MARSPOLAR GENERAL MISSION ASSESSMENT

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Revision History

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1 Introduction

1.1 Background

Marspolar project's schedule implies an establishing a Mars Settlement Habitat Simulation (MSHS) and a settlement on Mars, which are planned to be identical. This document will describe a conceptual design of an Environmental Control and Life Support System (ECLSS) which will be used both at the MSHS and at the martian settlement with maximal conformity which will be allowed by difference of Earth and Mars environment conditions.

The establishment of a settlement on Mars will depends on in-situ resource utilization (ISRU) deployment that are a little bit more capable than the current state of the art. Some hardware such still need to be developed and tested. Resupply logistics and sparing will play a large role for the planetary settlement. Thus, we develop a Mars settlement analysis that includes a habitat simulation with sparing analysis and ISRU sizing model.

A logistics model is utilized to predict the required amount of launch vehicles and provide a preliminary estimate of a portion of the program cost.

The logistics analysis revealed that the first crew for a Mars settlement will require approximately $4.5 billion in funding. The funding can be probalbly reduced to approximately $1 billion in a case of development of reusable vehicle technologies with an average propellant cost of $2,5 million for one vehicle and about $1 million for both liquid oxygen and nitrogen.

The Environmental Control and Life Support System (ECLSS) for the martian habitat should perform several functions:

- Provide oxygen for metabolic consumption;
- Provide potable water for consumption, food preparation and hygiene uses;
- Remove carbon dioxide from the cabin air;
- Regulate oxygen partial pressure to exlude crew poisoning;
- Filter particulates and microorganisms from the cabin air;
- Remove volatile organic trace gases from the cabin air;
- Monitor and control cabin air partial pressures of nitrogen, oxygen, carbon dioxide, methane, hydrogen and water vapor;
- Maintain total cabin pressure;
- Maintain cabin temperature and humidity levels;
- Distribute cabin air between connected modules.

The ECLSS functional simulation is used to provide estimates of atmospheric leakage, Extravehicular Activity (EVA) losses, agricultural cultures growth water usage, and other resource requirements for an ISRU sizing model. The ISRU model parametrically designs a soil processing module for extracting water from the soil and scales an atmospheric processing module to separate Nitrogen and Argon from the atmosphere. A detailed components list, including more than 100 unique items from both the ECLSS and ISRU systems, is compiled to provide a partial estimate of the settlement mass.

Sparing analysis determines the required number of spare parts to provide a probability greater than 0,99 that enough spares will be available to execute all the required repairs during the time between resupply missions.

The manifest of ECLSS and ISRU components, as well as the required number of spares, is compiled and fed into logistics analysis that determines the number of launches required to deliver such a mass to the Martian surface. This analysis is also shows an estimate of the production, launch, and logistics cost associated with supporting a planetary settlement.

1.2 Capability

The capability of this conceptual design is limited to planetary settlement ECLSS modules. Physiochemical ECLSS is empasized as there is no bioregenerative life support functionally provided by ECLSS module. Bioregenerative life support will be phased in as the settlement will grow.

The ECLSS provides part of the required ISRU functionality – in-situ resource processing (ISRP) is performed to extract water (H_2O) from externally supplied Martian regolith and Nitrogen (N_2) and Argon (Ar) from the Martian atmosphere. Before the first crew arrival, the ECLSS generates the habitat's pressurized breathable atmosphere (10.2 psia, 2.5 psi $O_{2,}$ balance of N_2 and Ar), as well as stored $O_{2,}$ and H_2O. The ECLSS also should maintain CO_2 and trace contaminants in the habitat atmosphere below harmful levels.

Very important question is an Oxygen (O_2) oversaturation in the habitat atmosphere. In-situ argricultural production can become a reason of unsafe oxygen levels in the habitat. There're two solutions for this problem:

- oxygen removal system;
- separation of the living units and crop growing units;

The first option needs a technology which is not completely presented now and not used anywhere. Thus, the most feasible option is a separation of the units. This can be achieved by using an airlocks between crop production facilities and other habitation units.

The conceptual design will also approach to providing other ECLSS functions that are considered as primary. These additional functions include positive pressure relief, internal habitat air filtration, air temperature control and circulation, fire detection and notification, air quality monitor, portable water quality monitor, and thermal control (heat collection, heat transport, heat rejection and insulation).

1.3 Purpose

The purpose of this Habitat ECLSS Conceptual Design plan is to document the architecture and hardware requirements prior to formal definition of the Development Component Baseline.

1.4 Methods

Design, development and documentation will be in accordance with Marspolar project's processes and processes of Marspolar suppliers.

1.5 General Concept Plan of Operations

1.5.1 Rover ground simulations and tests

Rover, designed by Marspolar's Rover Development team will be tested on Earth, in Marspolar test facilities

1.5.2 ComSat LEO launch and Rover control tests

Communication satellite developed by Marspolar's Satellite team will be launched to the Low Earth Orbit (LEO). Satellite and rover team will cooperate in data trasmittion tests and rover control test. Communication satellite will be used in the role of "relay station" between rover and its pilot, where the control will be comlicated by artificial up to 40 minutes delays, which are the ordinary problems for communication between Mars and Earth.

