National Aeronautics and
Space Administration

NASA EXPLORES

Efficient and Effective Requirements Development for Civil Exploration Missions

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Acknowledgements

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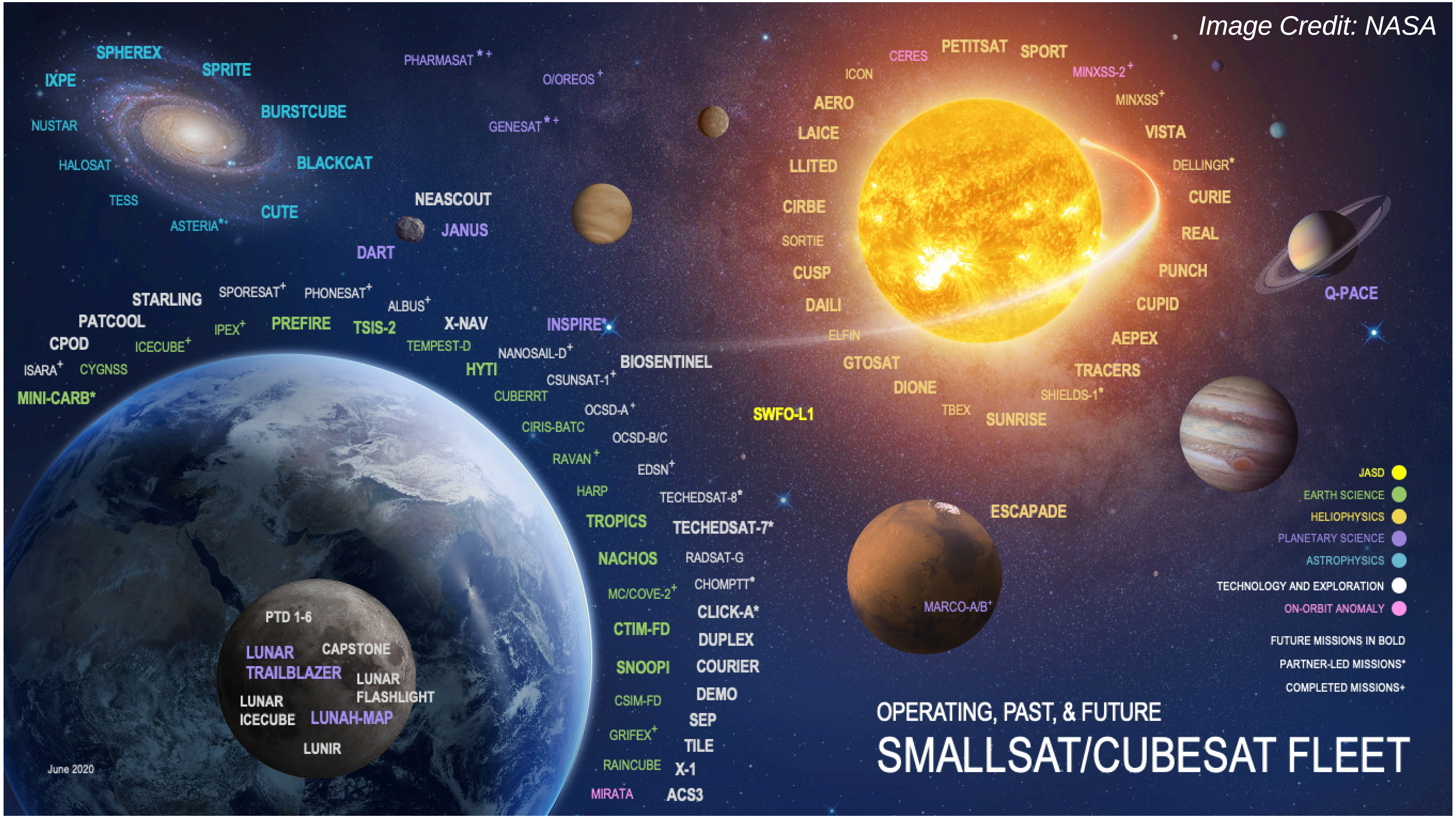
  - https://nepp.nasa.gov/
- NASA Engineering and Safety Center (NESC)
  - https://www.nasa.gov/nesc
- NASA colleagues and community peers

