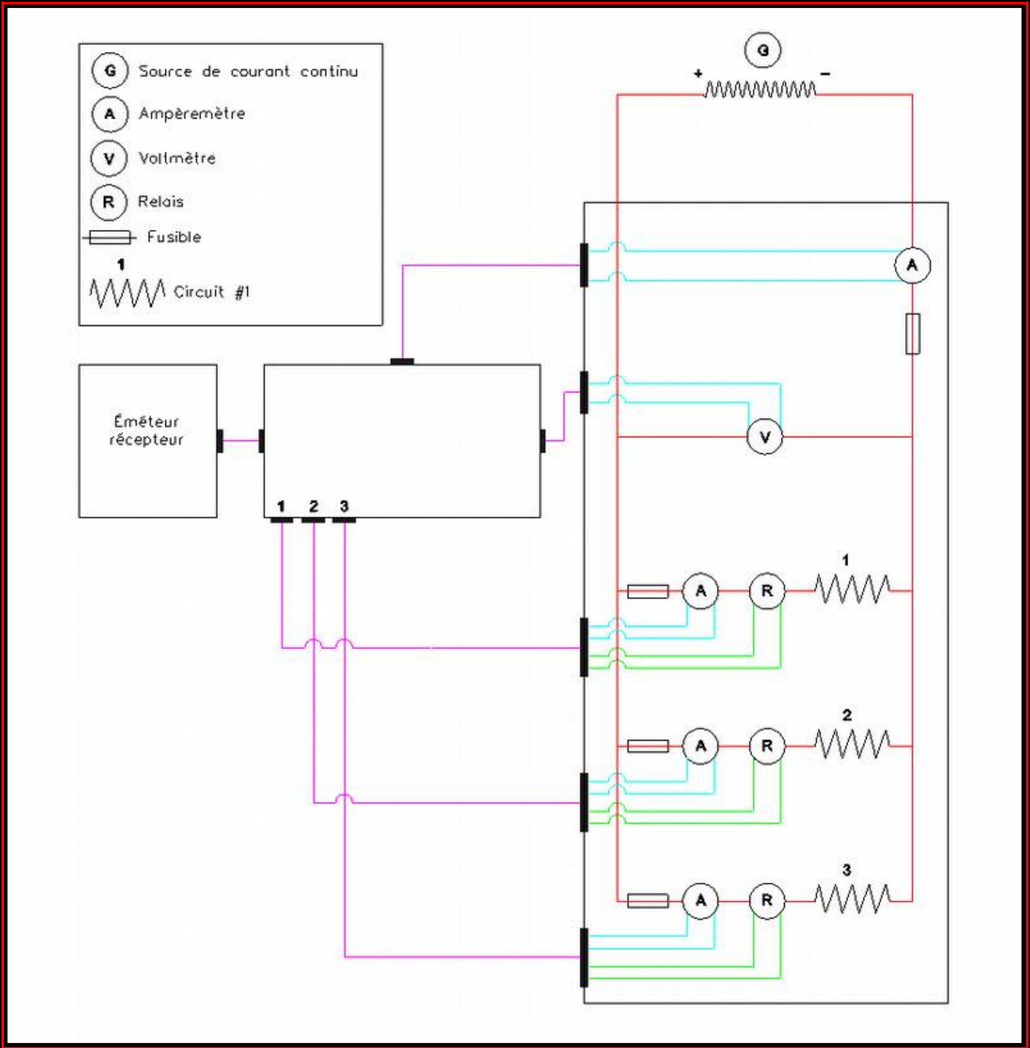
On the other hand, the chickens will provide fertilizer for the plants in the form of manure. This mixture of plant and animal residues, will produce in the long term an alternative solution for aeroponic crops.

PIGS MODULE

ELECTRICITY DISTRIBUTOR



The distribution of electricity will be rather simple than complicated. Each reactor pair has a continuous voltage that will be clean. This is to promote maximum economy while keeping the ice supply time as low as possible. That is, two reactors operating at the same time will be sufficient. All four reactors will gather at the center of the base using high capacity lines. The voltage values will correspond to the two most energy-consuming systems, ie the electrolysis of water and the sum of the lighting in series. The other voltages will be obtained thanks to motors-generators that can be connected to different power outlets with known voltages. I prefer this system compared to the AC system that should be rectified for electrolysis and LEDs. The lighting device should be in series to obtain a voltage promoting the saving of cables between the reactors and the center of the base.



The diagram on the previous page shows a reactor and its communication and control system. In red, the cyan supply circuit outputs and green the control inputs. The technology that will be used for transceivers will have to be long-range, ie satellite-based and inter-base. This in order to keep control of the Martian base, whether from the Earth or the site manager and in parallel with the main control system. So, an encrypted language will be used for release.

Each circuit will be equipped with a remotely controllable relay, a fuse and an ammeter to know at any time the values of electricity consumption and for monitoring the entire power grid. The electric power produced must be as stable as possible because the control on the reactor bars is non-existent. The decrease or sudden increase in amperage due to a decrease or increase in the total resistivity of the circuits could cause the voltage to vary rapidly. This global voltage variation could be dangerous on certain circuits and blow up the fuses, thus stopping the production of said systems.

In addition, it would be possible to engage or cut some circuits in series to compensate for stopping or starting a larger. An example of a simplified calculation could be this one: (Reference # 20)

Based on a reactor consisting of 17 generators connected in series, on the drive shaft, this to agree with the most energy-consuming system, the electrolysis of water. This circuit running in DC current, for obvious reasons of economy (thus avoiding transforming the alternating current for electrolysis), is described as the circuit # 1. I base this calculation on a number of 17, because in my preliminary calculations, I predict 17 batteries of electrolysis. Therefore, the required voltage is 1500 V and the power of 14706 W per cell, ie a current of 9.8 A.

When it disconnects one of the electrolysis cells, it generates a gap of 94.4 V of voltage to be filled.

Circuit # 1: Electrolysis of water

5 kWh / m^3 Hydrogen gas at TPN
Capacity 1 unit = 7.5 m^3 O_2 (g) / hour
Electrical voltage: 850 V DC

Respiration: 1089 L O_2 (g) per day / marsonaute → per 100 marsonautes = 108 900 L O_2 (g) / Day
4.5 m^3 O_2 (g) / hour

Oxidizing: 3 m^3 O_2 (g) / hour for outdoor marsonauts

It should be understood that here, the consumption is based on the marsonauts outside the complexes, which have to remove the CO_2, heated their combinations and support an improved mobility system (whatever it is). And all this from vehicles that must in turn have a minimum consumption of fuel and oxidants, and this without taking into account the energy required to access their working position:

Theory: 1 H_2 (g) + ½ O_2 (g) → 1 H_2O + -241.8 kJ / mol
Coarse assumption: 25% thermal energy to electric
Estimated energy requirement per marsonaute: 450 W
result:
450W * 10 marsonauts / 25% = 18,000 W
2/3 m^3 O_2 (g) / hour

Total respiration and oxidant = 5.17 m³ O_2 (g) / hour

For the circuit # 1:

1-a → 2 Units * 7.5 m³ O_2 (g) / hour * 5,000 Wh / m³ = 75,000 W
1-b, c, d, e → 10 Units in surplus total

Circuit # 2: Air Liquefaction

It is important to understand that the Martian atmosphere does not consist of air, but of CO_2 (fortunately a part of nitrogen). The goal will be to liquefy this part of nitrogen. In order not to underestimate the consumption of electricity, I will multiply the consumption by two to roughly estimate the fact that the nitrogen is slightly harder to liquefy than the oxygen present in the terrestrial air, and also that the CO_2 will be unnecessarily cooled by the compression unit, however, a subsequent heat extraction of the CO_2 will be economical from a thermodynamic point of view ... All this for two things: the creation of artificial air for the modules and the necessity to liquefy Hydrogen for fuel (using Liquid Nitrogen).

