

## Vehicle Shield Optimization and Risk Assessment for Future Human Space Missions

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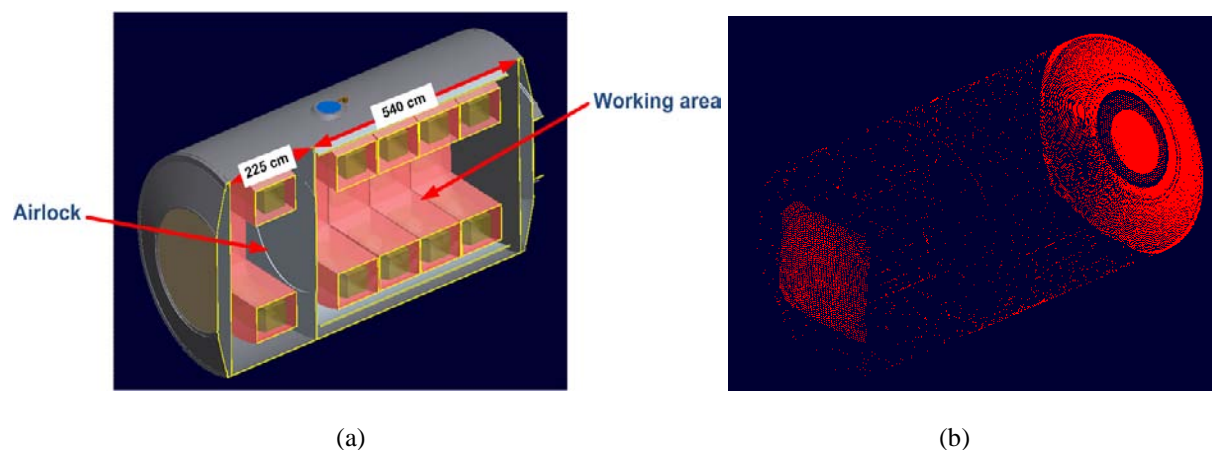
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As the focus of future human space missions shifts to destinations beyond low Earth orbit such as Near Earth Objects (NEO), the moon, or Mars, risks associated with extended stay in hostile radiation environment need to be well understood and assessed. Since future spacecrafts designs and shapes are evolving continuous assessments of shielding and radiation risks are needed. In this study, we use a predictive software capability that calculates risks to humans inside a spacecraft prototype that builds on previous designs. The software uses CAD software *Pro/Engineer* and *Fishbowl* tool kit to quantify radiation shielding provided by the spacecraft geometry by calculating the areal density seen at a certain point, dose point, inside the spacecraft. Shielding results are used by NASA-developed software, *BRYNTRN*, to quantify organ doses received in a human body located in the vehicle in case of solar particle event (SPE) during such prolonged space missions. Organ doses are used to quantify risks on astronauts' health and life using *NASA Space Cancer Model*.

The software can also locate shielding weak points-hotspots-on the spacecraft's outer surface. This capability is used to reinforce weak areas in the design.

Results of shielding optimization and risk calculation on an exploration vehicle design for missions of 6 months and 30 months are provided in this study. Vehicle capsule is made of aluminum shell that includes main cabin and airlock. The capsule contains 5 sets of racks that surround working and living areas. Water shelter is provided in the main cabin of the vehicle to enhance shielding in case of SPE. A cross section of the vehicle initial design and the associated hotspots are shown in Figure 1 (a) and (b).



**Figure1. (a) Cross section of the initial vehicle design and (b) Locations of shielding hotspots shown in red**