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 (EEEE) 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])

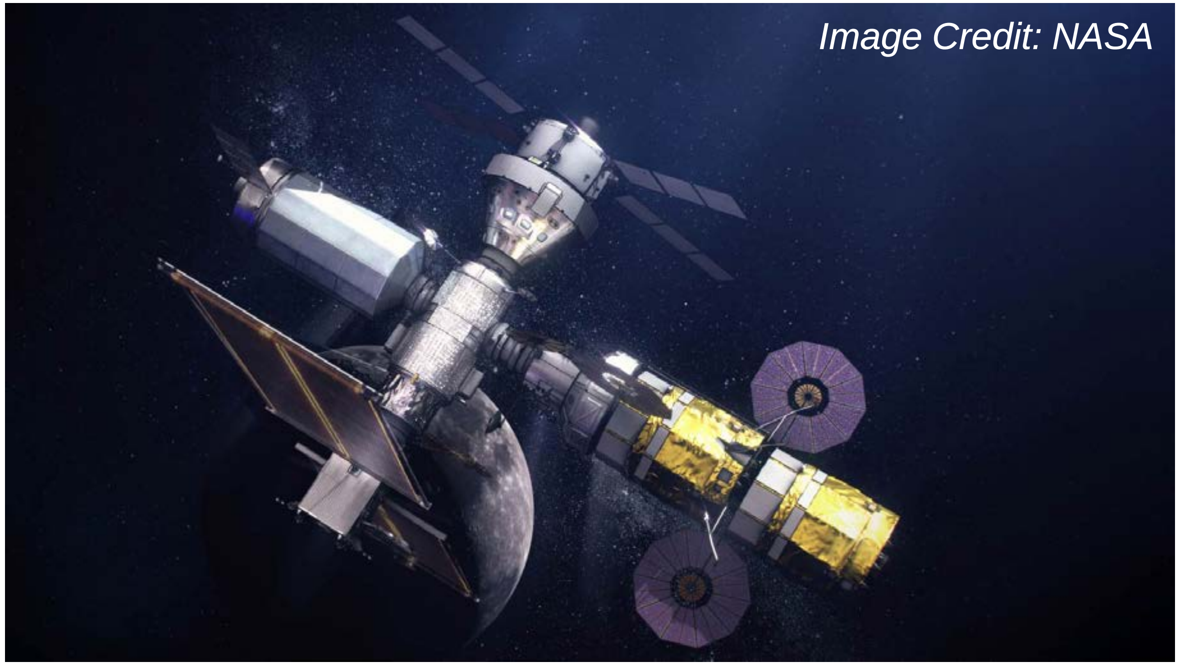
Size, Weight, and Power (SWaP) Demands



Artemis Program

Technology expectations and *exploration requirements*

Human Landing Systems & Artemis-Generation Spacesuits



Gateway, Orion, and the Space Launch System

ARTEMIS

Radiation Hardness Assurance (RHA) Guideline Development

To be presented by J. Pellish at the 2020 NASA Electronic Parts and Packaging (NEPP) Program Electronics Technology Workshop (ETW), June 15-18, 2020.