Air liquefaction: 1 liter / hour
425 volts (380 V original) → 4.5 kWh X 2 = 9 kWh / liter
Air Regeneration: The total air volume of the base is 10,000 m³ (very rough), which may give us a need to change the air once a month (for comfort reasons):

10,000 m³ / (24 hours * 31 days) = 13.44 m³ of air per hour (if it is taken as a decision to have a TPN atmosphere):
13.44 m³ (80% N_2) → 480 mol N_2
0.807 g / ml / 28 g / mol = 0.028821 mol / ml
480 mol / 0.028821 mol / ml = 16,655 ml → 16.66 liters / hour

So, we would need, to change the air of the complete base every 2 months, 8 Compression Unit:

8.33 * 9 kW = 75 kW (nitrogen)

Hydrogen production: Since the pure nitrogen will be recycled then re compressed, I do not apply this time of modifier:
15 m³ H_2 (g) / hour (see consumption of external marsonauts previously)

Theoretical Carnot: 23 / (70 - 23) = 49%
experimental = 10% * 49% → 5% profitability electric power with compressor 85%

H_2 (g) → H_2 (l) = 0.904 kJ / mol

15 m³ → 609 mol → 551 kJ / hour = 153 W → 40 W at 20 ° K = 4 Units (cryogenic AL-330)

CRYOMECH

Cryorefrigerator Specification Sheet

AL330 with CP2870

Cold head	AL330	
Cooling capacities (60 Hz*)	40W @ 20K	94W @ 30K
*reduced capacities @ 50 Hz	135W @ 40K	170W @ 50K
Lowest temperature	12K with no load	
Cool down time	25 minutes to 80K	
Weight	46 lb (20.9 kg)	
Dimensions	See cold head line drawing	
Compressor package	CP2870 available as water or air cooled	
Water cooled:		
Weight	247 lb (112 kg)	
Dimensions - L x W x H	19 x 18 x 24.5 in (48 x 46 x 62 cm)	
Electrical rating	200/230 or 440/480VAC, 3Ph, 60Hz // 200 or 380/415VAC, 3Ph, 50Hz	
Power consumption @ steady state	7.5 kW // 6.7 kW	
Cooling water flow rate	Minimum flow 2.3 GPM (9 LPM) @ 80°F (27°C) maximum temperature	
Air cooled:		
Weight	388 lb (176 kg)	
Dimensions - L x W x H	23.5 x 21 x 43 in (60 x 54 x 109 cm)	
Electrical rating	200/230 or 440/480VAC, 3Ph, 60Hz // 200 or 380/415VAC, 3Ph, 50Hz	
Power consumption @ steady state	8.1 kW // 7.3 kW	
Flexible lines		
Standard length	10 ft (3 m)	
Weight per pair	9.2 lb (4.2 kg)	
System parameters		
Helium pressure	220 ± 5 PSIG (15.2 ± .34 bar) @ 60 Hz	
	230 ± 5 PSIG (15.9 ± .34 bar) @ 50 Hz	
Ambient temperature range	45°F to 100°F (7 to 38°C)	
Maximum sound level		
Water cooled	70 dBA @ 1 meter	
Air cooled	74 dBA @ 1meter	
Shipping crate	Wood box	
Water cooled:		
Weight	470 lb (213 kg)	
Dimensions - L x W x H	48 x 40 x 38 in (122 x 102 x 97 cm)	
Air cooled:		
Weight	650 lb (295 kg)	
Dimensions - L x W x H	48 x 40 x 59 in (122 x 102 x 150 cm)	

113 Falso Drive, Syracuse, NY 13211 USA
315.455.2555 v 315.455.2544 f cryosales@cryomech.com www.cryomech.com

 Revised 29AUG13

609 mol H_2 for 15 m^3

28.8 J / mol * k → 30 ° * 609 mol * 28.8 = 0.5 MJ / hour → 150 W at 40 W at 20 ° K = 3.25 Unit (AL330)
Total of 7.25 units AL330
By the same calculation for AL600: 75 ° * 609 mol * 28.8 = 0.5 MJ / hour → 150 W at 400 W at 56 ° K = one unit AL600
We need to supply hydrogen gas at 125 ° K (125 ° cooling)
125 ° * 609 mol * 28.8 = 2.2 MJ / hour → 609 W takes 12 kW (clearly conservative: Carnot experimental)
7.25 * 7.5 kW (AL330) + 12.5 kW (AL600) + 12 kW (primary cooling)
Total of 80 kW for 15 m^3 / hour

Results: one unit → 80 kW * 20 Units ≈ 1,600 kW (theoretical: will never be used)

Circuit # 3 lighting greenhouses

ideal brightness: 250 W / m^2 (high performance LED)
Total area of greenhouses: 1000-1500 m^2 (depending on vegetation configurations)
250 W / m^2 * 1500 m^2 = 375,000 W
use 14.4 hours / day = 225,000 W / 15 sub-circuits = 15,000 W

This represents a possible example of electrical configuration, because there is a multitude ...
The important thing is to emphasize that I intend to use these LED circuits to compensate for the shutdown of the largest electrical circuits.

Circuit # 4 ores

Stone Breaker: 15 kW
Magnetic screening: 5 kW

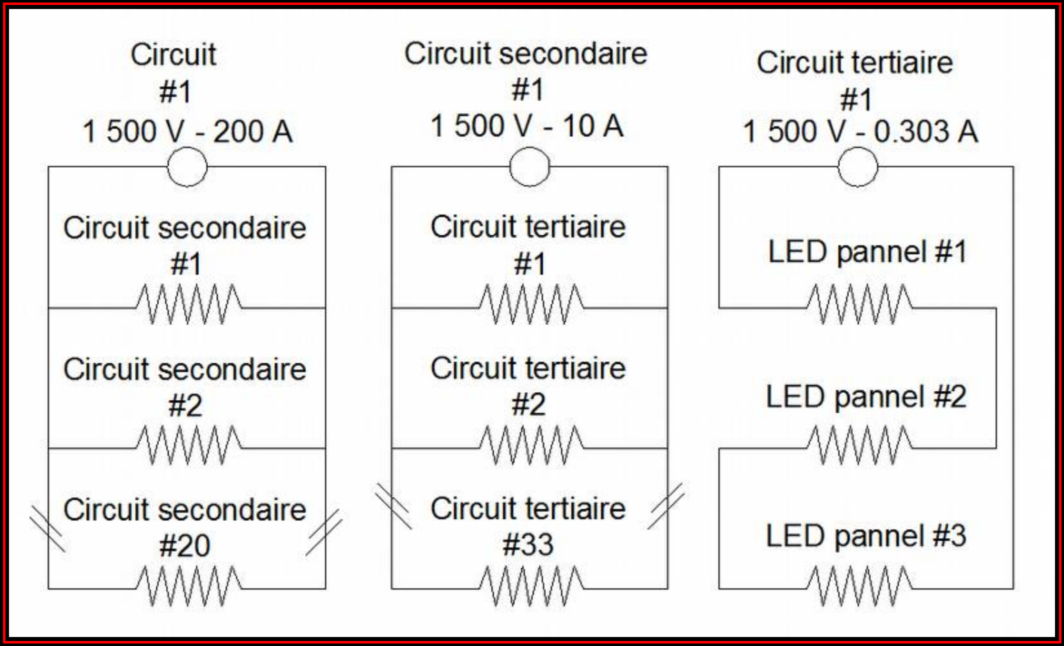
It can be deduced that the cutting or engagement of some high power systems can not be achieved at once, but gradually. So the circuits will have to be split into smaller systems, to allow some stability to the main power circuit. When shutting down or operating a circuit, the computer will shut down or operate one of the generators, if necessary, to maintain a stable current. The time interval between the deactivation of a generator and the response of the circuit must be almost instantaneous.

