Technical University Munich
School of Engineering and Design
Professorship of Human Spaceflight Technology

Task Description Master Thesis
Development of a Radiation Simulation Tool for Conceptual Design of Space Stations and Surface Habitats

Topic Description:

Human spaceflight missions beyond low Earth orbit—such as long-duration stays on the lunar surface—expose astronauts to significantly higher levels of ionizing radiation. During the conceptual design phase of space stations and habitats, engineers must evaluate different structural configurations and shielding concepts, yet detailed radiation modelling is often too complex and resource-intensive at this early stage. To address this gap a radiation simulation tool should be developed that enables rapid, physically grounded assessments of crew radiation exposure for conceptual habitat designs. The tool should be built using the TOPAS Tool for Particle Simulation. The aim is to create an accessible workflow that enables early-phase estimation of radiation exposure in conceptual designs of space stations and surface habitats, with a focus on Galactic Cosmic Ray environments. In doing so, this work can contribute to improving the design and safety of future human spaceflight missions.

Tasks:

1. LiteratureResearch
   - Review the characteristics of the space radiation environment, with emphasis on Galactic Cosmic Rays (GCR).
2. Radiation Modelling
   - Implement GCR definitions within the TOPAS tool.
   - Develop simplified conceptual habitat geometries and material models suitable for early-phase design evaluation.
3. Tool and Workflow Development
   - Create scripts or software modules to automate TOPAS input creation, simulation execution, and extraction of key dose metrics.
   - Develop a user-friendly workflow or interface (e.g. GUI) to run simulations.
4. Verification, Demonstration, and Documentation
   - Run test simulations using representative habitat designs.
   - Compare results with reference data or analytical approximations for plausibility.
   - Document model assumptions, limitations, and recommendations for future development

Requirements:

- Background in software engineering or programming
- Familiarity with Linux environments, preferably Ubuntu
- No prior knowledge of radiation physics required; willingness to learn the necessary fundamentals.
- Ability and willingness to access and use computational resources at partner institution (UniBW computing systems).
- Proactive working style, good communication skills, and ability to structure and document work clearly.

The thesis will be co-supervised by the Professorship of Human Spaceflight Technology at the Technical University of Munich and the Institute for Applied Physics and Measurement Technology at the University of the Bundeswehr Munich.

If you are interested in the thesis, please write an e-mail including a short motivation letter, CV and transcript of records to Lina Salman (Lina.Salman@tum.de).