SPACE LIFE SCIENCES SYMPOSIUM (A1)
Radiation Fields, Effects and Risks in Human Space Missions (4)

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SPACE RADIATION DESCRIPTION, EFFECTS AND HAZARDS MANAGEMENT FOR A 180-DAY HUMAN MISSION TO AN EARTH-MOON LAGRANGIAN POINT

Abstract

Future space missions foresee to overcome today's manned exploration boundaries, which are limited to Low Earth Orbits (LEOs), sending humans towards targets outside the protection provided by the Earth. The challenge to go far from Earth, beyond LEOs, with a manned payload, reflects numerous criticalities. In particular, this paper focuses on the space radiation issue, considered a crucial aspect for long duration missions (over 180 days). More specifically, a four-astronaut crew mission to an Earth-Moon Lagrangian Point (EML) is considered as reference case. The article starts with an introductory section to the radiation problem, presenting the type of radiation, the radiation-matter interaction phenomenology and the main radiation sources and the emitted particles characterizing the space radiation environment of the reference mission: hazards coming from the Sun, through the so called Solar Particle Events (SPEs), and the cosmic background radiation, better known with the acronym GCRs, Galactic Cosmic Rays. From this section, the definition of the main parameters describing a radiation field and its effects (acute and late) on biological systems, is considered. In addition, a distinction between physical (i.e. flux or absorbed dose, D) and protection quantities (i.e. equivalent dose, H, or effective dose, E) is presented. From this point, the countermeasures against the radiation (only protons) are studied in detail, specifically for our mission case. Initially the space infrastructure and the reference module (habitat, Crew Quarters, CQs, included) are introduced and defined in terms of mass and volume estimation of systems and sub-systems, inner layout, dimensions and primary and secondary structures (ISS-module like). Then, the habitat is partitioned into different areas in order to evaluate the protection (areal density) already provided by the habitat against protons and expressed as Al-equivalent. The minimum value of 4.3 g/cm2, considered as the Worst Case (WC), is assumed for the whole element (CQs excluded). Taking into account a standard day of the crew activities, in order to stay under a threshold limit, given by dosimetry data, of 0.25 Sv for exposure, an areal density of 36.1 g/cm2 is computed using two free software (SPENVIS and OMERE). Knowing the provided and needed protection, it is possible to identify the CQs areas where protection addition is necessary. As countermeasure, an engineering design solution foreseeing water and polyethylene, is defined and illustrated in detail especially in terms of thickness, mass, volume and operational complexity.