Main systems of the base (approximate details):

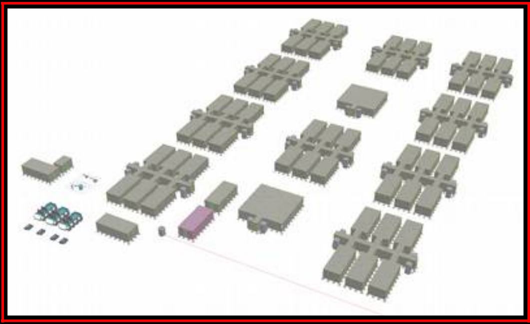
1. Electrolysis of water 75 000 W, 6 subsystems 14 706 W
2. Lighting 225 000 W greenhouses, 20 subsystems 15 000 W
3. Hydrogen Liquefaction 80,000 W
4. Domestic system of the main complex 6,250 W
5. 70,000 W Solder Stations, 10 7,000 W Subsystems
6. Nitrogen extractors 75,000 W, 8 subsystems 9000 W
7. Preparation ores 15,000 W
8. Aluminum electrolysis 562 500 W (246 plates / day), 20 subsystems 28 125 W

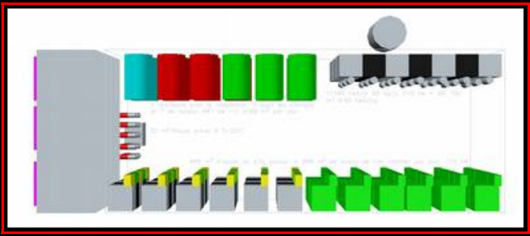
In addition, the four reactors will have to be operational before the start of phase 3.

In the case of cables, the reactors will be connected to the distributor by a three conductor type GNK cable (Reference # 21) weighing 677 kg per 100 meters and having a capacity of 1,845 kW at 1,500 V without correction factors. temperatures that will be clearly to our advantage (1.3 to 2.0). Since there will be four reactors all located at a distance of 250 m, the total weight will be 6,770 kg of cable, only to reach the center of the base. The primary circuits will be connected with smaller cables, for example the lighting system: 87 kg per 100 m X 330 meters = 287 kg. For the secondary LED lighting network the values depend on the type of crop, including the number of floors. For systems that do not accept the 1500 V or the value of the principal, it will be possible to couple two generators to obtain the desired voltage.



NITROGEN AND FUEL EXTRACTION MODULES





In order to make breathable air directly on the planet, we will have to extract nitrogen gas from the Martian atmosphere. The oxygen part will be provided by the electrolysis of the water. The hydrogen that will be produced during this last stage will be compressed and liquefied to serve as fuel, while some of the oxygen will serve as oxidant once liquefied. Truck statistics will be discussed in the chapter on them. You can see a general view of the module in the figures opposite.

Completely on the left, outside the module is a heat exchanger. A water pump and electric modulators are in the center. At the bottom is the extractors of nitrogen and oxygen. And at the top the electrolysis cells and the cryogenic modules used for the liquefaction of hydrogen. A temporary tank for liquid hydrogen is located at the top outside the module. The heat exchanger should not be a problem because the surface temperature should be very low on average. The water used will come from one of the reactors, and the temperature adjustments will be made by valves whose regulating functions will be for the volume and temperature of the water supplied to each module. Some modules will be heated and others will be cooled by it.

Composition de l'atmosphère de Mars	
Dioxyde de carbone	95.32%
Diazote	2,70%
Argon	1,60%
Dioxygène	0,13%

Current modulators will produce alternating current for compressors from direct current. The direct current will be directly delivered to the electrolysis system which will be the most energy consuming system of the base. The pump will deliver the amount of water needed to cool each system.

The maximum power for the hydrogen cells will be about 882 kwe, but this number will probably not be reached since some cells are redundant given the criticality of these. Of these batteries, 16% will be for breathing, 25% will be for trucks (fuel) and the rest surplus, for a total of 12 batteries. Hydrogen production will be 180 cubic meters at maximum TPN per hour. For more information on hydrogen fuel cells, see the chapter "Electrolysis of water".

The maximum power for the extractors of nitrogen and oxygen, whose function will be to liquefy the two gases, using compressors and coolers, will be 4.5 kwe multiplied by a possibility of 60 compressors in function, that is 270 kwe. As for the previous system, redundancy is required. In the case of maximum fuel production, 96% of the units would be in operation, ie 42 units for liquid nitrogen and 16 units for liquid oxygen. In the case of stoichiometric combustion, this assessment is valid, it remains to be seen what would be the optimal dosage on the planet Mars. We can take into account the main aspect which is the cost of production of energy which favors the production of liquid oxygen, the other aspect will be the temperature (variable) and the pressure (stable). The power required seems prohibitive, but the marsonauts will need the electricity produced by the turbines of the trucks to operate the carbon dioxide removal system incorporated in their suits, as well as the pump for the fluidity of movement (see chapter on the improved spatial suit). The characteristics of the extractor modules could be compared to that on the previous page. (Ref # 22)

To cool the hydrogen gas to a temperature of 80 K, in order to liquefy it, it will take 21 cryogenic units and compression units. Trucks will not be able to use all this fuel during normal use. The phenomenon of para and ortho hydrogen will be taken into account in the belly of trucks (double storage).

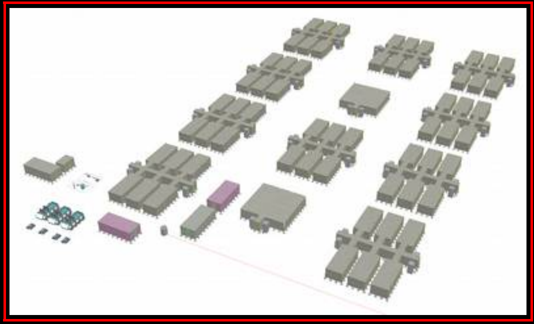
cryogenic unit PT-815

The storage of liquid hydrogen will be located in the trucks themselves, which will use the evaporation part to run the turbines. This evaporation will keep the temperature at an acceptable level, so the pressure too. A heat source will be required, as evaporation will not be enough!

Cryorefrigerator	
Cold head	PT815
Cooling capacity 2 stages combined	22W @ 20K avec 100W @ 80K
Plus petite température	2,8K sans charge
temps de refroidissement	60 minutes à 8K
Masse	25 kg
Compresseur	CP1110, refroidi à l'eau
Masse	190,5 kg
Dimension	61 X 61 X 79 cm
Puissance électrique	10,7 kw
Eau de refroidissement (flux)	11,5 litres par minutes (max 27 degrés Celsius)

Air liquid unit	
Flow rate (liquid air), l/h	no less than 1,0
Cooldown time (start of air condensation), no less than, no more than	90
Power consumption ~3 phase, 380 V/50 Hz, KW, no more than	4,5
Weight of unit, kg	185
Overall dimensions, mm	
Compressor unit	655 x 715 x 524
Cooler	196 x 297 x 555
Length of pipelines connecting compressor unit with cryogenic unit, m	to 30
Duration of continuous work during ambient air condensation, h, no less than	10
Helium is operating body (cryoagent) of small-size air liquefier	
Cooling is water. Heat rejection from unit should be made by water with range of temperature from 5°C to 35°C with consumption no less than 7,0 l / min and pressure no more than 0,6 Mpa.	
Operating conditions:	
Ambient temperature, °C	from +5 to +40
Relative air humidity at temperature +35 ° C, %	to 80
Life resource of small-size air liquefier, hour	no less than 10000
Frequency of maintenance works, hour	5000

AIR MODULE



The two air-survival modules are of capital importance, only one would have been sufficient from the space point of view, but from the point of view of the safety of fresh air supply, both will be useful. They will be located near the power source to provide temporary shelter for hydrolysis systems should this become necessary. The main function of the two modules will be to remove carbon dioxide from the used air from the base. In addition, it will be necessary to pump this air and remove some pollutants in addition to humidify.

The main system being the removal of CO2, it would be good to consult the chapter "improved spatial suit" about the Russian air purification module. For the functions on Mars, we will have to add a vacuum pump, to allow a partial pressure of carbon dioxide to be low enough to evacuate the gas contained in the zeolite. What in the void of space does not cause any problem, will be monitored on Mars, even if the atmospheric pressure is 160 times smaller, because this atmosphere is saturated with CO2. I believe, according to preliminary calculations, that a two-stage pump with a power of 500 W will be sufficient for the breathing of 150 marsonauts. As always, our best friend on Mars, will be the redundancy of key systems. We must take into account that a nearby base could be evacuated, resulting in a surplus of 150 marsonauts on the site. This system will need about 25 kwe and a supply of 21.5 liters of water per day, in the case of maximum utilization of production capacity.