1.5.3 Phase 1: Sending Robotic Probe to Mars

After successful simulations and on-Earth tests, the vehicle with a surface rover and the second communication satellite will be sent to the Martian orbit. The rover will land on Mars, in Hellas Planitia. This region is a plain located within huge, roughly circular impact basin Hellas located in the southern hemisphere of the planet. Hellas is the largest visible impact crater known in the Solar System. The basin floor is about 7,152 m

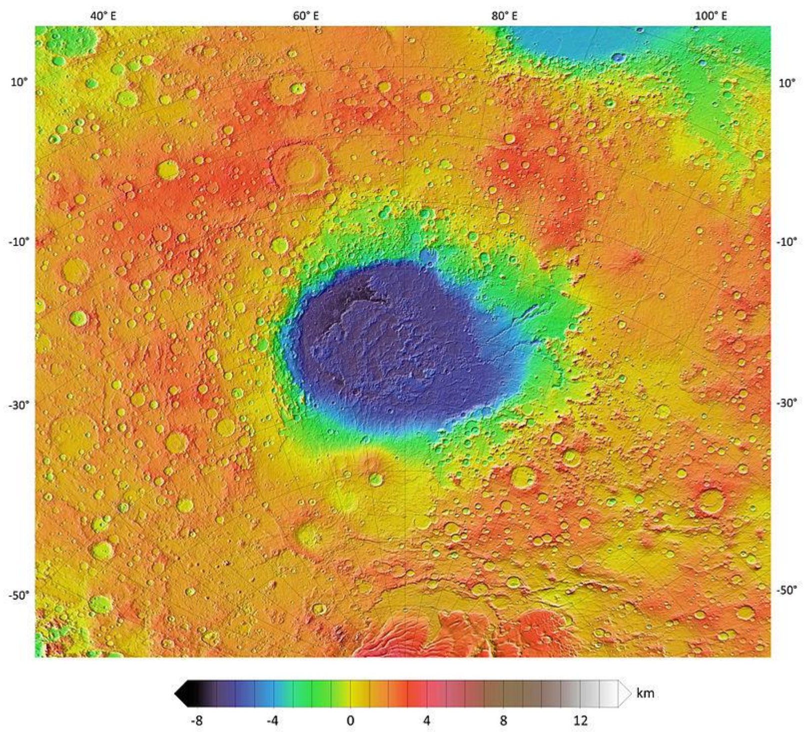

Fig. 1. Topographic map of Hellas Planitia and its surroundings in the southern uplands, from the Mars Orbiter Laser Altimeter (MOLA) of Mars Global Surveyor. The crater depth is 7,152 m (23,465 ft) below the standard topographic datum of Mars

(23,465 ft) deep and extends about 2,300 km (1,400 mi) east to west. It is centered at 42.4°S 70.5°E.

The altitude difference between the rim and the bottom is 9,000 m (30,000 ft). The depth of the crater which is 7,152 m (23,465 ft) explains the atmospheric pressure at the bottom: 12.4 mbar (0.012 bar) during the northern summer. This is 103% higher than the pressure at the topographical datum (610 Pa, or 6.1 mbar or 0.09 psi) and above the triple point of water, suggesting that the liquid phase could be present under certain conditions of temperature, pressure, and dissolved salt content.

The rover's task will be to conduct an operations of weather and surface analysis and geological prospecting to find an ideal place for deployment of the first habitat compoments.

Atmosphere pressure, typical for this region, rich presence of ice water in regolith will create more safe conditions for the colonists, than in the mosth of planet's regions. Climate conditions in the northern and central parts of Hellas Platinia are also acceptable for settlement presence. Average temperature for equinoxes and for summer solstice is 260 K, and for winter solstice is 280 K.

1.5.4 Phase 2: Cargo mission, pre-deployment

After the rover will succesfully complete prospecting of landing site, the first cargo mission will land on Mars. According to the first pre-concept plan, the payload of transportation vehicle will consist of (kg):

