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RADIATION SHIELDING PERFORMANCE OF CFRP-BASED SATELLITE STRUCTURAL PANELS IN LEO

Abstract

The harsh radiation environment of space requires spacecraft to possess sufficient shielding for protection against energetic particles. Insufficient radiation shielding can lead to increased rates of single event effects (SEE's), deep dielectric charging and surface charging of vital spacecraft electronics units such as payloads or navigation and control systems. For satellites in Low Earth Orbit (LEO), trapped electrons and protons in the radiation belts are the primary source of radiation exposure. The exact amount of radiation a spacecraft is subjected is highly dependent on several parameters including solar activity, the solar cycle, orbital parameters, and a satellite's intended trajectory. In recent decades, small and medium sized satellites ($<$ 1000 kg) have shifted towards lightweight sandwich panel designs as opposed to using solid Aluminium. These sandwich structures typically employ an Aluminium honeycomb core sandwiched between face sheets of either Aluminium or Carbon Fibre Reinforced Polymer (CFRP). In this work, we explore the radiation shielding effectiveness of several satellite structural panel designs for radiation protection in LEO. This study compares directly the radiation shielding of lightweight sandwich panels against solid Aluminium for the radiation experienced in LEO. We explore novel designs including external metallized coatings on the CFRP face sheets for improved radiation protection, as well as the use of Aluminium foam rather than honeycomb for sandwich panel cores. The trapped proton and electron fluences in LEO are calculated via SPENVIS. The radiation shielding capabilities of several panel designs are simulated in Geant4 (version 11.2.0). These simulations will calculate not only the reduction in dose to internal satellite components, but also the production rate of secondary particles and the resulting quality factor of the satellite's internal radiation field. Preliminary results demonstrate that satellite structures employing sandwich panel designs result in up to a 55% weight reduction while matching the radiation shielding performance of solid aluminium to within 5%. The results of this work are part of an industry collaboration and will directly contribute to the design and launch of a small ($<$ 500 kg) satellite.