Theories And Ideas On How To Prevent Space Radiation From Affecting OE Spacecraft

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1. Introduction

In this paper I will present a few theories on how to prevent the extreme radiation environment of deep space from affecting the crewed spacecraft sent to Europa. As you can see, I'm only a sub amateur scientist and engineer but that does not stop me from being open minded on such missions! I therefore have taken the opportunity to research on this matter and try to help OE in tackling this issue. The following account is not solely based on my ideas (if so, I would call myself a genius!) but I have taken considerable help from other online research journals that have been conducted and generously been made public.

Before going into the matter, there are a few abbreviations I have used which I'll post as a note here –

GCR: Galactic Cosmic Rays

SW: Solar Wind

SCR: Solar Cosmic Rays

SPE: Solar Particle Event

cSv: centi sieverts (standard radiation unit)

(a) Radiation preventing material analysis

Before we move into the materials, let us look at the types of radiation –

Alpha particles: These are actually physical particles of matter and are also considered to be among the "heavy class" type particles. They are comparatively much slower than other types and can barely penetrate a piece of paper.
Beta particles: These are smaller, and are actually electrons that have negative charges. All it takes to stop them is a sheet of Aluminium foil.
Cosmic radiation: GCR is an example of cosmic radiation. These particles require a lot of stopping.

Electromagnetic radiation (Gamma Rays): This radiation cannot be "stopped", but can be decreased by using shielding materials stacked along with each other. Such rays can only be "halved" upon contact with the preventing materials.

From what I have researched, the materials that I have come across frequently are Aluminium and water. Scientists have conducted many experiments based on them and they have been tested positive for prevention of some of the radiation types from entering wholly into their medium.

Aluminium : Aluminium foils or sheets can stop the penetration of Beta rays, but foils are not what we are looking for! To stop the radiation from SCR and GCR, we would require plates and plates of Al, with each one having a thickness of 1 meter.
According to researched data, in an SCR event (during its maximum), an Al sheet of above 100cm thickness would mitigate the radiation and limit it to 8.3 cSv in 6 months and 16.7 cSv a year, when the normal radiation dose without any shielding would result to 28.9 cSv in 6 months and its double in a year (provided that the environment is not "Earth protected"). Therefore if more research is performed on the sheet thickness, the radiation could be limited even if it's not as much as when the sheet is of 100cm thickness, which means that Al sheets are not the only answer to radiation mitigation. Here we need to look upon other materials.

Water: Water is considered a very good radiation mitigator. In certain places where work produces nuclear radioactivity, a good measure of water required to somehow mitigate the 100,000R/hr radiation is about 2 meters.
The amount required to decrease the annual GCR radiation (as mentioned in the case of Al) by a factor of 2 is more than 50 tons. That is a lot of mass to be rocketed out. What are the other promising materials?

Regolith: A new material that I have come across while researching is Regolith. Regolith is a loose, heterogeneous material that covers rock forms. Regolith can be dust, soil, broken rock etc.

The moon is covered almost entirely by regolith. Considering the radiation mitigation property of lunar regolith with that of regolith found on Earth, the lunar regolith performs better in a radiation environment. Research by scientists' shows that in a GCR environment during a SW activity at its minimum, the overall dose without a shield was found to be around 14 cSv during 6 months. In the same environment by adding a 50cm lunar regolith shielding, the dose was cut to less than 6 cSV in the same time. They also experimented its properties in an environment as deadly as a SPE of 1956, which is recorded as one of the highest ever SPE. The radiation without shielding was found to be 100 cSv and adding a 100cm lunar regolith shielding reduced it to less than 3 cSv.
By studying these facts, it may be possible to conclude that Regolith is one of the best substances to reduce the effect in most dangerous radiation environments.

Plastics: A very modern method to reduce radiation is plastic, according to researches conducted by scientists. Although the properties of plastics acting against radiation are not fully researched, they are a promising material that may one day be used in space missions; advantage being that they are effective as well as economical.

(b) Generating Power from Radiation

Nanomaterials: Nanomaterials such as Carbon Nanotubes (CNTs) can be used to store charge as super capacitors or rechargeable batteries by collecting radiation as the input. They can be placed in water or deep in the regolith layer where the shielding effect starts decreasing.