- Crew capsule: 8,000
- Main habitat structure: 5000
- ECLSS: 1,000

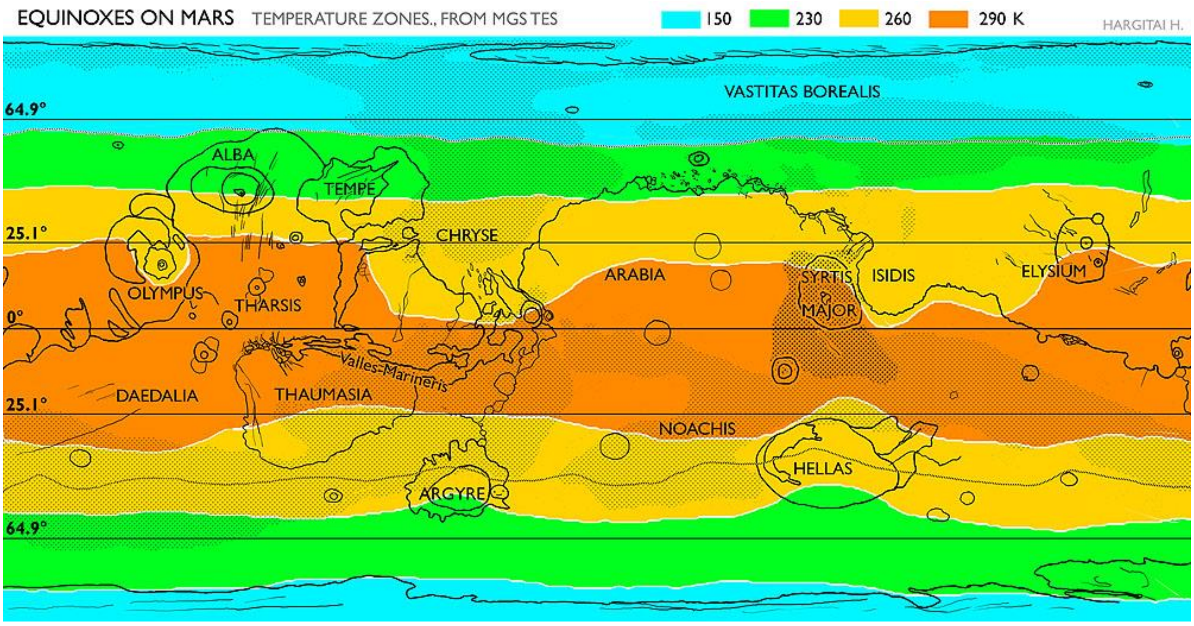

Fig. 2. Spring and Autumn Equinox (Ls=0, 180) temperature zone patterns modified by albedo and topography (Temperature values correspond to daytime maximums)

- Solar Arrays (20 kWe): 4,000
- Pressurized electric driven truck: 2,000
- 4 Inflatable habitats: 800
- Water extraction unit: 200
- 4 Inflatable water tanks: 200
- 4 Pressurized suits: 400
- Food: 3000
- Water: 6000
- Oxygen: 1140
- Spares and other: 3800

**Current composition of payload may be changed during the further mission planning process.*

It is planned that four inflatable habitats will be deployed automatically and connected to the main habitat structure. Four inflatable water tanks will be deployed near the habitat modules and connected to the ECLSS system using multipurposal rover as an additional water storage. Atmosphere pressure, which is twice as higher as triple water point, is enough to keep water liquid in conditions where the temperature interval is from 0,01°C to ~10°. Possible way of thermal insulation of water tanks is to use aerogel intercalation into a vessel surface. Aerogels are widely implementing by world aerospace agencies in different directions. Some sorts of such materials are flexible and have a very high temperature conductivity in a range from -200°C to +200°C. Aerogels are among the lightest solid materials known to man. They are created by combining a polymer with a solvent to form a gel, and then removing the liquid from the gel and replacing it with air.

1.5.5 Manned Missions

It is planned that after deployment of the first habitat modules and completion of all system tests, transportation vehicle with a first crew of colonists will be launched to Mars. The transportation vehicle will carry on board the additional copies of all cargo which will be sent with the first cargo mission. Transportation vehicle need to be landed within 50 km range from the first landing site. It will allow the crew to reach first habitat fast. Upon arrival, the crew will transport all of the equipment to the first colony facility and deploy additional units to expand the habitat.

Every two years the new resupply mission will be launched. It will contain all needed hardware and spares. Every new team of colonists will depart when the colony will be ready for the expansion.

2 System-Level Design

2.1 Atmospheric and surface conditions impact upon ECLSS

2.1.1 Atmospheric Composition

The atmosphere of Mars consists of ~95% of carbon dioxide, ~2.7% of nitrogen, ~1.8% of argon and less than 0,1% of carbon monoxide. Atmospheric nitrogen and argon are in sufficient amount to be captured and purified to use as balance gas in the astronauts living space. Carbon monoxide is also at significant concentration that it must be purposely excluded during the production of nitrogen and argon or actively removed by ECLSS trace contaminant control assembly to exclude the intoxication of habitat modules atmosphere.

The ability to utilize CO_2 as a source of O_2 may be considered. The CO_2 toxicity effect requires protection from this gas. As the crew enters and exits the habitat, there is potential for CO_2 contamination of the pressurized airlock volume. Condensation of expired H_2O in the airlock by crew in a high CO_2 environment will be a reason of carbonic acid formation which can increase corrosion rates on condensing surface. Thus the system-level design must be able to accommodate exposure to carbonic acid, preclude its formation, or employ a combination of both approaches.

2.1.2 Atmospheric Pressure

The average atmospheric pressure on the surface of Mars is 600 Pa which is about 0.087 psi. The average atmospheric pressure in the region Hellas Platinia is 1240 Pa (~0.17 psi), which are the more safe conditions for the pressurized hardware and the team of colonists. Considering this, Hellas Platinia is chosen to be the first landing site for the Marspolar manned mission. The normal atmospheric pressure on Earth is 101325 Pa (~14,7 psi) which is higher than Martian atmosphere pressure in about 81,7 times. Thus, such low pressure will necessitate the need for maintaining higher pressures within the habitable volumes constantly. With a lower pressure outside the habitat units, contamination of internal atmosphere will be significantly reduced. It will require the better management of airlocks to minimize habitat atmospheric losses during depress and repress.

