National Aeronautics and Space Administration

NASA EXPLORES

NASA Avionics Radiation Hardness Assurance (RHA) Guidelines

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To be presented by J. Pellish at the 2021 Radiation Hardened Electronics Technology (RHET) Conference, Nov. 1-4, 2021, Salt Lake City, Utah.

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  - https://www.nasa.gov/nesc
  - https://nescacademy.nasa.gov/
  - https://nepp.nasa.gov/
- Guidelines released publicly in July 2021: https://ntrs.nasa.gov/citations/20210018053

Acknowledgements – Team List

Name	Discipline	Organization
Core Team		
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Additional thanks to our peer reviewers too

- NESC staff members
- NASA community members
- External radiation subject matter experts

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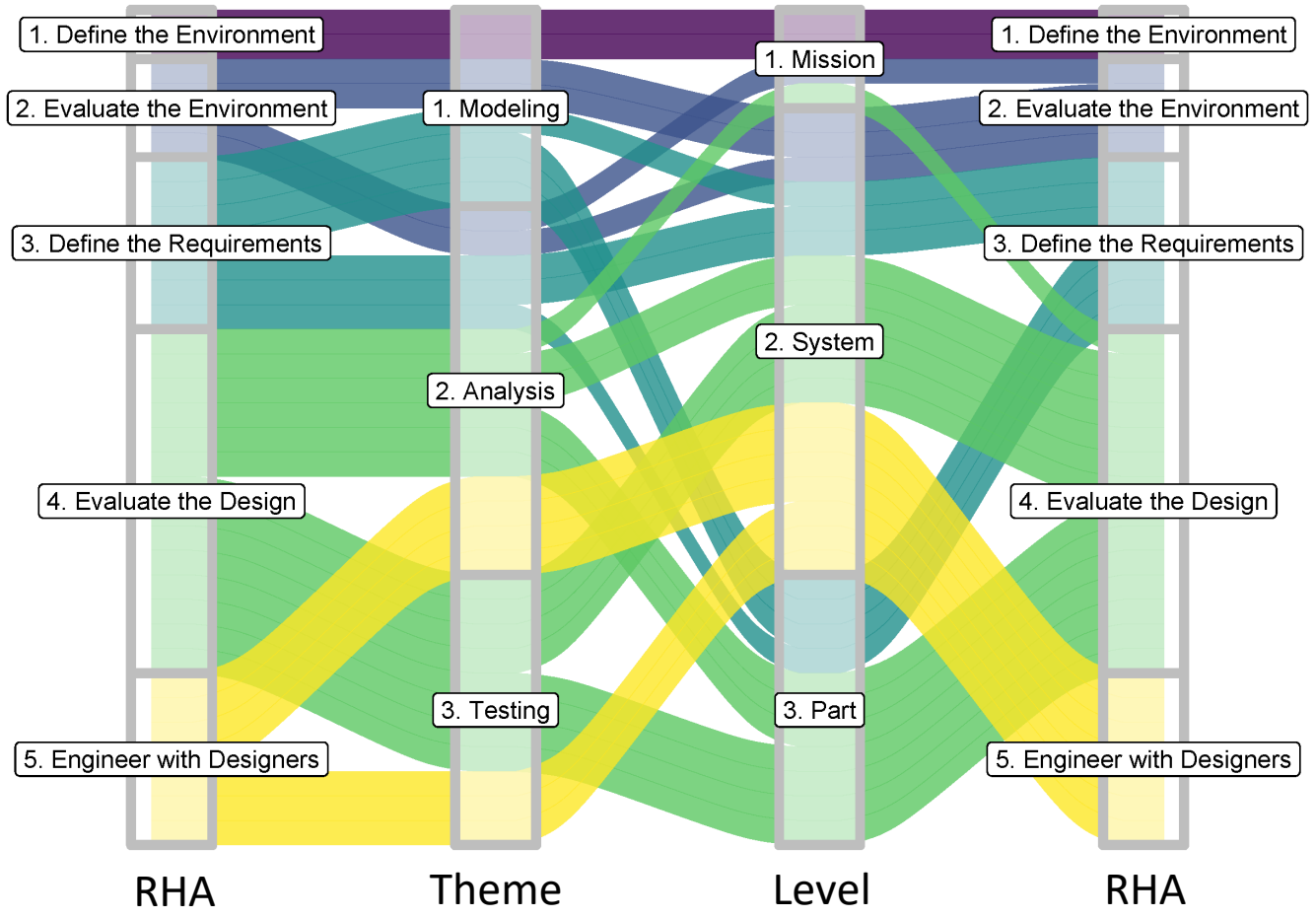
Scope of Effort to Develop Guidelines



