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RECYCLING OF PLASTIC WASTE MATERIALS ON-BOARD ISS INTO RADIATION PERSONAL PROTECTIVE EQUIPMENT USING ADDITIVE MANUFACTURING TECHNIQUES

Abstract

Space radiation exposure beyond lower-Earth orbit (LEO) consists of chronic exposure to galactic cosmic rays (GCRs) and probabilistic solar particle events (SPEs), potentially leading to detrimental health effects. SPEs are of primary concern due to their short warning times and relatively high cumulative exposure. Therefore, future flights beyond LEO demand continuous innovation to ensure that radiation personal protective equipment (PPE) will be available for the crew when needed. The AstroRad is an ergonomically efficient protective vest, co-developed by StemRad and Lockheed Martin, a PPE for astronauts that utilizes selective shielding to maximize shielding efficiency for mitigating crew exposure to space-borne radiation. It uses hydrogen-rich polymer such as polyethylene as a material for radiation protection. However, the payload constraints for mission launch are very critical. The additional payload-related mass of PPE can potentially cost millions of dollars. Fortunately, a large portion of the waste produced during space missions consists of recyclable hydrogen-rich materials, such as packaging materials. StemRad and Made in Space (MIS), a Redwire subsidiary, are developing the proposed innovation to recycle hydrogen-rich polymer materials on-board the ISS into the AstroRad vest with the Plastic Recycler and Additive Manufacturing Facility (AMF) designed by MIS and installed on the ISS. The project's objective is to solve three vital issues: lowering launch cost, solving in-space waste management issues, and radiation protection. The AMF facility is capable of 3-D printing recycled materials in zero-gravity conditions. The new shielding design must fit into the volumetric constraints of the AstroRad vest and additive manufacturing hardware on the station while satisfying shielding mass efficiency, volumetric shielding efficiency, ease of assembly, and ergonomic requirements. The works that will be done in this project include: developing a 3-D CAD model for a part of the radiation vest (shoulder panel), ground-based manufacturing of the shoulder panel, demonstration of 3-D printing with the recycled material, and finally, prototype production and integration of the shoulder panel into the AstroRad vest currently on-board the ISS. The comparison of radiation protection between the terrestrial manufactured part and on-orbit manufactured part will be presented. The ergonomic impact of the vest on astronauts will also be discussed.