Interreg Sudoe

EUROPEAN UNION

NANO STAR

European Regional Development Fund

Research and innovation

Radiation Sector Analysis of a 3U CubeSat

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Cooperation depends on you

www.interreg-sudoe.eu

http://nanostarproject.eu

NANOSTAR consortium

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APPLICABLE AND REFERENCE DOCUMENTS

APPLICABLE DOCUMENTS

https://nanostarproject.eu/student-challenges/registration-phase-2/

Specific challenges reports template

REFERENCE DOCUMENTS

FastRad GUI
User manual for OMERE v5.3
ECSS-E-ST-10-04C Space environment
ECSS-Q-ST-60-15C Radiation hardness assurance - EEE components
ECSS-E-ST-10-12C Methods for the calculation of radiation received and its effects, and a policy for design margins
ECSS-E-HB-10-12A Calculation of radiation and its effects and margin policy handbook
CDS Revision 13 CubeSat Design Specification

DOCUMENT CHANGE RECORD

TABLE 1: Change log record table

Edition/Revision	Date	Description of the change
V0.0.1	16/01/2020	Initial version of the document by M. BERNARD.
V0.0.2	24/01/2020	Completion of the document by M. BERNARD.

SCOPE AND CONTENT OF THE DOCUMENT

This document describes the specific challenge organized by University of Montpellier (NANOSTAR partner) in the frame of the NANOSTAR student challenges. This challenge is related to the sector-based analysis by using the FASTRAD software.

It contains all the information the students need to know to take part of the challenge.

RADIATION HARDNESS ASSURANCE

The Radiation Hardness Assurance (RHA) process overview is illustrated in **Error! Reference source not found.**. It follows an iterative and top-down approach where mission radiation environment is calculated from mission requirements and the radiation environments models and rules defined in ECSS-E-ST-10-04.

Top level requirements derived from mission radiation environment specification are employed as the starting point. Then, when necessary, **radiation environment is transferred to component level via sector analysis** or Monte Carlo analysis according to the methods described in ECSS-E-ST-10-12. Then, radiation analysis is performed at equipment level. Radiation sensitivity of each component is defined and its impact on equipment performance is analyzed.
An equipment electronic design is validated when the equipment can fulfil its requirement under exposure to the mission space environment with a sufficient Radiation Design Margin (RDM).

The assessment of the amount, type and energy of radiation arriving at any component location cannot be performed without an accurate knowledge of the external environment and also an understanding of the attenuating effect of any material between the location and the external environment. This attenuation is commonly known as **shielding**.

Shielding occurs in two ways:

- "**built-in**" **shielding**, that is the fortuitous shielding afforded by materials already included in the design, and
- "**add-on**" **shielding**, which is added specifically for the purposes of attenuating radiation.