- Background and problem description (motivated by Artemis Program)
  - As human exploration moves outside the protection of Earth's magnetosphere and embraces a broader range of missions in more severe radiation environments, it is crucial to ensure that all parties are cognizant of the risks posed by the requirements derived from mission, environment, application, and lifetime (MEAL) factors.
  - Critical knowledge for robotic science and space technology missions too
- Objective: develop and adopt timely and up-to-date guidance / best practices to ensure that natural space radiation environment threats do not compromise mission success
  - Covers total ionizing dose (TID), total non-ionizing dose (TNID) / displacement damage dose (DDD), as well as destructive and nondestructive single-event effects (SEE)
  - Updates guidance for performing a Single-Event Effects Criticality Analysis (SEECA)
  - Builds Agency consensus and supports knowledge transfer of critical Agency capabilities in the area of radiation effect approaches to manage mission radiation risks

Does not address surface or internal charging

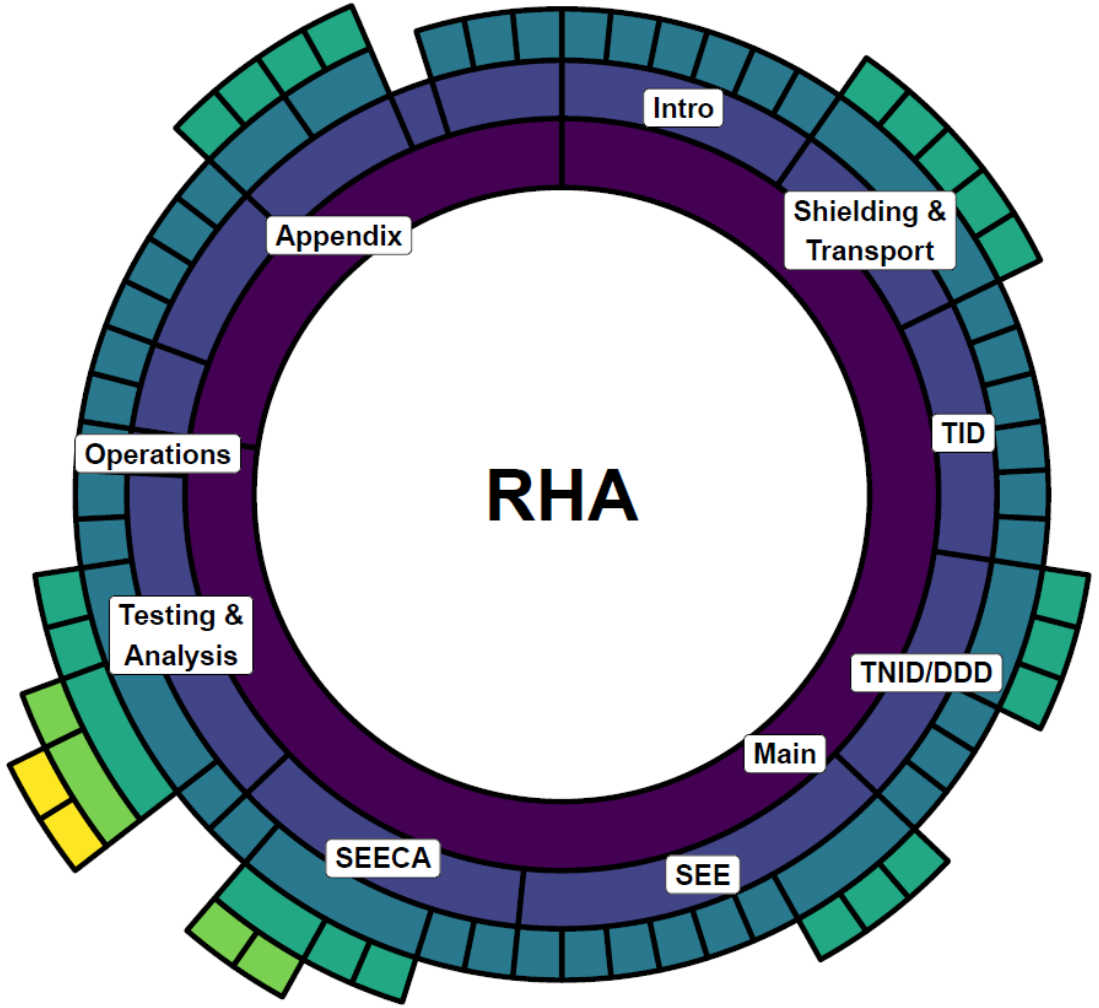
NASA RHA Processes



It helps to group RHA process activities by the type or "theme" of work (e.g., modeling, analysis, or testing), or to examine the "level" or scope to which these activities can address information (e.g., mission, system, or part level)