Complete & Synchronous System View

Images Credit: NASA

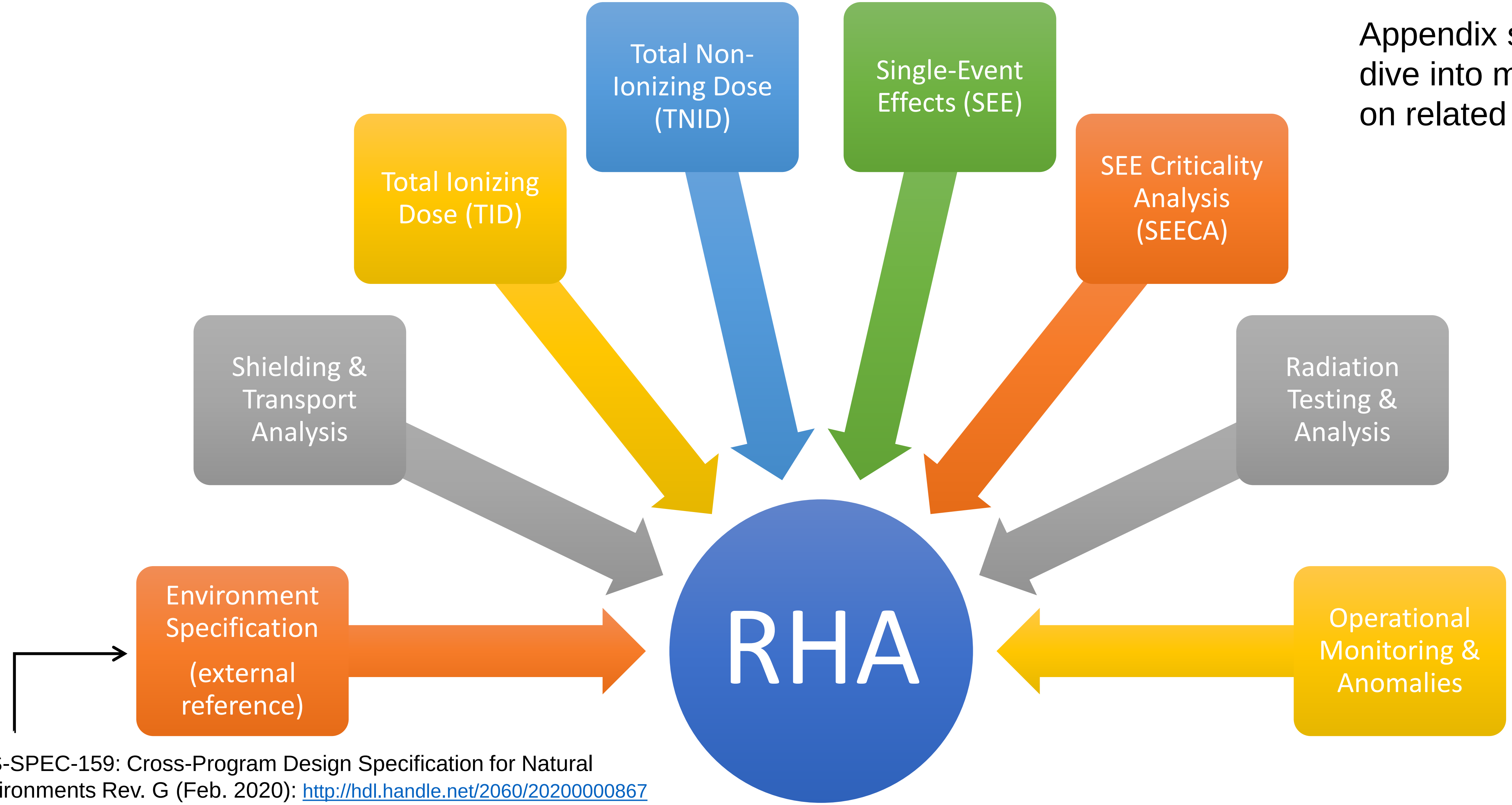
- Comprehension requires a complete synchronous vision of how technologies are to be used effectively
- Considerations summarized in these elements allow designers to effectively choose EEEE parts for their best performance in a given architecture
- Emphasizing one of these elements without understanding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

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…
  - M. A. Xapsos et al., "Inclusion of Radiation Environment Variability in Total Dose Hardness Assurance Methodology," in *IEEE Trans. Nucl. Sci.*, vol. 64, no. 1, pp. 325-331, Jan. 2017.
- 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

