Spacecraft Radiation Protection – A Two Day Professional Development Course

Course Outline:

Space Radiation Environment.

Trapped protons and electrons. Solar energetic particles. Cosmic rays. Neutrons and gamma rays from Radioactive Thermoelectric Generators (RTGs). Secondary neutrons from large space structures. Mars surface and high altitude Earth environment.

Total Dose and Effects.

Energy per unit mass. Units--rads, REMs, Grey, Sieverts. Ionization effects. Charge deposition, migration and collection. Effects on digital and analog MOS and bipolar devices including ELDRS. Annealing, recovery, rebound.

Displacement Damage.

Crystalline lattice deformations. Damage thresholds in silicon and gallium arsenide. Damage equivalence and NIEL. Effects of protons and neutrons on solar cells and detectors such as CCDs. Dark current, charge transfer efficiency, maximum power degradation.

Single Event Effects.

Ionization by primary particles and secondaries from nuclear collisions. Charge collection in small structures. Effects in digital and analog devices. Transient and permanent upsets, soft errors, latch-up, burn-out, SEFI. Volatile and non-volatile memories, micro and signal processors, DC/DC converters, optoelectronics.

Testing and Mitigation Techniques.

Total dose testing. SEE testing. Facilities. Shielding. Derating. Conservative circuit design. Systems mitigation. EDAC, latch-up protection circuitry, watch dog timers, autonomy.

Biological Effects.

Long duration exposure in low Earth orbit and interplanetary transport vehicles. Threat of high-energy neutrons to astronauts. Effects in tissue and organs. Dose Equivalent and weighting factors. Risk of carcinogenesis, DNA damage. CNS effects.

Dr. Alan C. Tribble, the winner of the the 2008 AIAA James A. Van Allen Space Environments Award. has provided space environments effects analysis to more than one dozen NASA, DoD, and commercial programs, including the International Space Station, the Global Positioning System (GPS) satellites, and several surveillance spacecraft. He holds a Ph.D. in Physics from the University of Iowa and has twice been a Principal Investigator for the NASA Space Environments and Effects Program. He is also the author of the textbook *The Space Environment – Implications for Spacecraft Design.*

What You Will Learn:

- What the models are for space environments, where to find them, how to use them.
- What the common radiation units mean.
- How to equate damage from different species of radiation.
- How to conduct total dose test.
- How to conduct SEE tests.
- How to use dose-depth curves in determining shield thickness.
- How to shield neutrons.

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