201 HW 3

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1 Reducing Human Radiation Risks

Human undertaking space travel and extraterrestrial habitation outside of a protective magnetosphere are subject to very high levels of highly damaging radiation [1]. Exposure levels are at least 3 times that experienced in low earth orbit (LEO) [2]. This radiation is of two distinct forms, Galactic Cosmic Rays (GCR)and Solar Particle Events (SPE). With equally distinct needed approach to shielding/risk reduction.

1.1 Requirements for risk mitigation

The radiation risk evaluation and mitigation is if the highest importance, as current "Mars mission models conclude that astronauts will vastly exceed the current limit for a career-based 3 percent increase in Risk of Exposure Induced Death (REID) over the course of a typical mission.[3]" Especially to vital organs, i.e. lungs and with a higher risk to female reproductive organs[3]. To have a mission be sustainable exposure must be brought to what is refereed to by OSHA and NASA as, "as low as reasonably achievable", or ALARA[4].

1.2 Shielding technologies to mitigate GCR/SPE Exposure

Three shield main shielding technologies have been investigated in [5]; aluminium, water, and liquid hydrogen all reduce GCR damage to BFO (blood forming organs) to 45 $rem.yr^{-1}$, 35$rem.yr^{-1}$ and 15$rem.yr^{-1}$ respectively at a minimum of 10 $g.cm^{-3}$ [5]

Where SPE are unpredictable both in time and power so a higher grade of aluminium shield, nearer 30 $g.cm^{-3}$ is needed to have same risk reduction.. Though the practicality is also a major factor. Mostly the concerns of each of the weight requirement of each, as the liquids and aluminium as sufficiently effective thickness's are impractically heavy when used on their own. As well as requiring added structural support [1]. This is where nano tube technologies are particularly promising in part because of their potential cross-application as structural materials as well. Tables 2-4 in [1] investigate their respective effectivenesses and show promising results:

Nanoporous carbon composites (CNTs).
Specific "best case" example under comparison: (C2H4)39.13 %(CH3)60.87
Hydrogen-loaded metal organic frameworks (MOFs).
Specific "best case" example under comparison: $C_{432}H_{1120}Be_{48}O_{144}$
Hydrogenated boron nitride nanotubes (BNNTs).
Specific "best case" example under comparison: BNNT + 20% by weight H2

1.3 Colony Design

In an option to reduce cost and extensive use of external shielding, the Martian regolith, ie in situ (underground) shielding can be used.

In terms of architecture, the base must be constructed to withstand a worst case SPE for long stay missions (600 days). This can be mitigated with base location, to reduce direct radiation exposure. Making use of geography and solar angle to reduce radiation intensity. In terms of radiation-effect mitigation, the mission must be supply with adequate medical supplies to cover the expected length and worst case exposure, (within planed protocols).

To have a successful human mission to Mars, with the objective to maintain crew health and safety, the mission must; maintain radiation exposure to acceptable levels, and mitigate effects of suffered exposure.

References

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