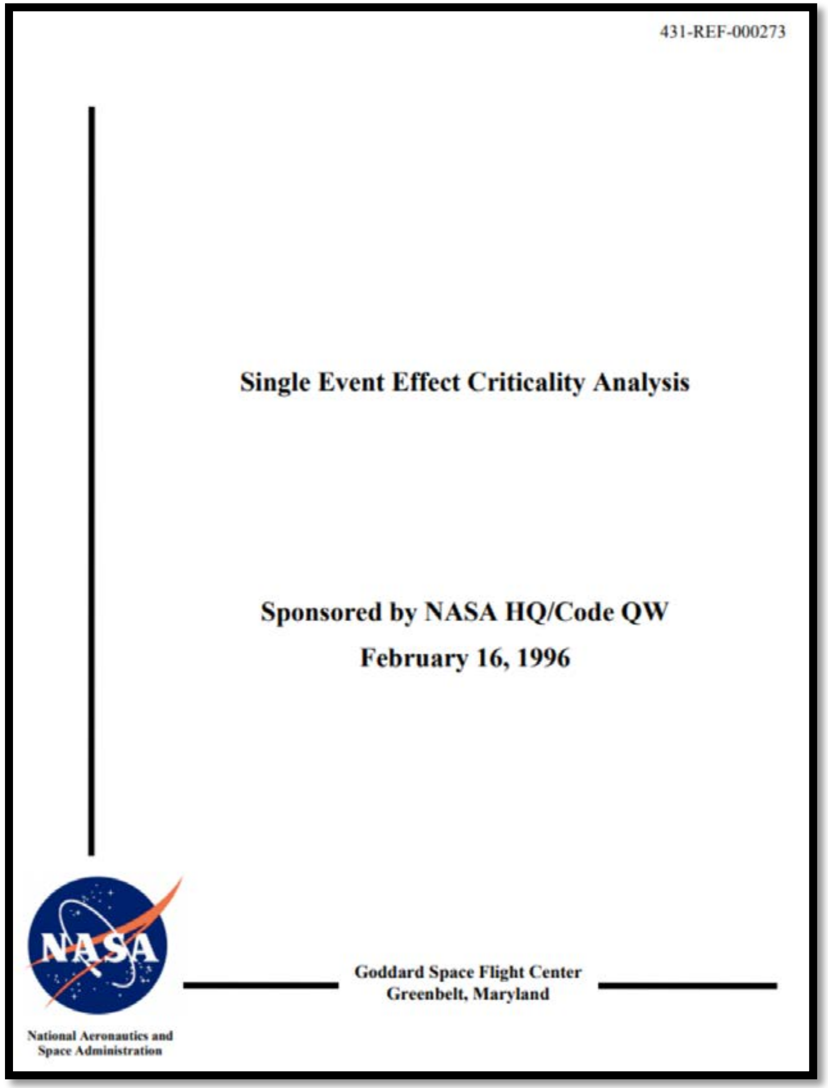
Proposed RHA Guideline Contents



Appendix sections dive into more detail on related subjects

SLS-SPEC-159: Cross-Program Design Specification for Natural Environments Rev. G (Feb. 2020): http://hdl.handle.net/2060/20200000867

SEE Criticality Analysis (SEECA)


431-REF-000273

Single Event Effect Criticality Analysis

Sponsored by NASA HQ/Code QW

February 16, 1996

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

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

- 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

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

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Acronyms

Abbreviation	Definition
EEEE	Electrical, electronic, electromechanical, and electro-optical
IEEE	Institute of Electrical and Electronics Engineers
MBMA	Model-Based Mission Assurance
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts and Packaging (Program)
NESC	NASA Engineering and Safety Center
RHA	Radiation Hardness Assurance
SEE	Single-Event Effects
SEECA	SEE Criticality Analysis
TID	Total Ionizing Dose
TNID	Total Non-Ionizing Dose
Trans. Nucl. Sci.	Transactions on Nuclear Science