Probabilistic Risk Model for Organ Doses and Acute Health Effects of Astronauts on Lunar Missions

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Introduction

• Exposure to large solar particle events (SPEs) is a major concern during EVAs on the lunar surface and in Earth-to-Lunar transit.
• 15% of crew times may be on EVA with minimal radiation shielding.
Therefore, an accurate assessment of SPE occurrence probability is required for the mission planning by NASA.

• We apply probabilistic risk assessment (PRA) for radiation protection of crews and optimization of lunar mission planning.

PRA Methods for Lunar Missions

Randomness of SPE occurrence: Using SPEs’ onset dates for the past 5 solar cycles1:
• Propensity of SPE occurrence defined as a function of mission period and time within a solar cycle.
• Randomness of each event size of SPE, Φ: Using historical database of measurements of protons with energies >30, >60, and >100 MeV2.
• Simulation of total Φ2 distribution in a mission period.

Transport properties of the shielding materials and the astronaut’s body tissues:
• NASA BRYNTN code system3.
• Shielding distribution by vehicle geometry on lunar missions:
  • Initial representative shield configurations: Spacesuit (0.3 g/cm2), Aluminum: Equipment room of a spacecraft (5.5 g/cm2), Aluminum.
  • Conceptual lunar habitat: Storm shelter and living quarters4.
• Small pressurized rover: Parametric study with astronauts’ orientation5.

Body shielding sensitivity at the sensitive organs of astronauts:
• Computed Anatomical Man (CAM) model6.

Twelve SPE Database for the Past 5 Solar Cycles and Model-Based Prediction of SPEs

Simulated Distribution of SPE Fluence at 30, 60, and 100 MeV for Mission Period

Effective dose of August 1972 SPE inside SPR

- Crew selection provided:
- Mitigation strategy easily utilized.
• Radiation analysis of small pressurized rover (SPR) for optimization of shield mass and dose reduction.

References