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A COMPARISON STUDY OF SPACE RADIATION DOSE ANALYSIS PROGRAMS: SPENVIS SECTORING TOOL AND SIGMA II

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ABSTRACT

A space radiation analysis has been used to evaluate an ability of electronic equipment boxes or spacecrafts to endure various radiation effects, so it helps design thicknesses of structure and allocate components to meet the radiation requirements. A comparison study of space radiation dose analysis programs SPENVIS Sectoring Tool (SST) and SIGMA II is conducted through some structure cases, simple sphere shell, box and representative satellite configurations. The results and a discussion of comparison will be given. A general comparison will be shown for understanding those programs. The both programs use the same strategy, solid angle sectoring with ray-tracing method to produce an approximate dose at points in representative simple and complex models of spacecraft structures. Also the particle environment data corresponding to mission specification and radiation transport data are used as input data. But there are distinctions between them. The specification of geometry model and its input scheme, the assignment of dose point and the numbers, the prerequisite programs and ways of representing results will be discussed. SST is a web-based interactive program for sectoring analysis of complex geometries. It may be useful for a preliminary dose assessment with user-friendly interfaces and a package approach. SIGMA II is able to obtain from RSICC (Radiation Safety Information Computational Center) as a FORTRAN 77 source code. It may be suitable for either parametric preliminary design or detailed final design, e.g. a manned flight or radiation-sensitive component configuration design. It needs some debugs, recompiling and a tedious work to make geometrical quadric surfaces for actual spacecraft configuration, and has poor documentation. It is recommend to vist RSICC homepage and GEANT4/SSAT homepage.

Keywords: space radiation transport, sectoring method, shield analysis

1. INTRODUCTION

A space radiation dose analysis has been used to assess the shielding effectiveness of electronic equipment boxes or spacecrafts to endure radiation effects of trapped electron and trapped proton and solar flare proton, so it helps design thicknesses of housing or structure and allocate components to meet the radiation requirements. Various computer models of radiation analysis has been developed and used in the diverse space programs. In this paper it sheds a light on the models using a solid angle sectoring method with raytracing. A comparison study of space radiation dose analysis programs

Table 1. General Characteristics Comparison.

Item	SPENVIS Sectoring Tool	SIGMA II
Update	2004	1974 (Revised)
Institute	BIRA/ESA	ex McDonnell Douglas (Boeing)
Computing base	Web-based	PC (FORTRAN77)
Geometrical objects	Using three elementary objects (sphere, cylinder, rectangular box, detector) up to 7	Quadric surfaces up to 100
Extent of problem solved	Simple representation of spacecraft using geometrical objects	Complex configuration using quadric surfaces
Method of solution	Solid angle sectoring with ray-tracing	Same as left
Numerical method of integration for solid angle	Not available	Simpson's rule
Results	Interactive Window, VRML & Plain Text	Plain Text
Prerequisite[1] or Post[2] programs	Orbit generator[1] SHIELDOSE[2] or SHIELDOSE-2[2]	OGRE[1] CHARGE[1]
Dose point or Detector	1	Up to 25
User-friendly extent	Easy	Hard (FORTRAN77 Source Code)
Man model	Not Applicable	Available but simple
Cost	Free but registration required	$ 400.0 (RSICC)

SPENVIS (SPace ENVironment Information System) Sectoring Tool (SPENVIS Help Documents 2004) and SIGMA II (Yucker 1971) is conducted through some structure cases, simple sphere shell, box and representative satellite configurations. The results and a discussion of comparison will be given. A general comparison will be shown for understanding those programs. The both programs use the same strategy, solid angle sectoring method with ray-tracing to produce an approximate dose at points in representative simple and complex models of spacecraft structures.

2. GENERAL CHARACTERISTICS COMPARISON

A comparison of the general characteristics of two space radiation analysis programs is shown in the Table 1. As to the Table 1 there are good and bad points depending on to the extent of radiation analysis. Shielding estimates based on simple geometrical models can be made easier for SST than SIGMA II. For SIGMA II it is obviously a tedious work to construct quadric surface equations for geometrical complex configuration. But by the personal communication with B. Quaghebeur, a programer of SST, it is said that "I put the limitation of 7 in the first place because in the first version of the tool, all parameters had to be input on one page. As there is now a page for each shape, the limit is less stringent. However, as this is a web based tool, and we want to limit the calculation (and response) time to a minimum, we let a limitation to a small number of shapes".

SIGMA II is usually used in conjunction with other codes such as, the OGRE program which computes external, mission-integrated radiation environment defined in intensity, energy, and time, and the CHARGE program which uses the OGRE environmental data to compute basic dose transmission data through materials for idealized spherical or slab geometries. It is worth to note that SIGMA II can use the radiation sources of SPENVIS as input data which is output of CHARGE program.

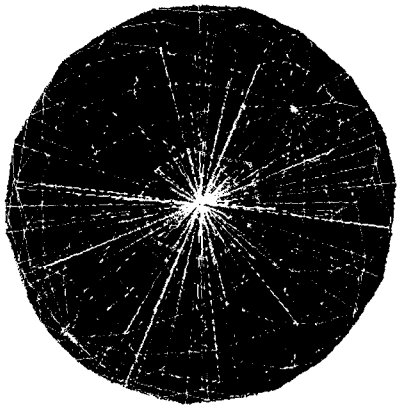

Figure 1. CTU EQM Box.

