Efficient and Effective Requirements Development for Civil Exploration Missions

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Outline

• Why bother updating our requirements development and validation approach?
  • Decision and information velocity
  • Radiation effects has advanced considerably over the past 10-20 years
• Move towards updated guidelines for radiation hardness assurance in an era of rapid exploration expansion and electrical, electronic, electromechanical, and electro-optical (EEEEE) parts and components diversity
• We also have new ways to view and decompose system safety objectives – such as goal structuring notation and model-based engineering (e.g., NASA-STD-8729.1 [NASA Reliability & Maintainability Standard for Spaceflight and Support Systems])
Size, Weight, and Power (SWaP) Demands
Artemis Program

Technology expectations and exploration requirements

Human Landing Systems & Artemis-Generation Spacesuits

Gateway, Orion, and the Space Launch System
Radiation Hardness Assurance (RHA) Guideline Development
Complete & Synchronous System View

- Comprehension requires a complete synchronous vision of how technologies are to be used effectively.
- Considerations summarized in these elements allow designers to effectively choose EEEE parts for their best performance in a given architecture.
- Emphasizing one of these elements without understanding the others can compromise the integrity and performance of the parts and mission success.

Images Credit: NASA

Adapted from NASA Technical Report TM-2018-220074
Guideline Development for Avionics RHA

• Support the Artemis Program’s objectives for human-rated vehicle functionality beyond low earth orbit – and provide benefits to NASA’s other mission directorate lines of business

• Document current state-of-the-practice and evolution over past two decades

• Focus on defining radiation effects’ impacts in terms of system availability & reliability to provide consistency

• Incorporate recent developments in environment specification and probability of success calculations – such as…

• Reinforce existing and new methodologies for TID, TNID, and single-event effects testing and analysis, including stipulations for commercial-off-the-shelf and new technologies

Proposed RHA Guideline Contents


- Total Ionizing Dose (TID)
- Total Non-Ionizing Dose (TNID)
- Single-Event Effects (SEE)
- SEE Criticality Analysis (SEECA)
- Shielding & Transport Analysis
- Radiation Testing & Analysis
- Operational Monitoring & Anomalies

Environment Specification (external reference)

Appendix sections dive into more detail on related subjects

SEE Criticality Analysis (SEECA)

- Blast from past, but perhaps remains more relevant than ever
- SEECA fuses radiation effects from the part- to the system-level
- “Criticality classes” are unique in that they capture the consequence of unintended operation at the system-level
  - Bottom-up and top-down linkage is essential for good engineering communication
  - Can help more easily address both availability & reliability constraints

https://radhome.gsfc.nasa.gov/radhome/papers/seecai.htm
Summary

• We must evolve with our mission requirements and engineering intents – in the face of ever-increasing challenges

• Radiation hardness assurance can leverage prior art and recent innovations to yield new frameworks that support new mission objectives
EXPLORÉ
HUMANS in SPACE

Leading Discovery, Improving Life on Earth
### Acronyms

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<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>EEEE</td>
<td>Electrical, electronic, electromechanical, and electro-optical</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<td>MBMA</td>
<td>Model-Based Mission Assurance</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>NEPP</td>
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