The Ionizing Radiation Envionment for Exploration J. H. Adams, Jr.[1], [1]NASA Marshall Space Flight Center, Mail Stop VP62, National Space Science and Technology Center, 320 Sparkman Drive, Huntsville, AL 35805, james.h.adams@nasa.gov

Introduction: The ionizing radiation environment poses a hazard for space crews and a challenge to the reliability of electronics.

The radiaton hazard for crewed missions lasting < 3 months is due to the total absorbed dose from solar energetic protons. These effects are acute and deterministic, that is they occur soon after exposure and their occurrence in individual crew members depends primarily on the absorbed dose they receive. For missions > 3 months in duration there is an additional hazard from Galactic cosmic rays. This hazard is produces long term stochastic effects such as cancer induction. Crew members have an increased lifetime risk of these effects, but whether an individual will develop one of these effects is a matter of chance.

For both solar protons and galactic cosmic rays to pose a health hazard for the crew they must be sufficiently energetic to penetrate the material shielding surrounding the crew.

The ionizing radiation environment has effects on electronics that depend on the total exposure and others that depend on the ionization of individual particles. Total exposure effects include displacement damage (principally in solar cells) and total dose effects in electronic components. The effects of individual particles are called single event effects and they include effects ranging from spontaneous changes in the information stored in memories to the disctruction of individual electronic components.

Characterizing the Radiation Envionment: The galactic cosmic ray environment is the easiest to characterize. The particle flux is isotropic and its intensity is essentially the same everywhere in the inner heliosphere. The absolute cosmic ray spectra vary with the 11-year solar cycle and they depends on the surrounding shielding (e.g. the flux on the Moon is about ½ that in free space. The radiation exposure from cosmic rays also includes secondary production, both fragmentation of the incident cosmic rays in shielding materials and the production of energetic fragments from the nuclei in the shielding material (principally neutrons).

There are several models [1,2,3, and 4] that predict the absolute galactic cosmic ray spectra in the inner heliosphere. These reproduce the historic data base accumulated during the space age to an accuracy of 20% or better. These models are quite useful for designing spacecraft and planning missions.

Solar energetic particle events occur at random and cannot be predicted in advance. For spacecraft design and mission planning purposes, the historic data base of solar particle events has been used to estimate the probability of the occurrence of solar paricle events as a function of their size [5] and individual events can be used as “worst-case” models. There are models of absolute solar enegetic paricle spectra available for the largest particle events recorded during the space age [6] and there are composite models that combine the worst features of several events [7].

The exposure to solar energetic particles depends on the surrounding shielding and on the anisotropy of the particle flux.

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