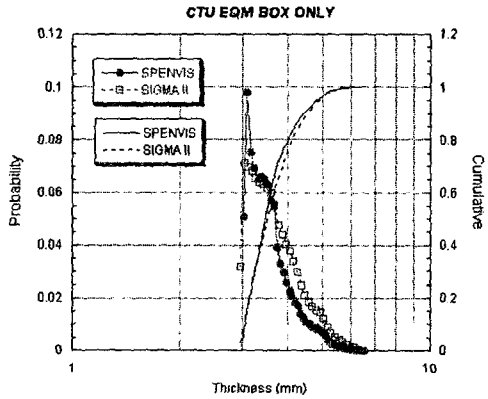

Figure 2. Comparison of Shielding Analysis of CTU EQM Box.

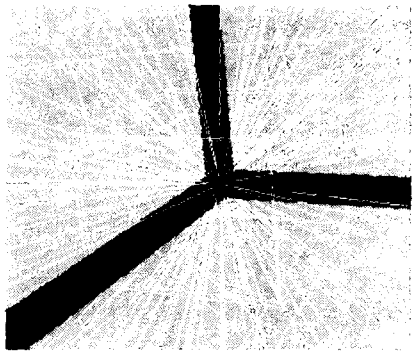

Figure 3. CTU EQM Box within Spherical Shell.

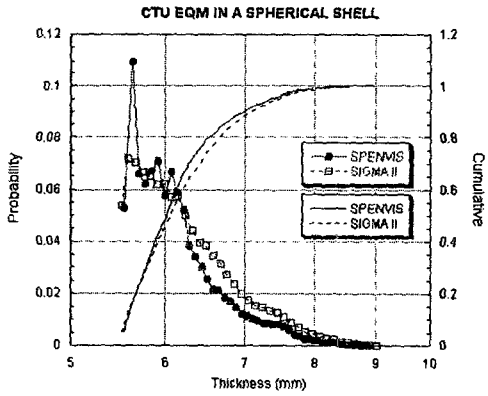

Figure 4. Comparison of Shielding Analysis of CTU EQM Box within Spherical Shell.

3. COMPARISON OF SHIELDING ANALYSIS

The particle environment data corresponding to mission specification and radiation transport data are used as same input data (Location: GEO 116 E, Mission Life: 12 years, Launch: 2008. 1. 1.). But there is a distinction between both the programs. In a simple spherical shell case they results in same shielding thickness distribution. A little difference results are shown in Figures 1 to 4 because of the difference of calculating shielding thickness. The resolution of SST might be better that of SIGMA II in this case. As a specific case CTU EQM box's space radiation shielding analysis is conducted. This box is located on the south panel of the 2005SAT (Figure 5), a communication and broadcasting satellite but in this case as a simplified model (Figure 6) the significant shielding structures (panel box, core structure, and propellant tanks) are just adopted. The calculated radiation dose level of CTU EQM within a simplified 2005SAT is about 27 krad.

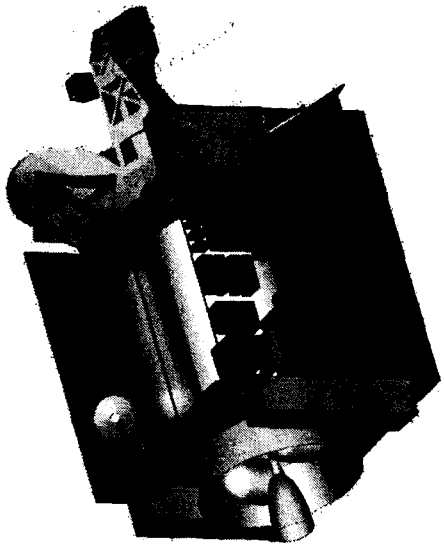

Figure 5. 2005SAT CAD Model.

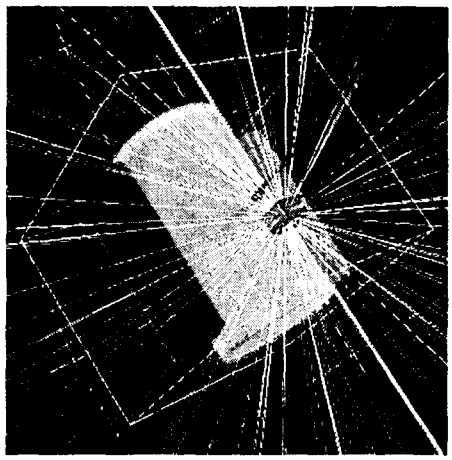

Figure 6. A Simplified 2005SAT Model.

4. CONCLUSION

Based on the above results, it is better to use SPENVIS Sectoring Tool in preliminary phase then SIGMA II to the next phase. But if SIGMA II is used for farther phase, the user will suffer for reference documents and limitations imposed on possible region configurations and some common input errors associated with this description. It is recommended to visit http://www-rsicc.ornl.gov and http://www.space.qinetiq.com/geant4/ssat.html for other space radiation analysis programs.

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