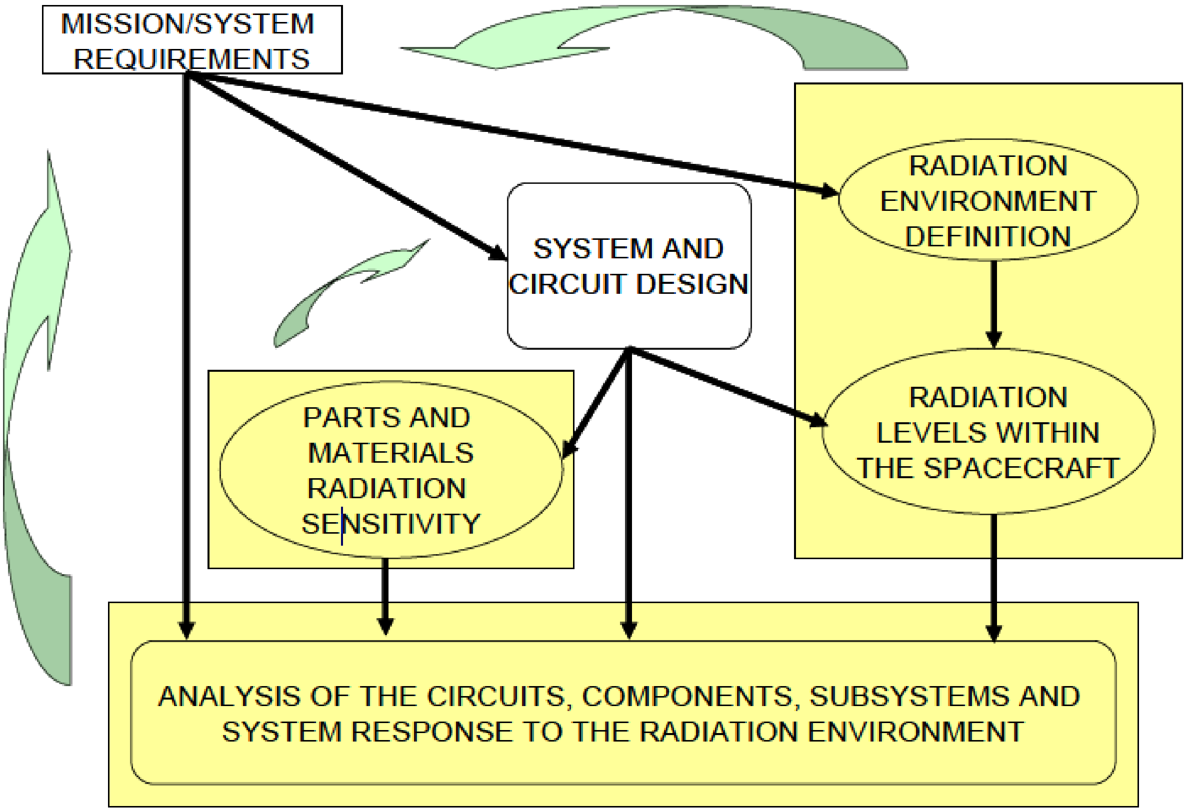

FIGURE 1: RHA PROCESS.

SPECIFIC CHALLENGE DESCRIPTION

This challenge consists in performing a sector-based radiation analysis on a nanosatellite.

CHALLENGE OBJECTIVES

The challenge objective is to perfom a radiation sector based anaylsis on a nanosatellite. To do so, you have to create a Radiation Model based on a 1U CubeSat or a 3U CubeSat standard [CDS] which includes at least: deployable solar panel(s), deployable antenna(s), magnetorquer(s), reaction wheel(s), a battery set, 3 solar sensor(s), an Aluminium structure and various pcb with EEE parts.

Note that no harness nor RBF are expected in the radiation model.

SECTOR BASED ANALYSIS

The goal of a sector analysis is:

- to create a radiation model of the satellite;
- to evaluate, for each subsystem, the equivalent “built-in” shielding provided by the satellite structure and close elements;
- to calculate the received dose on detectors located inside the satellite, at subsystem/part levels.

A 3D sector shielding is used to evaluate the deposited dose calculation.

Sector based analysis is performed using a numerical solid angle integration around a target point. For each solid angle sector, a ray is traced from the target to the outside of the geometry model.

INPUTS

This section identifies the standard approaches to be used when calculating the effects of shielding on the radiation environment experienced by a component or a system.

The shielding geometry used is the **SOLID SPHERICAL SHIELDING**. It is used for conditions where components are shielded to a finite level over all solid angles. It is the most common geometry used for the dose-depth curve of sector shielding analyses.
The solid spherical shielding dose-depth curve is obtained by using the OMERE software.

The “**SLANT**” approach is used for calculating the amount of material along a path, and the **solid sphere geometry** for production of the dose-depth.

METHODOLOGY

1. Create a 1U/3U CubeSat model in FASTRAD software from scratch or by importing some .step files provided by CubeSat equipment suppliers. Include some detectors at appropriate locations (EEE dies for example). Add the material of all the elements included in your Radiation model. You may have to create “density equivalent material” for element that have inhomogeneous density.

2. Run an OMERE calculation to get the expected radiation environment at a typical CubeSat orbit: SSO 600 km – duration 5 years from 2020.

