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Radiation Fields, Effects and Risks in Human Space Missions (5)

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INTERNATIONAL SCIENCE PAYLOAD ABOARD ORION EM-1: THE MATROSHKA ASTRORAD

Abstract

Future long duration Exploration missions require renewed efforts to adequately mitigate risks of crew health effects due to radiation exposure. Orion is NASA's next generation human Exploration spacecraft. Radiation protection constitutes a design driver for Orion. During the spacecraft development process, Lockheed Martin has proactively pursued radiation protection approaches in compliance with the ALARA principle. A collaborative effort with StemRad Ltd, Israel, resulted in the development of personal protective equipment for astronauts, the AstroRad. AstroRad provides customizable protection focused on stem cell rich organs and tissues. Orion's first test flight beyond Earth orbit (BEO) is Exploration Mission 1 (EM-1) and scheduled for 2019. EM-1 presents the opportunity to perform a detailed characterization of the radiation exposure of human body analogs located internal to the spacecraft in the free-space environment beyond the Earth's magnetosphere protection. MARE has been proposed by the German Aerospace Center (DLR) and the Israel Space Agency (ISA) as an Orion science payload, approved by NASA, and in May 2017 was manifested on the EM-1 flight. In the past year, significant progress towards AstroRad customization, active detector development, and integration for MARE has been accomplished. This paper will present MARE and its current status. MARE consists of two tissue-equivalent female radiotherapy phantoms, one fitted with the AstroRad, an extensive complement of radiation detectors, and ancillary hardware for vehicle installation. The science and payload integration is performed by DLR with support from ISA and NASA participating as co-PIs. Lockheed Martin and StemRad support development of the science objectives associated with AstroRad. Lockheed Martin enables efficient payload integration as an interface to the Orion program on behalf of the international team. The MARE detectors are provided by international research teams on three continents who participate as co-Is. This is performed both for purposes of inter-calibration, and to account for various detector sensitivities being optimal for specific ranges of particle species and energy distributions. Passive detectors including thermoluminescence- and optically stimulated luminescence dosimeters (TLDs and OSLDs) and plastic nuclear track detectors (PNTD) such as CR-39 are provided by NASA, DLR, and other researchers with heritage participation in the DOSIS-3D ISS experiments. Active detectors are provided by DLR (M-42 silicon detector), NASA (CPAD) and ESA (EAD MU-O). MARE serves as an example of international collaboration for space exploration. Measurements performed on EM-1 will constitute valuable risk assessment and mitigation input data for future Exploration missions and enable safe space exploration by humans.