Another method to derive electricity from the radiation bombardment is to stack layers and layers of CNTs, although in this case they have to be covered with gold and lithium hydride. When the particles slam into the gold covering, they push out electrons which move into the CNTs to the lithium hydride and are then pushed into the electrodes causing current to flow. This can be a free method of generating/storing electricity. Is it necessary that there has to be a radioactive material on board or can radiation be used from the space bombardment? I'm not sure about that. I hope we can know later on whether the latter is possible!

(c) An untested method to mitigate radiation

Based on all these material properties, I have created an image depicting the order of the shield layers that I believe must work even though they may lack detailed information or contain errors of my own in its making.

The shielding can be created around the entire spacecraft, though the human quarters must definitely contain the maximum.
The first shield has to be Aluminium, or it could be the second layer depending on which material is used to build the spacecraft. I don't exactly know how much the thickness has to be but if given that Al is used as the first layer, then I would go for 100cm. It could also be that 50cm is used and then just underneath plastic can act as the second layer (I have not depicted this in the image).

If the condition is that Al is the second layer, then Lunar Regolith must be the third. I guess another 100cm for it. Since it has proven to be an excellent shield against GCR, 100cm thickness has to be the minimum. Lunar regolith has to be collected at first, and then returned to Earth for usage in the spacecraft building. That would require another rover!

The next shield could be water. If this method is tested, then there could be a chance that the first 2-3 layers can halve the radiation to a very small dose. Water may then be unnecessary. The thickness of the water shield could be 100cm or less again, but since all these might act as huge loads, then uploading water might not be economical. If so, then layers of plastic could be arranged between the main layers so that the sum total could act as a shield.

Last of all, Nano materials can be uploaded into the beginning layers or deep within the regolith layer where its shield property starts decreasing. Most probably the better option is the former. If the deposition is enough then CNTs packed with gold and lithium hydride could be used (which I have explained in the previous section). They can act either as Super capacitors or generators of electric power.