Also, the protection against the atmospheric leakage and its detection and repair should be considered. The nominal and contingency gas leakage rates will increase sizing of gas production subsystems as well as size of the storages. Careful arrangement and inclusion of the ability to connect or isolate discrete pressurized volumes within the Surface Habitat should be implemented to minimize the magnitude of worst case contingency leakage rates and volumes.

The safety growth will also depend on increasing the habitable pressurized volume. This moment will increase the time, which colonists will need to recover the leakage.

2.1.3 Thermal environment

The over 2000 km wide basin, created by an ancient meteor impact, is in places more than 7000 meters below the mean planetary horizon. It is believed to be the lowest place on the planet. It is located at about 40 degrees south latitude, similar to that of central Argentina, and Melbourne, Australia. The Basin is one of the areas in which dust storms frequently erupt. It is also unusual because there are very few craters there.

Because of its latitude and great depth, it seems likely that there is an abundance of water ice under the surface in the Hellas Basin. Mossbaur spectra, which can detect the presence of hydrogen, suggest that, except for the poles, this may be one of the "wettest" places on the planet. It may possibly be the last place where liquid water ever existed on the surface of Mars. In mid summer, it is one of the "garden spots" of the whole planet, with atmospheric pressure of over 10 millibars, more than twice what it is at the mean planetary horizon. Since the vapor pressure of water is lower than 10 millibars if the temperature is less than 60 deg. F (16 deg. C)(4), this may be one of the few places on the planet where any water on the surface will not immediately boil away. The days are long and relatively warm, and the nights are fairly mild, considering how far north the Hellas Basin is located.

Summertime temperature vs. time curves for the Viking Landers were reported in 1977 (1). These curves are similar in appearance to those obtained in deserts on the earth, though the vertical scale on the Martian curves are considerably larger. Those for Viking II are shown in Figure 2. They indicate a summertime temperature variation of about 80 deg. F (44 deg. C). Dust storms do not cause much change in the mean daily temperature, but the difference between the high and low temperature on a given day can be greatly reduced from what it would be when the air is clear.

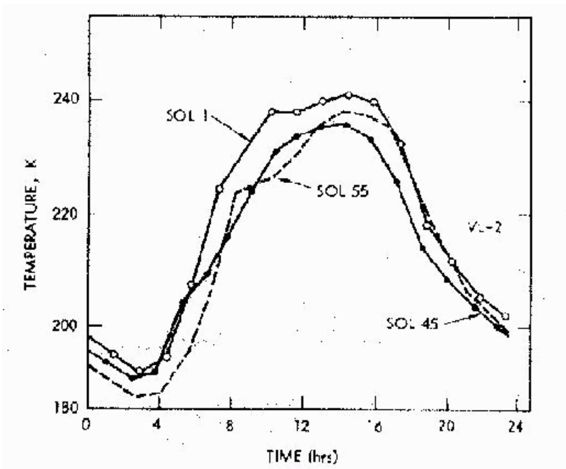

Figure 4: Temperature Curves for Viking II (1). Distortions in two of the curves resulted from dust storms

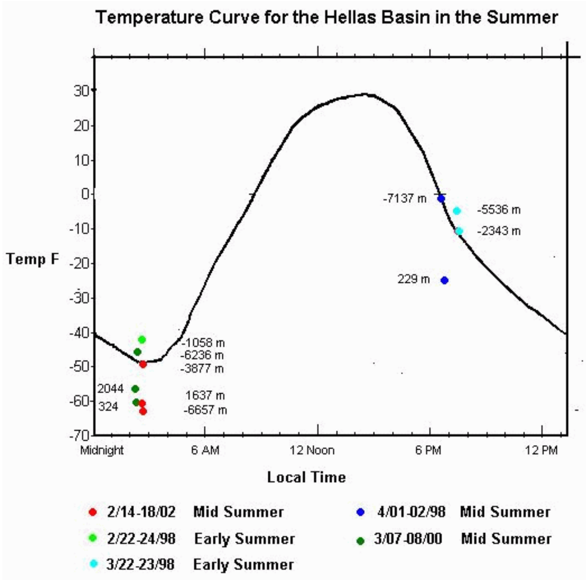

Figure 3: Temperature curve adjusted for summertime temperatures in Hellas Planitia

Late afternoon temperatures in the Hellas Basin are generally near or slightly above 0 deg. F (-18 deg. C), and nighttime temperatures at 2:00 AM are about 50 deg.F (-46 deg. C). Sometimes early morning temperatures at the lower altitudes can be unusually cold, possibly because of cold air pooling when there is little or no wind. Temperatures for different times during a Martian day can be estimated, using data obtained from the Viking spacecraft, which landed on Mars in 1979. The curve shown in Figure 3 was adjusted from the most symmetrical of the three curves in Figure 2 to fit the temperature data from the Hellas Basin. It should be a fairly good match, as Viking 2 is about as far north of the equator, as Hellas is south of it.