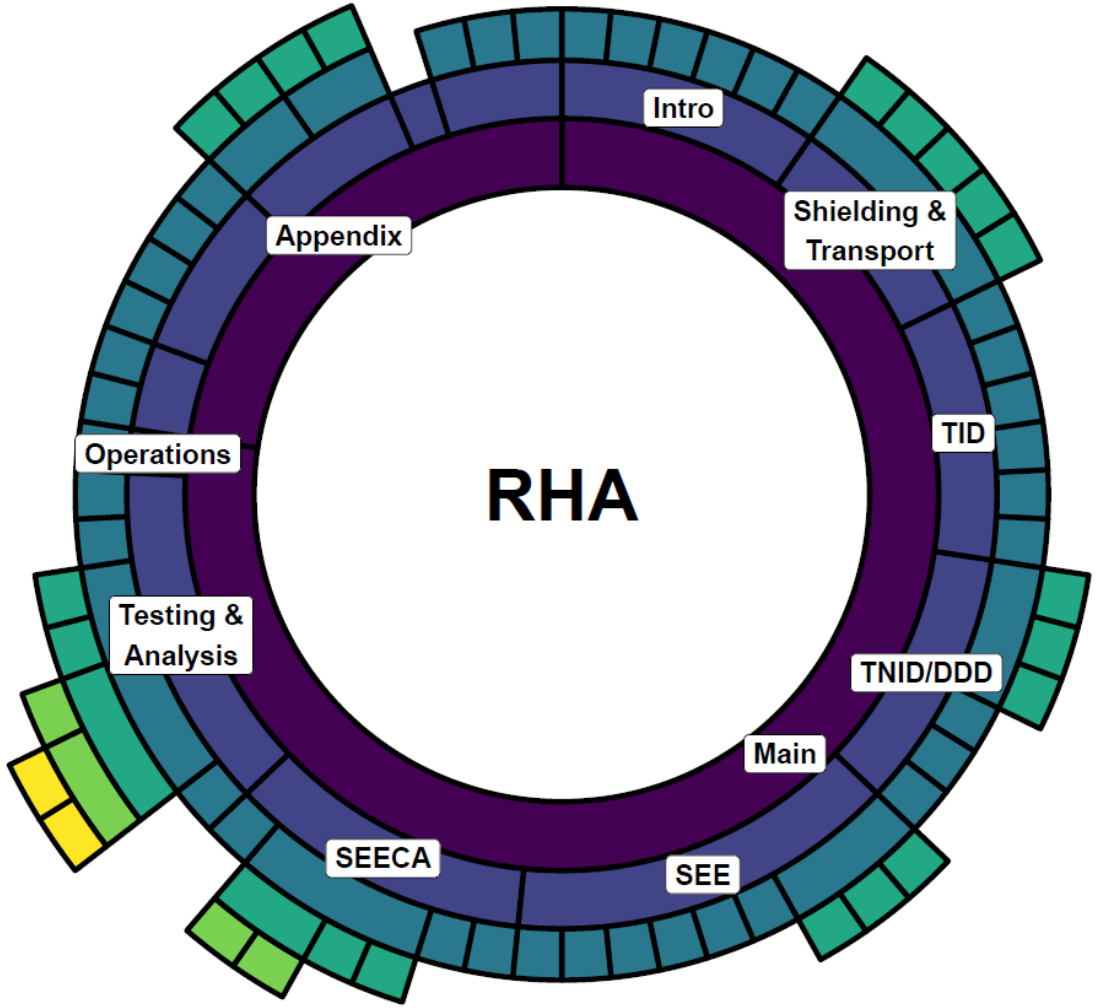
Report Organization

- Report technical content is organized into eight primary sections, supported by five related appendices
- Hyperlinked figures are placed throughout the report (see right) to speed navigation – radial distance ≈ depth of material coverage
- Introduction covers background, context, and overall RHA philosophy
- Subsequent sections address specific aspects of radiation effects and RHA