3. Run FASTRAD calculation to get the expected dose at various location.

4. Generate the 6 face equivalent shielding of critical locations.

5. Analyse and discuss the results. It is strongly recommended to add pictures in this section.

6. Report this activity in a report that complies with ECSS standards.

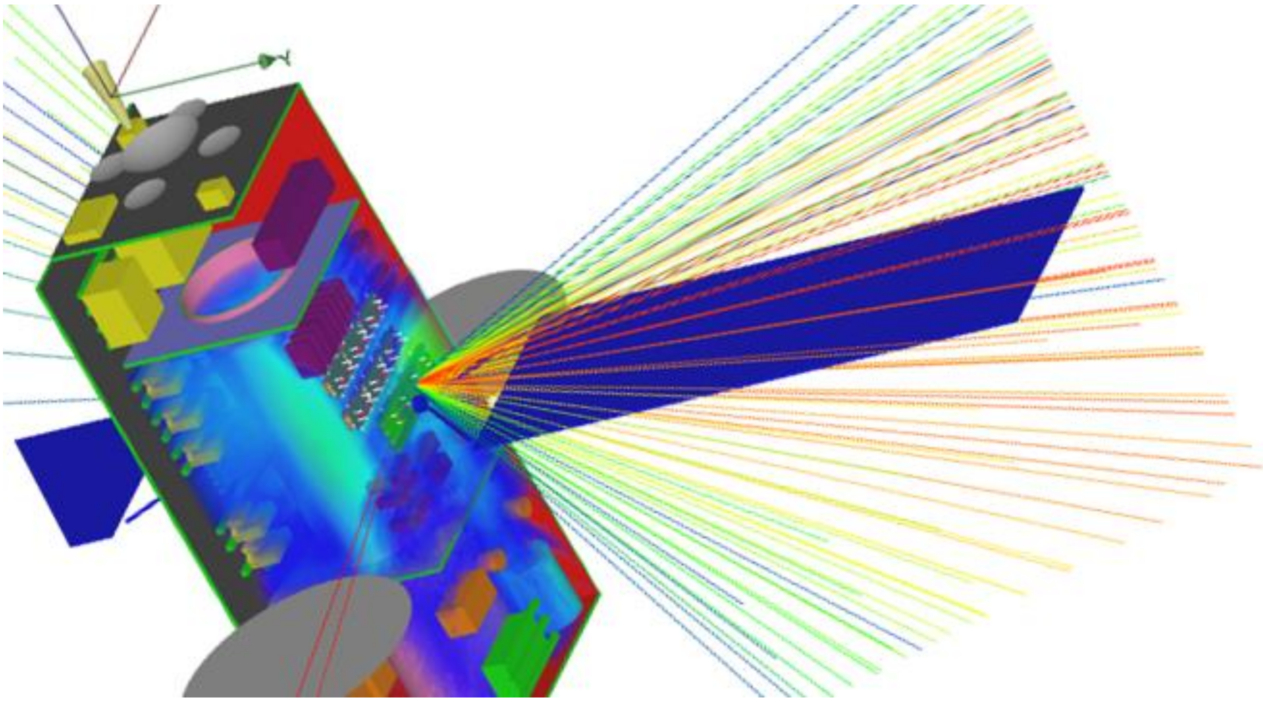

FIGURE 2. EXAMPLE OF A SECTOR ANALYSIS PERFORMED WITH FASTRAD. CRÉDITS TRAD.

Duration of the challenge: 2 to 4 months

Deliverables:

A “Sector Analysis Report” in pdf, in English, including, at least:

- List of acronyms, Applicable and Ref documents
- A methodology description,
- Assumptions considered
- List of elements in the radiation model and their material nature and density,
- a dose-depth curve of a typical nanosatellite LEO mission,
- views of the model.ray, analysis
- a table of the expected Dose at equipment/part level for various detector
- a 6-face shielding

20 pages max without Annex, 50 pages max including Annex.

Composition of the team: One or more students from the Universities of the NanoStar project. If possible as much women as men and from different countries.

Project funded by the Interreg Sudoe Programme through the European Regional Development Fund (ERDF)

Rewards: A diploma of participation, a visit and goodies from the University Space Center of Montpellier (CSUM), the University of Montpellier (UM) and NanoStar project and others rewards for the most innovative team.

If you are interested in this challenge, contact us at nanostar-projet@umontpellier.fr or on the NanoStar website.

UNIVERSITY SPACE CENTER OF MONTPELLIER

CSUM is a space center of the University of Montpellier that develop nanosatellites.

In France, the CSUM is one of the leaders in the development of student nanosatellites. It is also a European center of reference devoted to bring together equipment and skills for the development, production, testing and operation of nanosatellites. These projects involve student interns and encourage regional economic development.

To do this, the CSUM has facilities and equipment dedicated to nanosatellite engineering:

- A control center including a transceiver radio station and antennas in UHF and S-Band;
- A dedicated CDF room (concurrent design facility);
- AIT facilities (Assembly, Integration and Testing) including a 200 m² clean room and multiple workshops;

The CSUM develops its own nanosatellite technology producing 1U and 3U CubeSats with the support of the Van Allen Foundation and the French and European space agencies (CNES and ESA).

This challenge is support by TRAD that provides free FASTRAD licence for student registered in this student challenge.

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