PATH TOWARD A UNIFIED GEOMETRY FOR RADIATION TRANSPORT

The Direct Accelerated Geometry for Radiation Analysis and Design (DAGRAD) element of the RadWorks Project under Advanced Exploration Systems (AES) within the Space Technology Mission Directorate (STMD) of NASA will enable new designs and concepts of operation for radiation risk assessment, mitigation and protection. This element is designed to produce a solution that will allow NASA to calculate the transport of space radiation through complex computer-aided design (CAD) models using the state-of-the-art analytic and Monte Carlo radiation transport codes. Due to the inherent hazard of astronaut and spacecraft exposure to ionizing radiation in low-Earth orbit (LEO) or in deep space, risk analyses must be performed for all crew vehicles and habitats. Incorporating these analyses into the design process can minimize the mass needed solely for radiation protection. Transport of the radiation fields as they pass through shielding and body materials can be simulated using Monte Carlo techniques or described by the Boltzmann equation, which is obtained by balancing changes in particle fluxes as they traverse a small volume of material with the gains and losses caused by atomic and nuclear collisions. Deterministic codes that solve the Boltzmann transport equation, such as HZETRN [high charge and energy transport code developed by NASA Langley Research Center (LaRC)], are generally computationally faster than Monte Carlo codes such as FLUKA, GEANT4, MCNP(X) or PHITS; however, they are currently limited to transport in one dimension, which poorly represents the secondary light ion and neutron radiation fields. NASA currently uses HZETRN space radiation transport software, both because it is computationally efficient and because proven methods have been developed for using this software to analyze complex geometries. Although Monte Carlo codes describe the relevant physics in a fully three-dimensional manner, their computational costs have thus far prevented their widespread use for analysis of complex CAD models, leading to the creation and maintenance of toolkit-specific simplistic geometry models. The work presented here builds on the Direct Accelerated Geometry Monte Carlo (DAGMC) toolkit developed for use with the Monte Carlo N-Particle (MCNP) transport code. The workflow for achieving radiation transport on CAD models using MCNP and FLUKA has been demonstrated and the results of analyses on realistic spacecraft/habitats will be presented. Future work is planned that will further automate this process and enable the use of multiple radiation transport codes on identical geometry models imported from CAD. This effort will enhance the modeling tools used by NASA to accurately evaluate the astronaut space radiation risk and accurately determine the protection provided by as-designed exploration mission vehicles and habitats.