For a midsummer day in which the 6:00 PM temperature was 0 deg. F and the 2:00 AM temperature was of -50 deg. F (-46 deg. C), it is estimated from the temperature curve that the high temperature would probably be near freezing. The daily maximum soil temperature is about 45 deg. F (25 deg. C) warmer than the air temperature, or about 75 deg. F (24 deg. C) on the warmest days (1). Because the low point on the curve is at about 3:00 AM, the low temperature would be about -50 deg. F (-46 deg. C). The least cold morning temperature reported was -42 deg. F (-41 deg. C) in early summer. Early morning soil temperatures are about the same as the air temperatures.

Winter, is different. With the short days and long nights, temperatures are much colder, dropping at night down to -140 F (-96 deg. C). The less cold winter nighttime temperatures may have resulted from dust in the air following a major dust storm in the northern hemisphere or equatorial regions.

2.1.4 Wind-blown dust

Wind loads are expected to be minimal (dynamic pressure is dependent on density) though not fully insignificant on large surfaces. Pollution of external parts (vents, ports, door lock, seals, solar arrays, etc. will need to be mitigated.

In the period of unmanned mission we will need to test a weather and dust composition to understood these conditions to be able to predict it and to develop ways how to minimalize the risks of situation which can appear in the reason of such conditions.

2.1.5 Electrostatic dust

Martian dust is electrostatically charged. This particles may be attracted to astronaut suits and things that is moved in and out of the habitat by them. As a result it can be possibly brought into the habitable volume, even with active mitigation strategies.

2.1.6 Superoxides in Regolith

In the presence of ultraviolet radiation, superoxides break down organic molecules. The expectation is that materials such as polymers and elastomers may degrade relatively quickly and introduce trace contaminants into the habitat internal atmosphere if not carefully screened for compatibility. We need to collect and remove that migrates into the habitat pressurized volume during the time when colonists will be passing through the airlock. In fact we should consider a regular cleaning the pressurized suits from the dust particles. The physical methods are the most effective and simple. Thus, after each enter to the airlock from the external environment the suits and the airlock should be physically cleaned using special brushes and vacuum cleaners, dust should be collected and removed out of the airlock during the next EVA.

2.1.7 Radiation

Radiation may be defined as energy in transit in the form of high-speed particles and electromagnetic waves. Electromagnetic radiation is very common in our everyday lives in the form visible light, radio and television waves, and microwaves. Radiation is divided into two categories - ionizing radiation and non-ionizing radiation.

There are three naturally occurring sources of space radiation: trapped radiation, galactic cosmic radiation (GCR), and solar particle events (SPE).

Ionizing radiation is radiation with sufficient energy to remove electrons from the orbits of atoms resulting in charged particles, and it is this type of radiation that is evaluated for purposes of radiation protection. Examples of ionizing radiation include gamma rays, protons, and neutrons.

Non-ionizing radiation is radiation without sufficient energy to remove electrons from their orbits. Examples are microwaves, radio waves, and visible light.

Space radiation consists primarily of ionizing radiation which exists in the form of high-energy, charged particles. Two forms of radiation pose potential health risks to astronauts in deep space. One is galactic cosmic rays (GCRs), particles caused by supernova explosions and other high-energy events outside the solar system. The other is solar energetic particles (SEPs) associated with solar flares and coronal mass ejections from the sun.

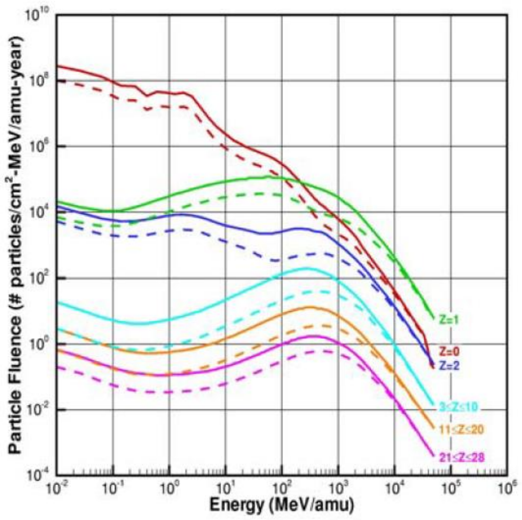

Fig. 5. - GCR environment during the 1977 Solar minimum and the 1990 Solar Maximum on the Martian surface (mean altitude) using the Marsgram atmospheric model.

The environment near a large celestial body is modified by interaction with local materials producing an induced environment and shielding within the subtended angle of such a large body. The surface exposure on a Martian plain is shielded below the horizon but experiences an induced environment (mainly but not exclusively neutrons) produced in the atmosphere and local surface. The Martian surface GCR environment is shown in Fig. 3 at the 1977 solar minimum and the 1990 solar maximum. In addition to the GCR ions and induced environment streaming from overhead, large numbers of neutrons are produced in the Martian surface materials and diffuse from below the surface as shown in Fig. 2 (Z=0).

Large SPE have only been observed to occur during times of increased solar activity conditions, and very large energetic events of grave importance to human protection occur only infrequently (avg. 1 or 2 per cycle) and only outside of two years of solar minimum. Among the large events, the largest observed ground level event of the last 60 years of observation is that of February 23, 1956, which produced a 3600 percent increase in neutron monitor levels on the terrestrial surface. The next largest event observed is the September 29, 1989 event with ground level increases of 400 percent or an order of magnitude smaller than that of the Feb. 1956 event. Numerous other ground level events of smaller magnitude have occurred but are about a factor of four lower in magnitude than the Sept. 1989 event. It is known that large SPEs are potentially mission threatening and astronauts in deep space must have access to adequate shelter from such an occurrence. The SPE particle energy spectrum used here has been derived from the event, which took place on September 29, 1989.

