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Radiation Fields, Effects and Risks in Human Space Missions (4)

Author: Mr. Gideon Waterman
Israel

Dr. Oren Milstein
Israel
Mr. Yuri Zlatsin
Israel
Ms. Tamar Nix
Israel
Mr. David Murrow
United States
Mr. Bill Lytle
United States
Mr. Hesham Hussein
Lockheed Martin Space Systems, United States
Dr. Razvan Gaza
United States

ASTRORAD: PERSONAL RADIATION PROTECTION UTILIZING SELECTIVE SHIELDING FOR DEEP SPACE EXPLORATION

Abstract

Natural space radiation exposure consists of prolonged exposure to galactic cosmic rays (GCR) and periodic solar particle events (SPE) which potentially lead to detrimental health effects. SPE are of concern due to their short warning times and high intensities. In 1972, between the Apollo 16 and 17 missions, an SPE capable of delivering high doses occurred. For future manned missions beyond Low Earth Orbit, the necessity for radiation protection increases along with mission duration as both the cumulative doses will increase with time as well as the probability of encountering a significant SPE. In spaceflight, efficient use of mass is crucial, and the development of a radiation shielding strategy which offers a ratio of protection to mass is required. Prior work by StemRad Ltd. has shown the effectiveness of selectively shielding the BFO of first responders to radiological scenarios using the 360 Gamma personal shield. The AstroRad personal shield utilizes a similar strategy which is based on innovative passive shielding worn by astronauts to maximize the solid angle of coverage while selectively protecting those tissues which are most radiosensitive. Some tissues disproportionately influence the effective dose through their high tissue weighting factors, such as BFO, stomach, lungs, glandular breast tissue, colon and gonads. Furthermore, focusing protection on tissue resident stem cells within these organs provides even greater benefit as they give rise to a disproportionately large number of daughter cells, so a stem cell with a radiation-induced mutation gives rise to thousands of mutated daughter cells, increasing the likelihood of cancer within that organ exponentially. Simultaneously, stem cells possess a high capacity for tissue regeneration post-exposure which is especially applicable to acute exposures. Selective protection of these tissues was accomplished by designing the shielding thickness to be inversely related to the thickness and radiodensity of the underlying tissue at each point and point surrounding the targets for protection. Low-Z materials, especially materials with high hydrogen content, exhibit the largest mass stopping power

and present low cross-section for generation of secondary radiation including neutrons. Therefore, low-Z materials can then be used in a vest-like design in order to provide a high ratio of reduction in effective dose to shielding mass. Novel nanomaterials are being investigated for inclusion in the AstroRad, and the design team has developed innovative ergonomic concepts which ensure user comfort and flexibility. CAD models have been designed and HZETRN simulations show promising results for SPE mitigation.