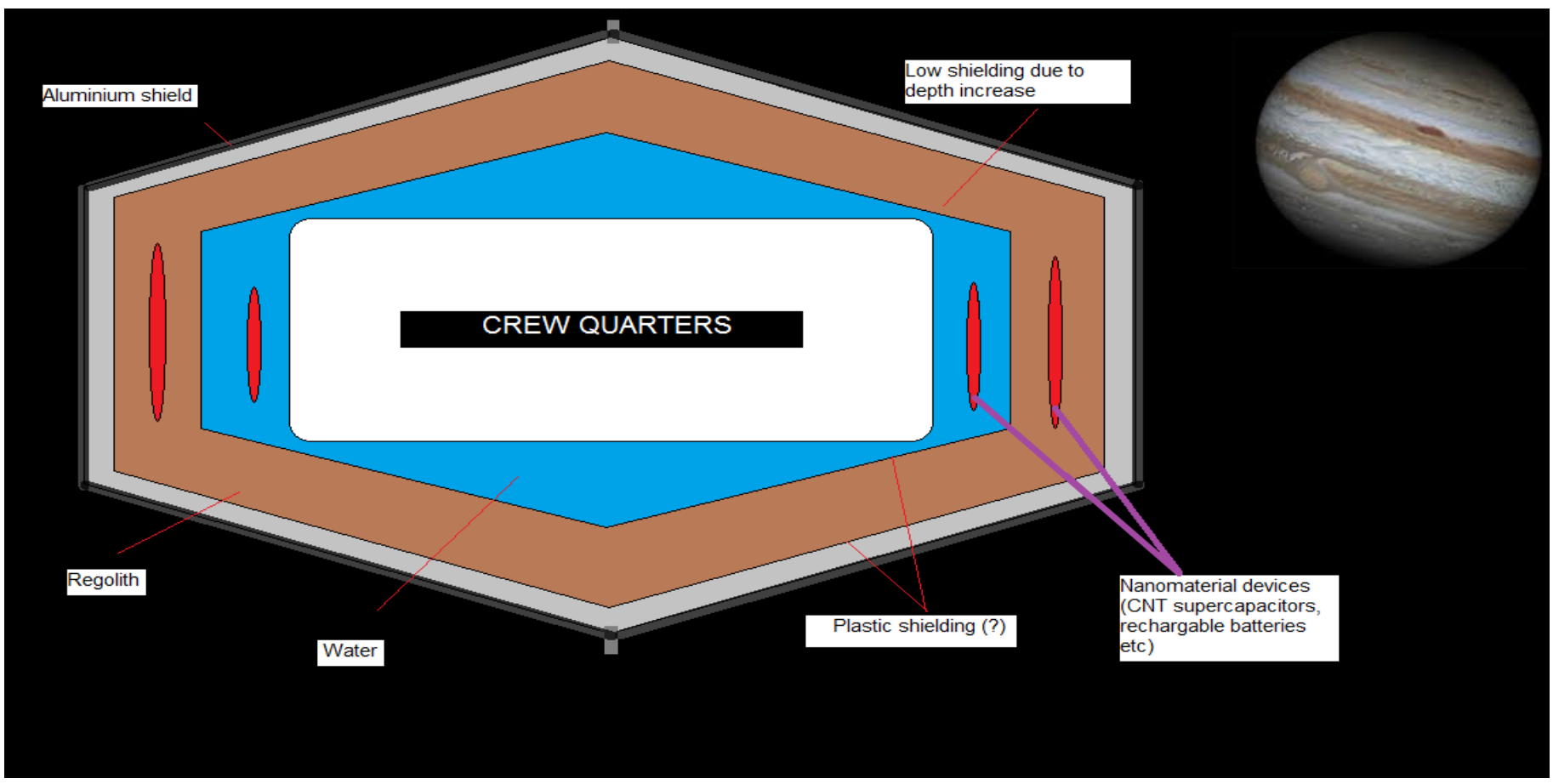

Image: Crew/sleeping quarters. Depicts the outside shielding layer by layer. The black space and Jupiter are for some visual effects!

The crew quarters can be placed right in the middle after the sum total of shielding has been tested and observed to be positive.

2. Conclusion

Based on all the data that I have studied, I have finalized my view on how to implement them in the radiation environment. I guarantee that there will be many mistakes in this idea in the layer thickness, usage of nanomaterials, electronic circuit paths through the entire spacecraft, difficulty in EVA procedures etc. , but I'm pretty sure that on the whole, the basic idea must work.

This idea needs testing, and I hope that in the future a basic implementation similar to the one I have provided will be used. It would be a great joy to see a similar idea being tested and shown the green signal. I also really hope that OE becomes a success and its construction uses a depiction not far from this one. That would be my reward.

3. Acknowledgements

I was very inspired by a NASA funded research project that studied the shielding capacities of various materials that could be used in a future mission to build a lunar base for astronauts. I have provided its name below:

"Interim Report for the Human Exploration of the Moon and Mars: Space radiation protection and mitigation strategies for a long term duration lunar base (a NASA funded study)"

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Andrew Daga & Associates LLC Malvern PA, USA.
Pablo de Leon
Department of Space Studies, University of North Dakota, Grand Forks, ND, USA.
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This project lead me to think of making a report myself for OE based on the data that they have provided in it. My sincere thanks to all involved in it, though they don't know me!
(Almost all mathematical data that I have provided in this report are extracted from the above project.)

I also want to thank Mr. Ali, Research Administrator of Objective Europa, for inspiring me to go forward with this report. He had also offered help from his side in the making of this report.

I would also like to thank Mr. Chris Weeks, Objective Europa Artist, for inspiring me with his wonderful images. The image that I have provided in the report was only a clumsy way to emulate him!

4. Bibliography

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***2.* "Engineering Physics",** *by P Raghavan*
3. *http://www.newscientist.com/article/dn13545-nanomaterial-turns-radiation-directly-into-electricity.html on usage of nanomaterials in a space radiation environment.*
4*.Google searches, Wikipedia.*

A Note to the readers: If you do find errors, corrections or improvements that can be done on the data and ideas that I have provided, please do mention them in the forum section. As much as I would like approval of this report, I also await the necessary corrections that I have missed out.