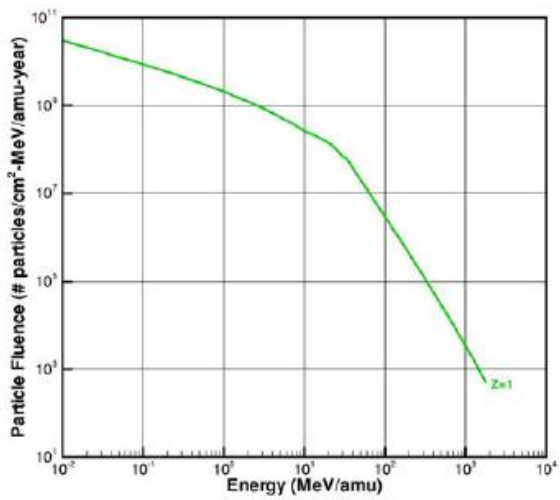

Fig. 6. - SPE spectrum during September 1989 as observed near Earth.

To provide a baseline worst-case scenario we assume an event of the order of four times larger than that of September 29, 1989, as an event comparable to the August 4, 1972 event from the point of view of space exposure. The September 1989 SPE spectrum is shown in Fig. 4. If we meet 30-day dose rate constraints on an event four times larger than the September 1989 event then it is unlikely that an added factor of two or so larger events (like that of Feb. 23, 1956) would have serious medical consequences. The SPE are likewise altered by the presence of a large body similar to the GCR. The corresponding Martian surface environment is shown in Fig. 5. Neutrons play a relatively more important role on the Martian surface where added neutrons are produced in the overhead atmosphere and the SPE protons are greatly attenuated compared to their effects on lunar surface.

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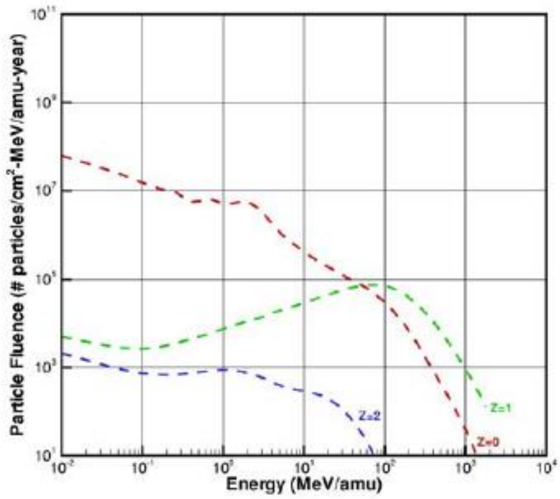

Fig. 7. - Martian surface environment during the September 1989 SPE

2.1.7.1 GCR and SPE Protection

One of the many challenges of deep space flight is the radiation environment that vehicles must withstand. In particular, galactic cosmic radiation (GCR), a constant background source of radiation in deep space, is difficult to shield against, requiring large thicknesses of material to provide any measurable difference in the dose to crew and electronics. Mitigating this exposure is approached via a multi-faceted methodology focusing on multi-functional materials, vehicle configuration, and operational or mission constraints. The materials that have proven to be the best radiation mitigators are low-Z materials, such as high-density polyethylene (HDPE). However, large amounts of HDPE for purely shielding purposes (parasitic shielding) leads to extra mass in a vehicle that can increase launch costs significantly. Thus, finding materials with multipurpose uses and developing a multifaceted shielding approach is far more mass and cost efficient.

According to results of NASA-JPL research, astronauts on ISS are recieving daily dose of radiation, which is about 1mSv/day. NASA-JPL incorporate data that RAD gathered during Curiosity's eight-month cruise through space and the rover's 450 days on Mars, where it touched down in August 2012. RAD's data show that astronauts exploring the Martian surface would accumulate about 0.64 millisieverts of radiation per day. The dose rate is nearly three times greater during the journey to Mars, at 1.84 millisieverts per day. This fact means that manned mission to Mars need to have at least twice more effective radiation protection during the flight than ISS.

Currently, International Space Station (ISS) using its aluminum shell as basic material for radiation protection. As an additional shielding polyethylene (C_nH_n) was tested. Polyethylene is a relatively inexpensive, stable, and, with a low atomic number, an effective shielding material that has been certified for use aboard the ISS. Several designs for placement of slabs or walls of polyethylene have been evaluated for radiation exposure reduction in the Crew Quarters (CQ) of the Zvezda (Star) Service Module.