The humidification system of the air will avoid problems such as:

1. Breathing dry air is potentially a health risk, which can cause respiratory problems such as asthma, bronchitis, sinusitis, nosebleeds or general dehydration of the body.
2. Problems with irritation of the skin and eyes.
3. Static electricity problems.
4. Problems related to the sensation of temperature.

The relative humidity of the air should be kept above 25% and below 60%. A system of humidifiers will not be a problem from the point of view of the electric consumption, but a problem of monitoring and distribution of this humidity inside the living areas.

With regard to the removal of certain organic compounds produced by the human body and which will have to be removed, the use of basic techniques such as charcoal filters will be useful. I am currently looking at an arc-type technology that produces a plasma to break down these materials, but it may be that ozone production is holding back this concept. I imagine that the combustion temperature and a method to concentrate the pollutants will be points to test. It will be possible to change the air once in a while, liquefying the nitrogen from the air and expelling the rest.

As for the ventilation system, electricity consumption will not be a problem. However, the system will have multiple valves controlled by a wireless network, and accessed by the base computer control system.

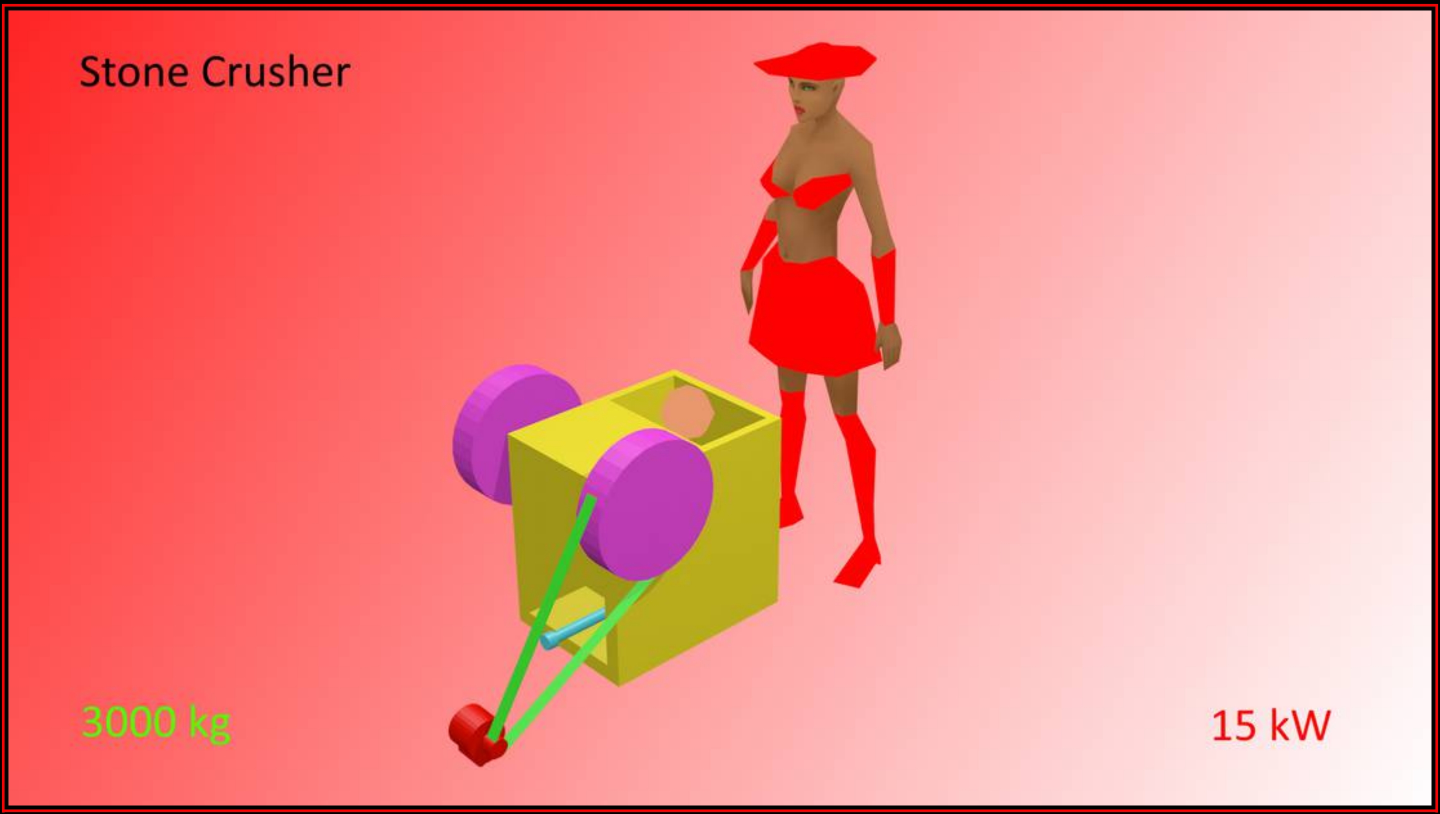
FISHERING MODULE

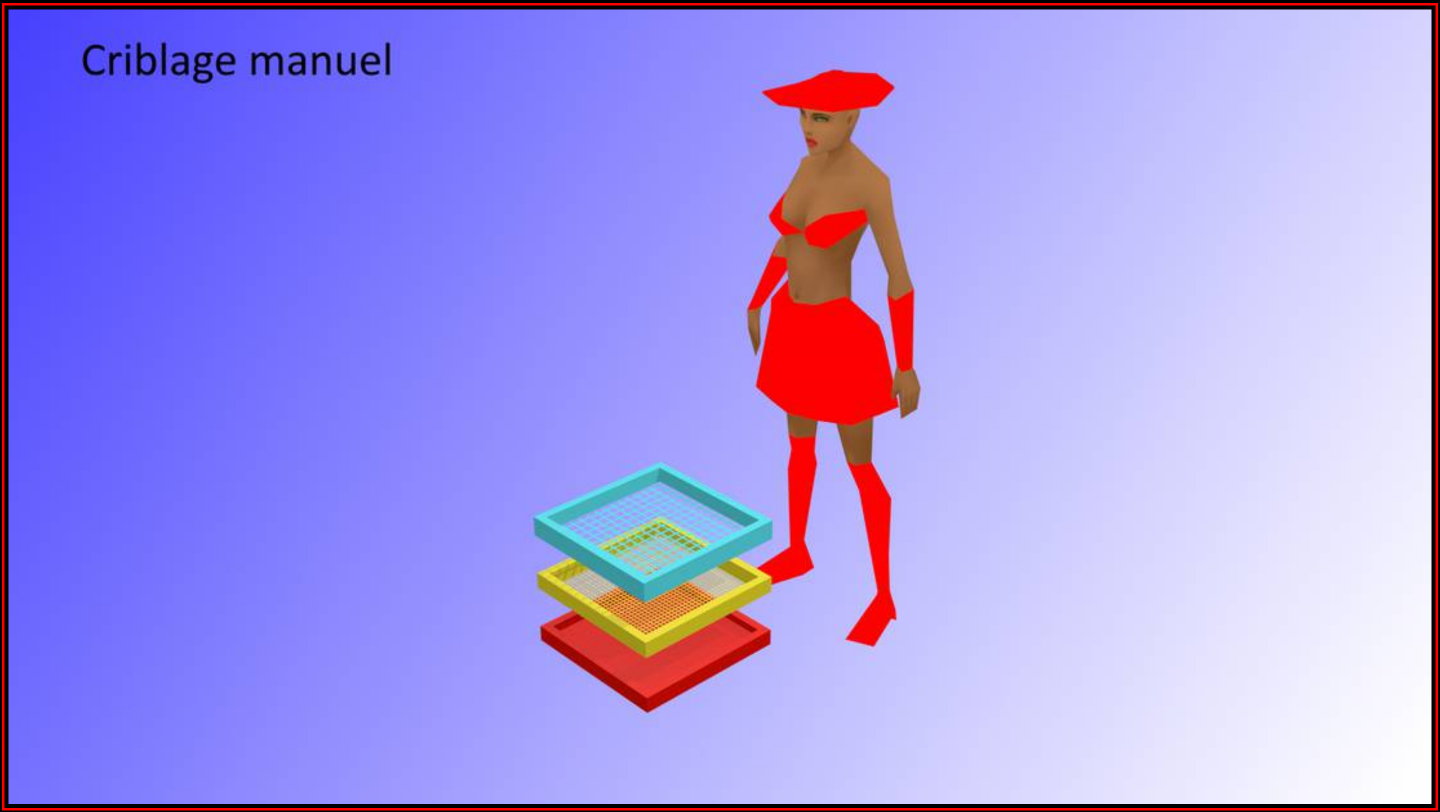
As you can see, I did not include the image of the base representing the said module in phase 2. The reason is that breeding fish on Mars remains purely hypothetical. Although on Earth, this mode of production continues to grow, the fish itself may not appreciate the Martian gravity. The different species of known fish are rather fragile and could die well before being harvested.

