The Suborbital Space Radiation Environment: Challenges and Opportunities

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Impetus

Space radiation is a generally poorly characterized human factors consideration for astronauts and spaceflight participants. Even amongst space professionals not directly associated with the field of health physics, (particularly as it relates to the human-habitable areas of a spacecraft), radiation exposure and detection is the subject of common misconceptions. Meanwhile, the suborbital space environment presents a unique set of radiological conditions separate from any other region of Earth or cislunar space.

Space Radiation Sources and Suborbital Attenuation

The native space radiation environment is supplied by several sources, those being solar particles (dominated by protons and electrons) and galactic cosmic radiation, dominated by heavier atomic nuclei, (HZE ions). As suborbital spaceflight takes place entirely within the mesospheric, mesopausal, and lower thermospheric regions of the Earth's atmosphere, the suborbital environment differs from that of either aircraft or orbital spacecraft, where interactions between native space radiation and the mesosphere act both to attenuate a spacecraft's exposure while simultaneously producing secondary radiation (e.g., cosmic spallation of nucleons and gamma rays). Further, attenuation of radiation by spacecraft materials produces a shower of secondary radiation in the spacecraft interior that varies with spacecraft orientation. Finally, the recent discovery of ephemeral Van Allen belts invites further possible variability in the suborbital radiation field.

Space Radiation Effects: Knowns and Unknowns

The biological effects of space radiation are identified in only the most general sense. While the lowest confirmed cancer incidence risk-effect values are well-known (i.e., 0.5-1% for exposures exceeding 10 rem), recent research concerning the effects of space radiation on other aspects of human physiology have only begun to be identified, (e.g., the possible relation to cataracts, neural synapse degeneration, others).

Limitations of Radiation Detection Instrumentation

Despite common conceptions, no radiation detection method comprehensively surveys all radiation particle types, (gamma-photons, alpha and beta particles, neutrons, and heavy nuclei,) nor do even instruments sensitive to a particular type of particle measure those particles at all emission energies, vastly complicating the issue of astronaut dosimetry. Further, because radiation in the space context can achieve higher energies than those experienced in a terrestrial environment, the most comprehensive instruments (TEPCs) are also the most cumbersome and power-intensive, while the most representative of a given astronaut's radiation exposure (dosimeters) suffer from reduced sensitivity and necessitate extrapolation.

Regulations, Research Opportunities, and Conclusions

Like with civilians on commercial aircraft, it is likely that suborbital spaceflight participant exposure to cosmic radiation will go unregulated. However, continued evaluation of the mesopausal radiation environment, the functionality and calibration of terrestrial dosimeters, and the appropriateness of developing regulatory dose limits and tracking for suborbital spaceflight crews and/or professionals is not only warranted but also presents an opportunity for targeted terrestrial analogue, high-altitude balloon, and suborbital research. Astrowright Spaceflight Consulting promotes and is currently engaged in such research.