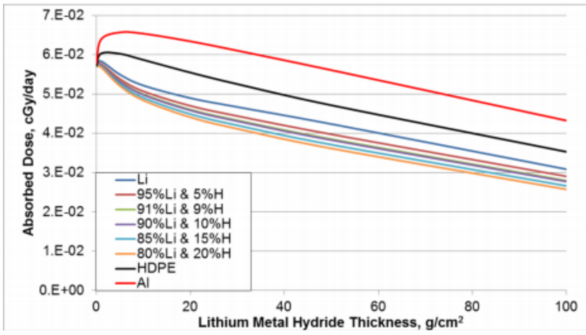

Fig. 8. – Lithium Metal Hydride Thickness/Absorbed Dose, g/cm²

Some of Carbon Composites (CNTs) and Lithium Hydrides according to study of American Society for Gravitational and Space Research in Pasadena are performed better as aluminum and polyethylene (Fig.6 and Fig.7).

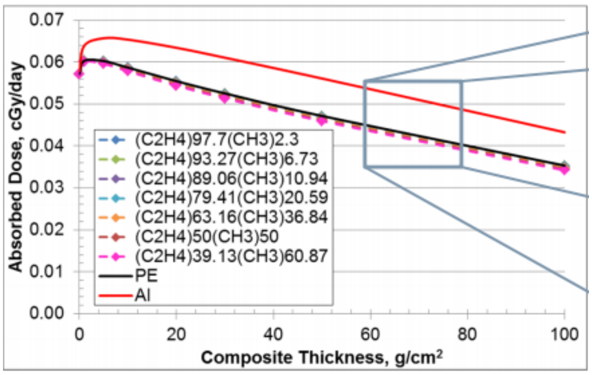

Fig. 9. – Composite Thickness/Absorbed Dose, g/cm²

Composite aerogel multifoil protective shielding can be also used to provide thermal insulation,

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while also shielding spacecraft or components from radiation (and hypervelocity particle impacts). Multiple layers of foil separated by aerogel would act as a thermal barrier by preventing the transport of heat energy through the composite. The silica aerogel would act as a convective and conductive thermal barrier, while the titanium powder and metal foils would absorb and reflect the radiative heat. It would also capture small hypervelocity particles, such as micrometeorites, since it would be a stuffed, multi-shock Whipple shield. The metal foil layers would slow and break up the impacting particles, while the aerogel layers would convert the kinetic energy of the particles to thermal and mechanical energy and stop the particles.

2.1.8 Gravity and magnetic field

Mars has approximately 38% surface gravity of Earth. Given the appreciable gravitational field of Mars, technologies that exploit passive gravitational force should be utilized whenever practical to simplify operations. Analysis and some design modifications to existing mature terrestrial processes will be required to accommodate changes in the particle and fluid behavior in the reduced gravity environment. The reduction of buoyancy driven convection relative to Earth-nominal will also have to be considered with regards to heat transport and atmospheric mixing.

Mars has large crustal magnetic anomalies, nearly ten times larger than those on the Earth. Since crustal magnetic anomalies are the product of the