However, the qualities of intensive fish production force me to consider such a possibility. It is possible that a species genetically modified or relatively resistant to flotation at the surface or at depth (as the case may be?) Can do. It would then suffice to multiply shallow basins and take advantage of the benefits of fish farming. There are also other factors such as the dissolution of minerals and oxygen. We could put forward a plan considering all the possibilities, but the complexity of the artificial ecosystem of the base would become too complex to justify the production of such a food.

In conclusion, I advise against fish farming on Mars, during the initial phases, but encourages the study of the various phenomena on the spot, when time allows it. And maybe one day we can eat fish on the red planet.

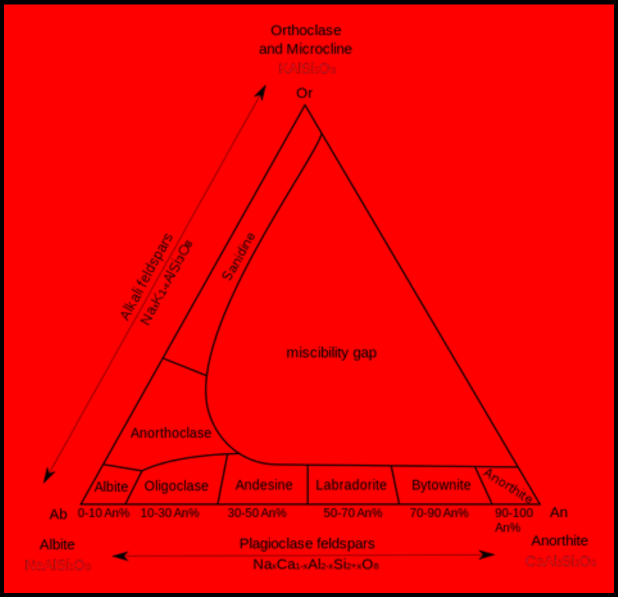
MINERALS MODULES





Can be paired with an electric stirrer :)

Aluminum



This image, taken on Wikipedia, by Muskid (personal work), shows us the organization of the important class of ores, the feldspars. Important, especially because of the abundance of it on the Earth, about 41% of the earth's crust in mass. So, we will certainly find some on Mars. And wonderfully, plagioclase contains aluminum that can be extracted by acid dissolution. The higher the Anorthite content, the more complete the dissolution, except for albite, which is insoluble. If you pick up a rock on Mars, it probably contains aluminum ...

You could, have fun finding the name of each?

By Rob Lavinsky, iRocks.com
« By UCL Mathematical and Physical Sciences c/o:Mary Hinkley »

In the literature, there is also the possibility of converting kaolin into aluminum, by an acidic dissolution as well. Kaolin is one of the most abundant minerals on Earth ...

90°C à pH = 2 pendant 1 heure: 0.5 m² / gramme

Anorthite $CaAl_2Si_2O_8 + 8\ HCl + 2\ H_2O = CaCl_2 + 2\ AlCl_3.(6\ H_2O) + 2\ SiO_2$

$2\ AlCl_3.6\ H_2O \Longrightarrow Al_2O_3 + 6\ HCl + 3\ H_2O$

kaolinite $Al_2Si_2O_5(OH)_4 + H_2SO_4$ + ethanol (voir pdf) = Al_2O_3

Production of γ-Al_2O_3 from Kaolin

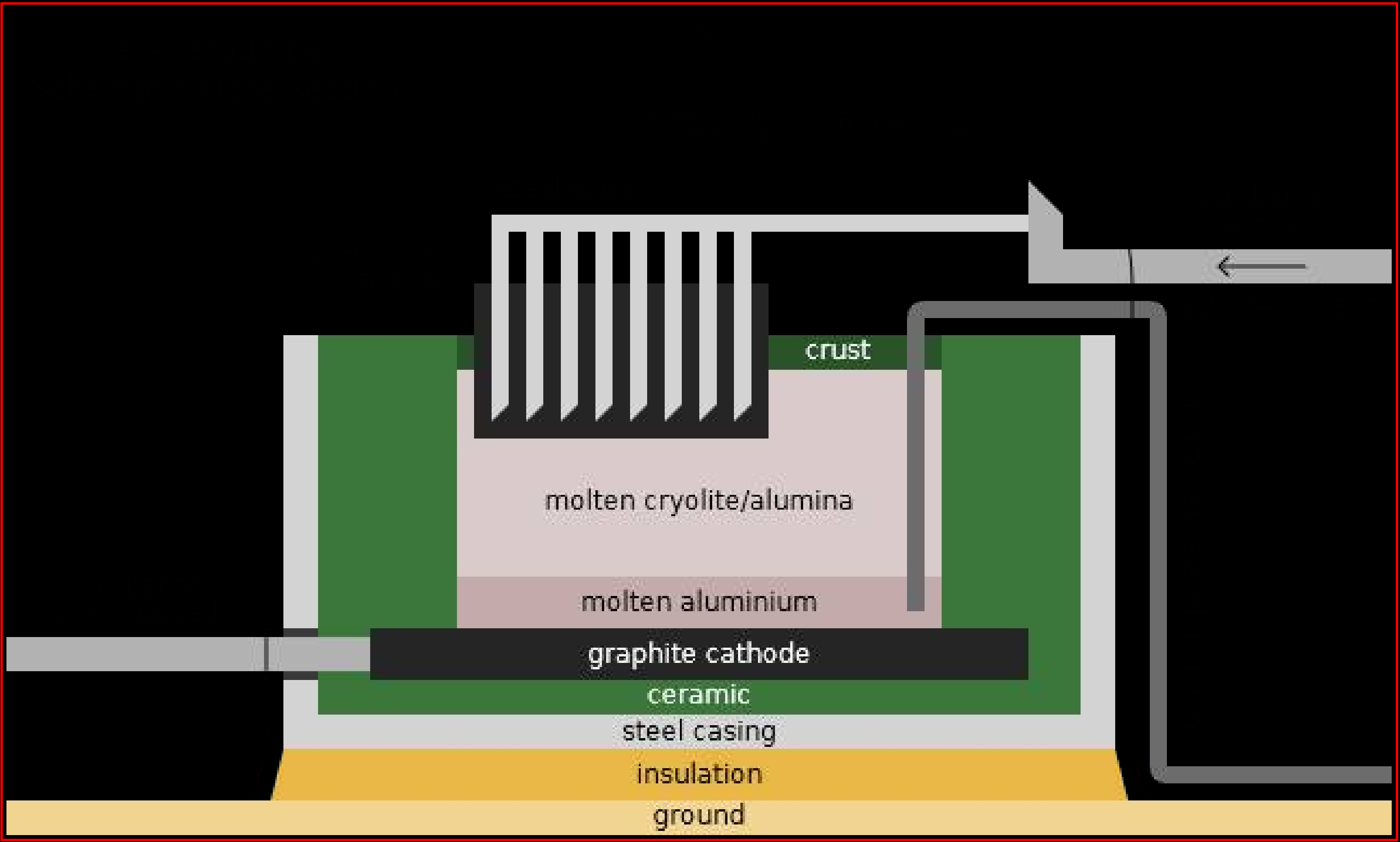
Seyed Ali Hosseini*, Aligholi Niaei, Dariush Salari

Department of Applied Chemistry, Faculty of Chemistry, University of Tabriz, Tabriz, Iran

The Kaolin, used as a starting material was supplied from Zonoz mines (Marand, Iran). The chemical compo-sition of Zonoz kaolin is given in **Table 1**. After extract-ing from mine and grinding the kaolin, it was ground in an agate mortar to particles below 0.5 mm in size. The powdered kaolin was calcined at 800°C for 2 h in an electric furnace to loosen the alumina components. Then, the kaolin powder was dispersed in a 2.0 N H_2SO_4 solu-tion to attain a solid/liquid ratio of 1:20 by weight. The mixture of kaolin powder and acid (250 mL) was con-tained in a 500 mL round flask. The reaction flask fitted with a reflux condenser and the mixture was mixed with magnetic stirrer for 18h. The temperature of mixture was set at 70°C.