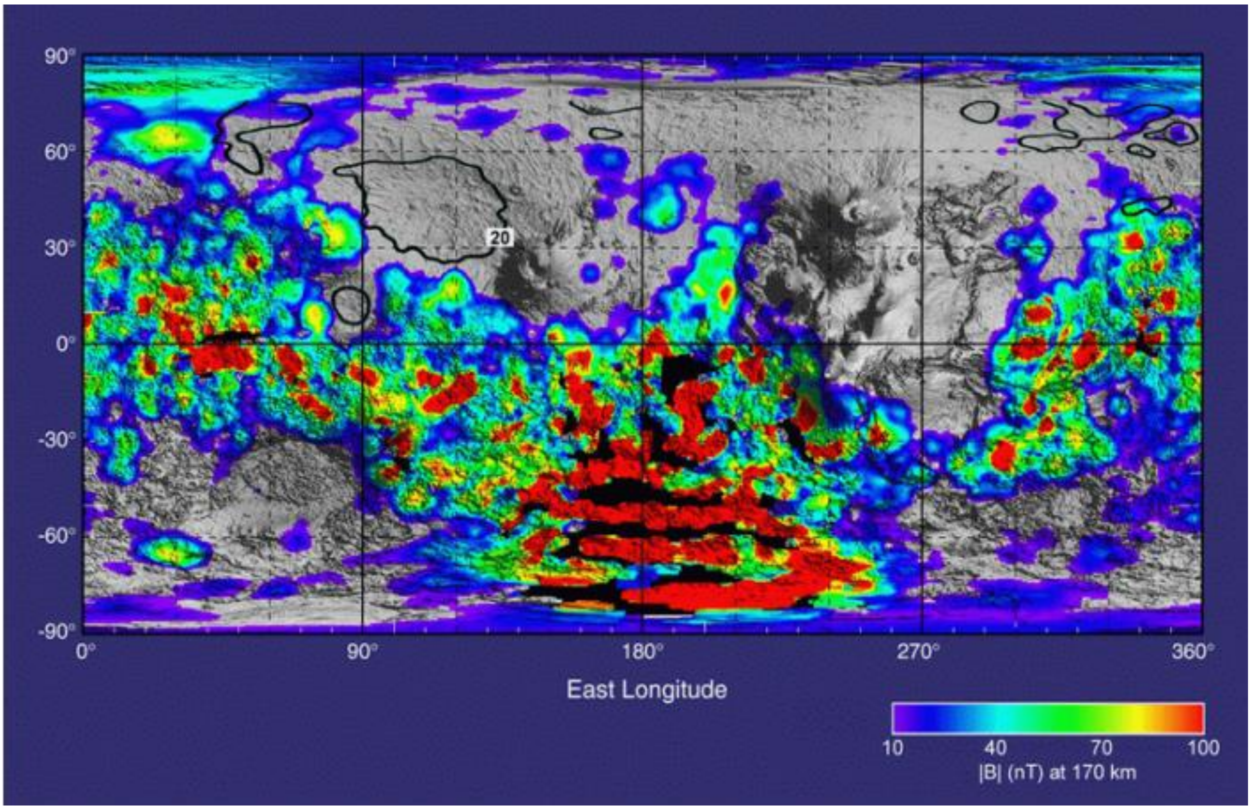

Fig.10. – The crustal magnetic field amplitude at an altitude of 170 km (B170), as inferred from electron reflectometry, is represented as colors superimposed on a shaded relief map of MGS-MOLA topography. Grayscale regions have B170 < 10 nT. White regions contain no data. Regions with thin crust in the northern hemisphere are bounded by a 20-km crustal thickness contour (from [9]).

thickness of the layer of magnetization, both the magnetizing material and the thickness of the layer of this material must be very different on Mars than Earth. Furthermore, the martian anomalies can only be produced by remanent or fossil magnetization, in contrast with the Earth where both induced and remanent magnetization are producing these anomalies. Crustal magnetic anomalies on the Earth are mainly produced by single-domain, iron titanium oxides, in the form of magnetite being the most common on Mars the main magnetic mineral(s) are unknown. The thickness of the martian magnetized layer in comparison with the Earth remains a major area for research.

However, the planet have large demagnetized areas, with weak magnetic field which is below 10nT. Among these areas is Hellas Basin. It have some local maximas found close to volcanic centres (Hadriaca Patera, Tyrrhena Pater and Pityusa Patera).

The Electron Reflectometer (ER) onboard Mars Global Surveyor (MGS) detected a plasma boundary between the ionosphere and the solar wind as latter is diverted around and past the planet. Photoelectron boundary (PEB) around Hellas Basin is sensitive to pressure varaitions and moves vertically in responce to changes in the ionospheric pressure from below and the solar wind pressure from above. The PEB is also sensitive to crustal magnetic fields, which locally increase the total ionospheric pressure and positively bias the PEB altitude. The PEB altitude bias which is found over the Hellas that give rise to a several-nanotesla horizontal field at 400km altitude, then these same sources should give rise to crustal fields of at least several tens of nanotesla at 100 to 200km aerobraking altitudes. Although low-altitude MAG measurements over Hellas are sparse, there was no evidence for crustal sources of this strength. Furthermore, electron reflection data detected only a few isolated sources within Hellas Basin. Thus, there are two possibilities for the observed PEB bias over the basin:

1) Horizontal fields over Hellas arise from magnetiv sources around the basin perimeter;
2) The solar wind flow is perturbed by crustal sources in the southern hemisphere such that the effective solar wind pressure over hellas is systematically reduced.

Thus, with demagnetized crust in the Hellas Basin, we have a photoelectron boundary which is on the same level with other areas in southern hemisphere. According to this, we can say, that we will have no loses in radiation shielding, related to demagnetized crust in the bottom of basin.

2.2 Habitat ECLSS Design

2.3 Plant Growth Support. Aeroponics

The crew of astronauts should work on plant growth to provide self-sufficienty of the colony in the case of constant food supply. From the first stages of settlement establishment, bioregenerative life support will be incorporate into the functional ECLSS architecture.

It is planned, that for food production, Aeroponics will be used as basic. Aeroponics is the process of growing plants suspended in air, without soil or media, provides clean, efficient and rapid food production. Crops can be planted and harvested year-round without interruption, and without contamination from soil, pesticides, and residue. Aeroponic systems also reduce water usage by 98 percent, fertilizer usage by 60 percent, and eliminate pesticide usage altogether. Plants grown in aeroponic systems have been shown to absorb more minerals and vitamins, making the plants healthier and potentially more nutritious.

The suspended system also has other advantages. Since the growing environment can be kept clean and sterile, the chances of spreading plant deseases and infections commonly found in soil and other growing media are greatly reduced. Also, seedlings do not stretch or wilt while their roots are forming, and once the roots are developed, the plants can be easily moved into any type of growing media without the risk of transplant shock. Lastly, plants tend to grow faster in a regulated aeroponic environment, and the subsequent ease of transplant to a natural medium means a higher annual crop yield. For example, tomatoes are traditionally started in pots ands transplanted to the ground at least 28 days later; growers using an aeroponic system can transplant them just 10 days after startingthe plants in the growing chamber. This accelerated cycle produces six tomato crops per year, rather than the traditional one or two crop cycles.

These benefits, along with the great reduction in weight by eliminating soil and much of the water required for plant growth, illustrate why this technique has found such enthusiastic support from NASA. Successful long-term missions into deep space will even require crews to grow some of their own food during flight. Aeroponic crops are also a potential source of fresh oxygen and clean drinking water.

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