After the mixture of kaolin and acid had been leached, it was cooled to room temperature and filtered to remove leach residue, which mainly consisted of silica. The fil-tered leach liquor then was added dropwise at a rate of 6.0 mL/min into 600 mL of ethanol while the ethanol was stirred with a magnetic stirrer. Ethanol was used as a precipitating agent because aluminum sulfate can be se-lectively precipitated by ethanol from the ionic solution [1]. The precipitates were washed again with the ethanol and with distilled water and then dried at 70°C for 10 h. Finally, the precipitates were calcined at 900°C for 2 h in an electric furnace.

Aluminum electrolysis



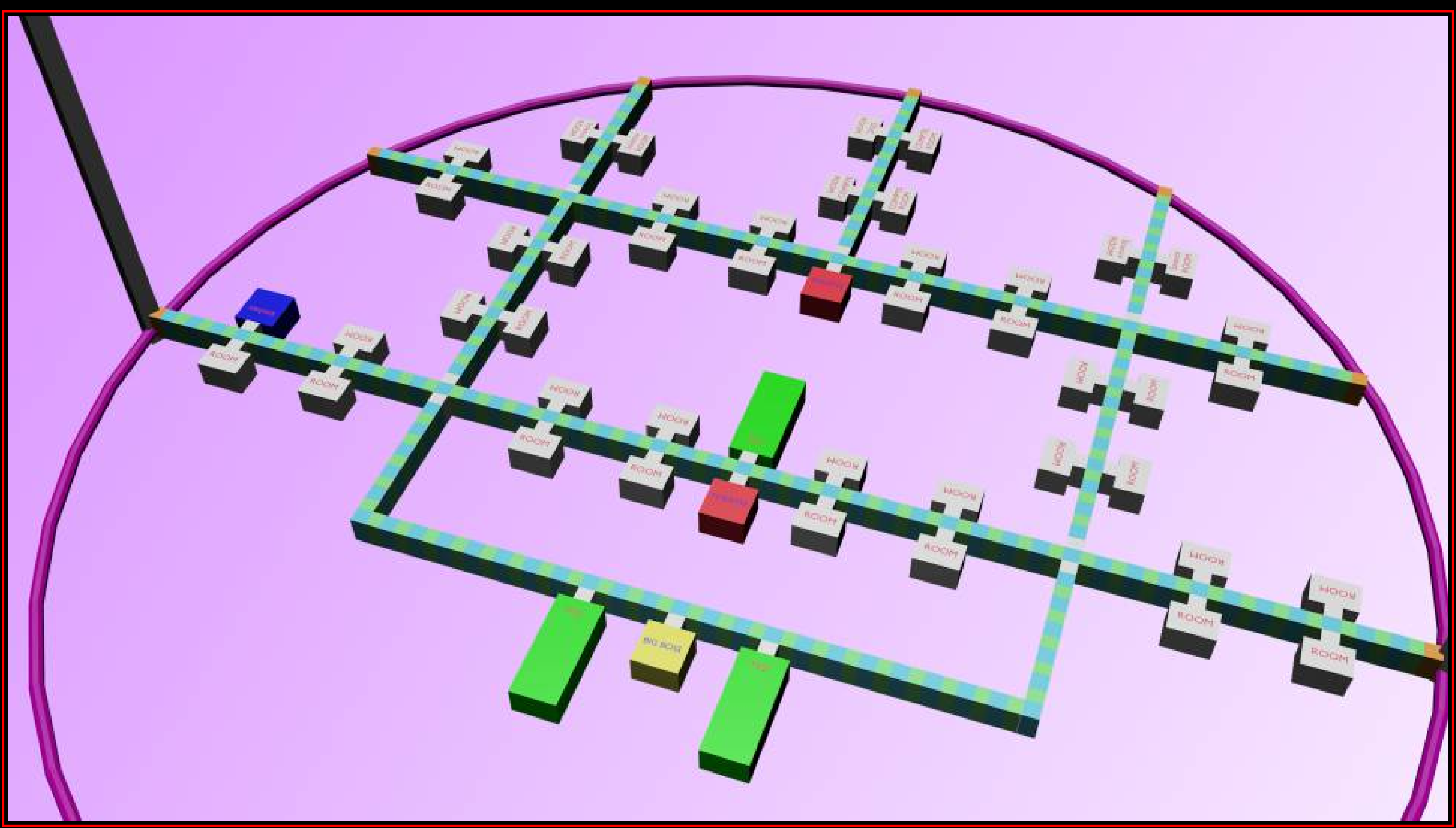
First, the aluminum oxide must be converted into cryolite to reach a melting temperature of 1000 ° C. I think it's possible to do without the next step at the cost of an increase in the electricity bill ... But this game is worth it because aluminum fluoride would be needed to perform this process, which seems to me too annoying :(The operating temperature would then be a little less than 1000 ° C, instead of 940-980 ° C.

Secondly, to obtain a fairly high value of current, the industries branch several cells in series to saturate the voltage of 1000 V obtained optimally by the rectifying systems of the modern AC current. On Mars, the current will be produced directly in direct current, which preserves the limit of 1000 V, but not the need to connect several cells in series. It would be foolish to think that we could build a land-based plant at the beginning of colonization, but the extreme miniaturization of cells and a non-optimal approach to energy use would allow us to start production from the very first weeks. An example, not optimal, possible could be this one:

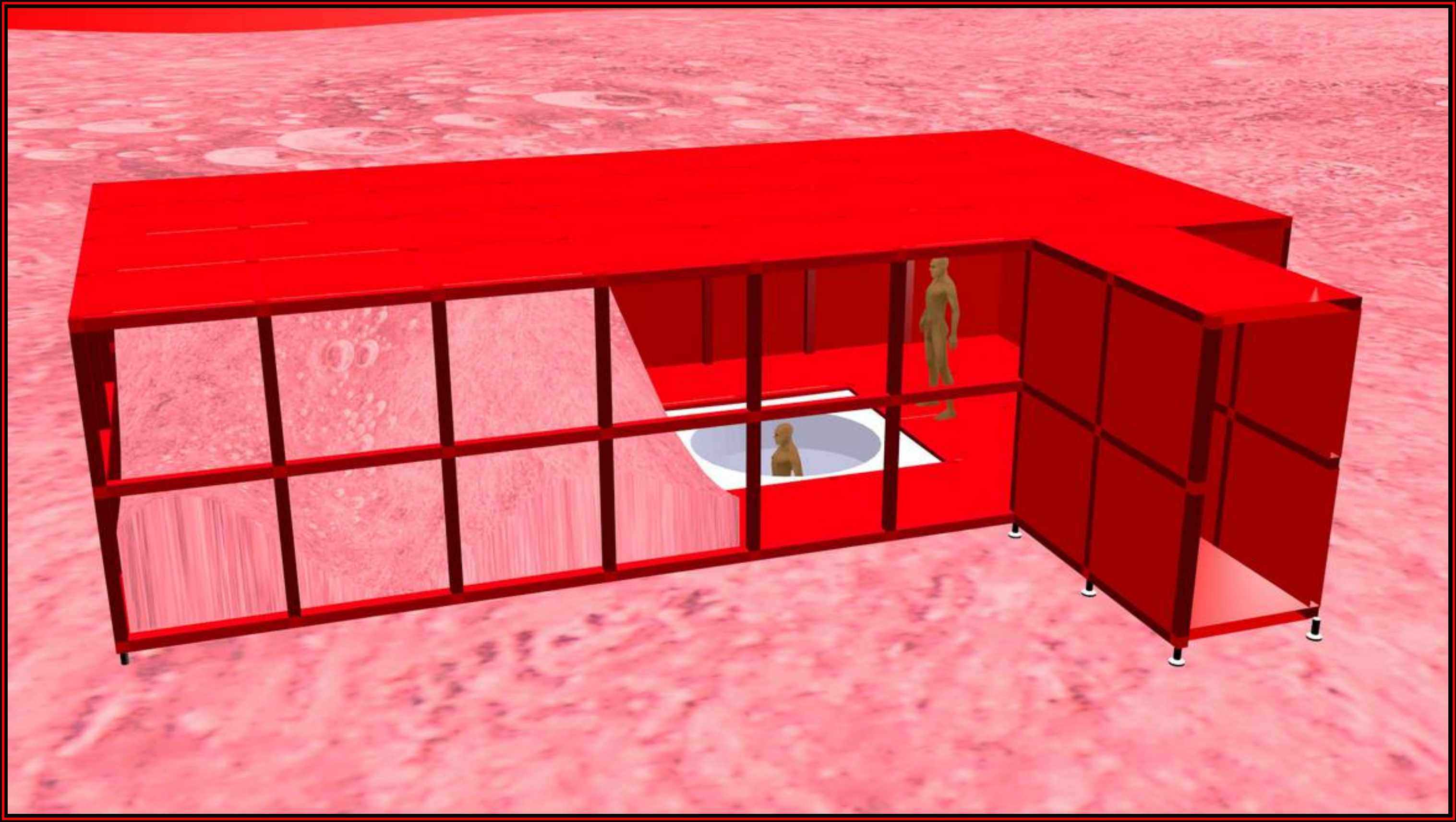
PHASE 3

Once Phase 2 is over, the marsonauts will be able to survive on Mars for a few months. Phase 3 will begin when Phase 2 systems are ready or about to be ready. The main goal of this phase will be to secure life on Mars beyond a few months. At a depth of at least 70 meters, living beings will not receive enough radiation to put their lives at risk in the long term.

Depending on the basics, the structures of this phase will be dug in ice or rock or both. It would be astonishing that sediments from an ancient sea could form a soft layer of sufficient thickness to test the marsonauts. But, if that happens, they would be equipped to deal with this problem. The most preferable situation would be a sedimentary rock that would be easy to dig and strong enough to avoid the use of too much solidification structures. It is in order to cope with all situations that the design of the structures of this phase is spaced and small. If the situation allows it would be possible to use more spacious and closer modules. In any case, phase 4 will bring comfort for the marsonauts. Also, if a problem were to occur on one of the 23 sites, this phase would allow a regularization of the situation. In conclusion, it should be noted that surface radiation will force us to limit exits and perform personnel rotations for outside work. It is conceivable to expose the marsonauts to about 2 hours of exposure per day on average (15 hours per week). The point is that living cells must repair themselves before experiencing other damage (flexibility to test).

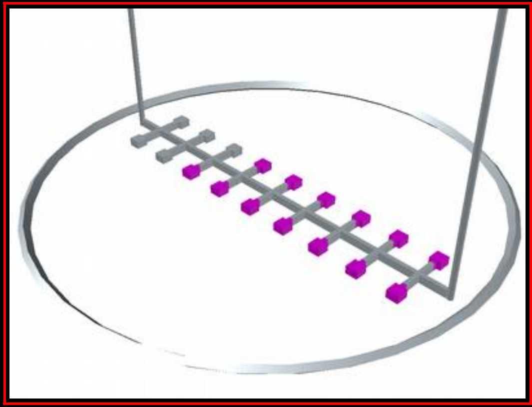


THE DIGGER

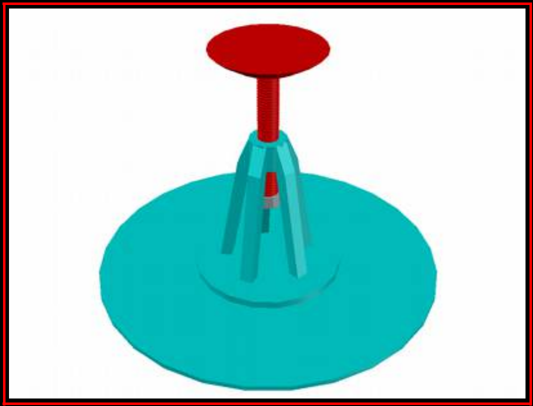


For getting underground, we will need to be protected from the low pressure of Mars atmosphere. This way, it could happened... The marsonautes, will be protected by a special spacesuit with no air in it, so if there is a leak, they will inflate like a balloon and don't die :) One men with ordinary spacesuit will watch, and the unfortunate one will dig, with some tools... Without high temperature and with water as sealing device, it is going to be nice :)

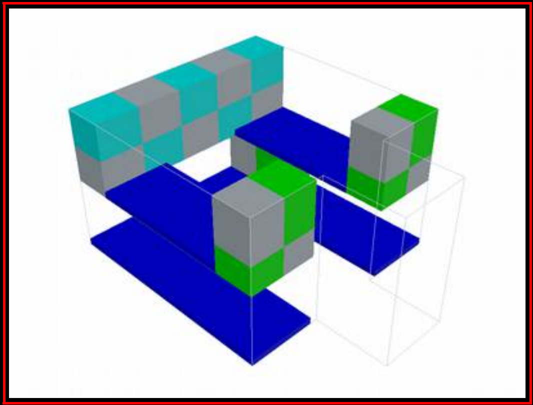
UNDERGROUND DORMITORY MODULE



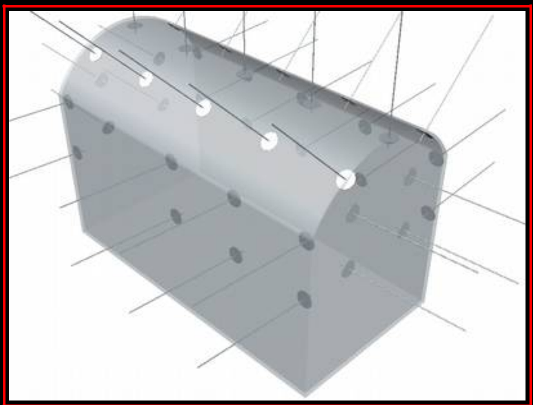
These modules will be 13 and will be able to accommodate 4 marsonauts each. This will shelter the 150 settlers that will count the base. The assembly parts will not be the same as for the external modules, because there will be no greenhouses or modules of this type which requires a higher height. On the contrary, these modules will have to be as small as possible, in order to counter the various possibilities of underground on Mars.



The underground base should have a minimal thermal footprint, because if it is in the ice, it should not melt it. Jacks will be a key element in the temperature control strategy. Since the contact surface is limited to the maximum, only radiation and convection exchange will take place. As for convection, the low pressure will play in our favor by limiting the heat exchange. The aluminum surface will make thermal radiation almost negligible. In addition, the structural double layer of the modules will act as an insulator, in addition to providing security for gas leaks. So, it will be enough for a slight ventilation of the underground space to do nothing melt.

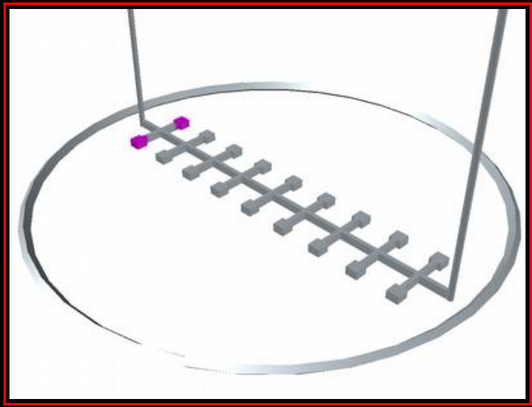


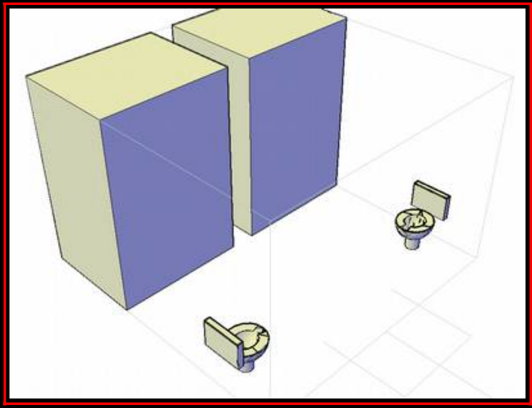
Since at this stage, a certain level of security will be reached, the marsonauts will be entitled to a little more comfort. Personal items will have been recovered and individualized and compartmentalized spaces will be available. Entirely allowed to sleep without their suit, they will be well installed while waiting for the supreme comfort of the phase 4. The modules of the underground base may not be connected as on the surface in a big complex, but will rather be provided with an individual lock (My last revision included linked modules). The disadvantage will be at the toilet, but we will have no choice. The control of the heat, the aspect of solidity compared to the maximum torque over a long distance, the quantity of building materials and a new priority, the centrifuge, will overcome the comfort associated with the accessibility of the toilets.



We can see here a strategy that it will be possible to implement to solidify the compartments of the underground base. Widely used on Earth, these screws with a giant head are surprisingly effective. For more details on mining-type constructions, see chapter "underground construction 101". If the mining conditions are favorable, the dormitory modules will be as presented in this chapter. On the other hand, if they are clearly unfavorable, modifications may be made to the design. A narrow and elongated shape lends itself better to difficult stresses, while a cubic form has spatial and thermodynamic advantages.

UNDERGROUND TOILET



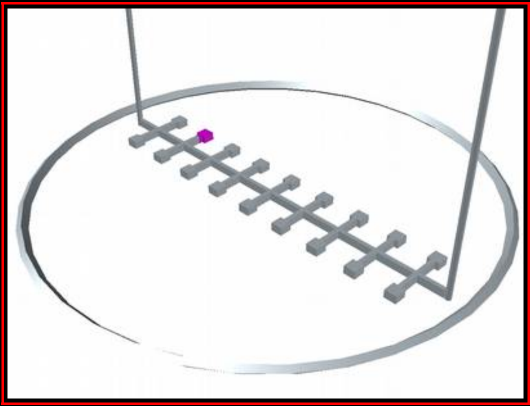


The toilet modules for phase 3 will be complementary to the ones on the surface. Even if the time allocated for the outings will be about 2 hours a day, the marsonauts will not go out every day. I believe that in most cases we will be entitled to 4 hours outings every other day. So, some settler will be able to do their needs outside the underground base. As for the showers, there will be 4 or two per washroom. The shower time will be important because it will allow a small period of respite and relaxation. With this equipment, each marsonaute will be entitled to a little more than 30 minutes of shower a day, two showers of 15 minutes. Just like the outdoor showers, the new water saving system will be in place to minimize the impact on the total consumption of this resource.

The conceptual drawing on the right gives a glimpse, without details, of the layout of the sanitary material. The module will be accessible by an SAS, which will be a real problem for quick access to the toilet block. The next phase modules will all be interconnected as on the surface, but in the meantime, the settlers will have to manage their pressing desires. This management could include laxative and constipating substances, in order to achieve some risk-free productivity.

The transport of residual materials will be done by means of 2 pumps, one at the bottom, which will build a positive pressure in the pipe, and one with suction, at the top, which will draw the said materials (liquids and solids) towards the outside. The arrival of the resources will be done by one of the chimneys and the expulsion by the other. The ventilation will follow this principle which gives an additional security, because the flow of the pipes can be reversed, if necessary.

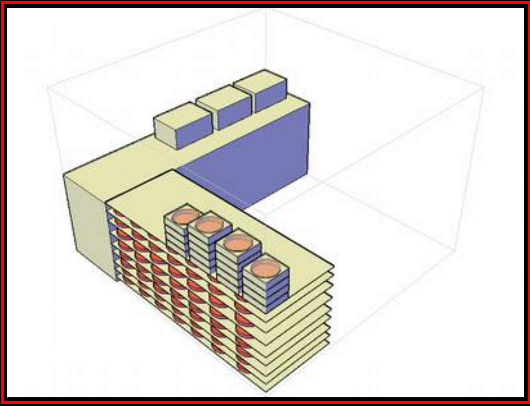
UNDERGORUND KITCHEN MODULE



The first underground kitchen will be simpler. Its existence being justified only by the dose of radiation that it would be necessary to impose to be able to eat outside. The outdoor time is an absolute priority.

The settlers will have only a few pieces to weld, and some instruments to move from the kitchen outside.

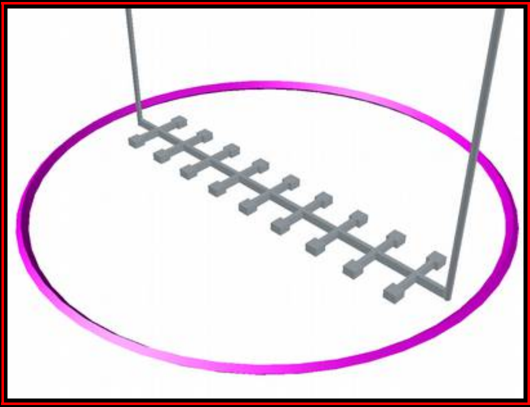
The operation of the meals will be rather simple, they will spread over a period of 24 hours. The trays will be served in the SAS and at the same time the returns will be deposited.



Each marsonaute will have his bowl, which will be served in an insulated container. The infinite efforts devoted to the production of food, in order to maintain an exceptional morale, will have to extend from the kitchen to the plate. The colonists will have to give back a clean bowl that will not need to be washed, because anyway, there will be no device to wash it. Plates and utensils will be licked until the last crumb. The person or persons whose turn will come to take care of the kitchen, will have to prepare the meals according to the specifications in place.

The typical meal: Salad and small pieces of roast chicken.

CENTRIFUGAL UNIT



This module is included in the case where controlled human gravity tests reveal that gravity on Mars, 1/3 of that on Earth, is insufficient to maintain good long-term health for settlers. It is known that the absence of gravity induces a decrease of the muscular mass and weakens the bones. These two phenomena would make the colonization of the red planet impossible. So, in this case, using a centrifuge of this type would eliminate the problem. The cost of implementing such a structure is huge, but would be essential in the case of a negative response to the tests ordered.

For a more detailed description of the tests to be performed, see the chapters: "The terrestrial orbital base" and the "Test phase" chapter..

PHASE-4

Phase 4 will be characterized by the construction of a new infrastructure, the atomic power station. Along with this major construction, there will be the welcome of new settlers. We are in cycle two, and colonization is going well. I personally believe that this phase will be the last one on the initial marshaling site, because it will have to get closer to the minerals (if we find of good quality and in quantity), and also to move away from the radiations and waste of the stinking sites of the departure. It will surely remain activities on the initial sites, but the future constructions will be more and more towards the south.

The atomic power station, should be shared by all nations on site, and high voltage lines (AC current this time!), Will make the link between the future site and the old. In my opinion, it would be preferable that at this stage we regroup our activities for a cost issue. It is not necessary to make Jews sleep with the Palestinians, but simply to share the costs for the hospital and the school. Industrial infrastructures will make their appearance and it would be advantageous to share them as well. At a cost of USD 17,500 per kg of material sent, it will be extremely profitable to produce primary resources such as metal and polymers on site.

PLASTIC FACTORY

- resources:
  - CO_2, the atmosphere of Mars
  - Energy, the new nuclear power plant
  - Metallic catalysts

- processes:
  - Sabatier: $CO_2 + H_2 = CH_4$
  - $CH_4 + O_2 = C_2H_4 + H_2O$ (Process: Siluria's OCM Catalyst)
  - Ziegler-natta: $C_2H_4 + C_2H_4$ = Polyethylene
  - Benzene: catalytic reforming
  - Phenol: cumene process

- products:
  - Rubber, for the waterproof joints of doors ...
  - Resin, for carbon components of rockets ...
  - Plastic, for various containing chemicals ...
  - TNT, explosive ...
  - Anti-septic: phenol ...

We can notice that following these basic reactions and other, it is possible to build all that we need and that it is possible to manufacture on Earth.

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