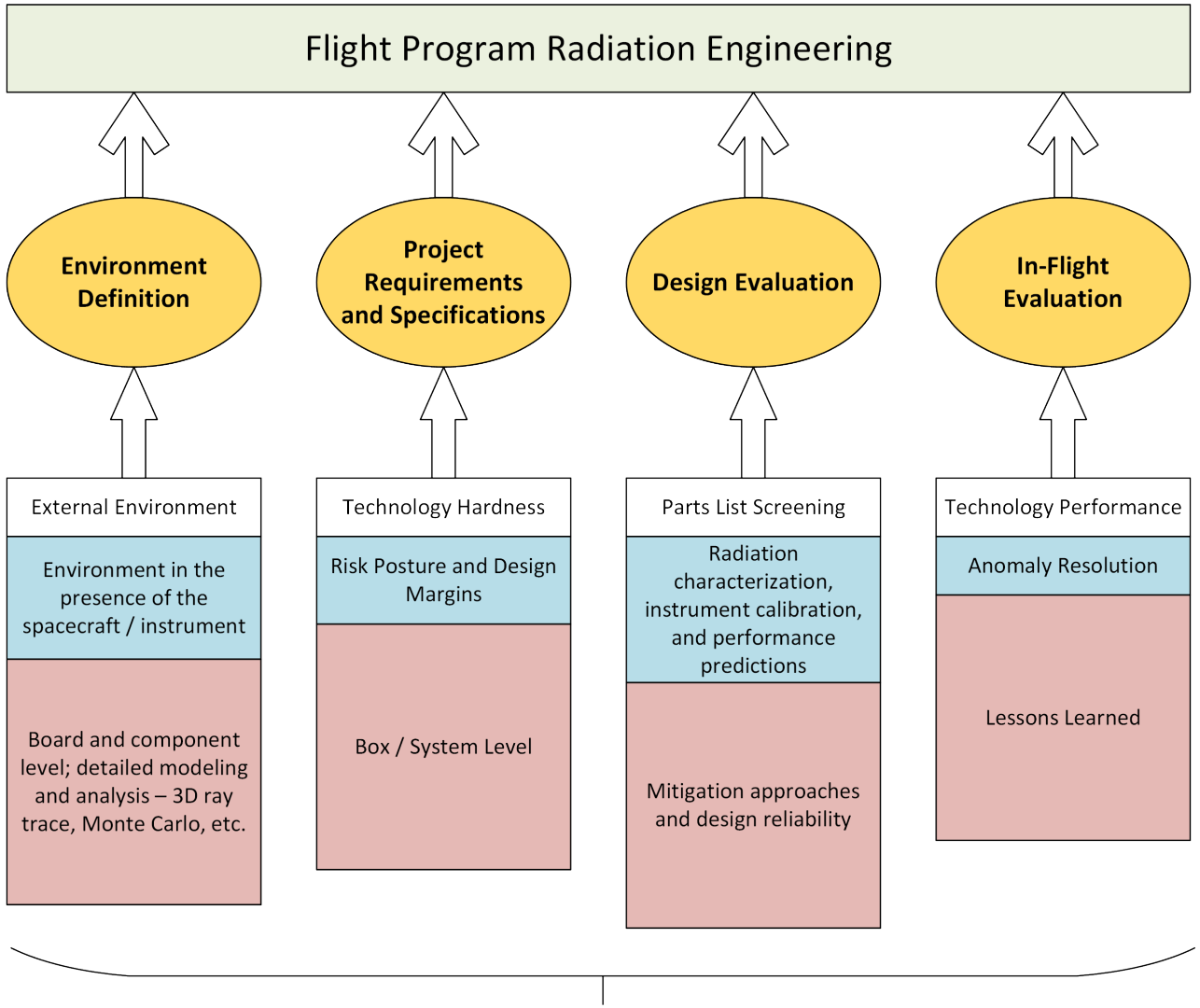
Report Organization

- Appendix sections
  - Ray Trace/Shielding Analysis Checklist for NOVICE simulations
  - Generating Radiation Requirements
  - Goal Structuring Notation (GSN) and Model-Based Mission Assurance (MBMA)
  - Proton Testing at Medical Therapy Facilities
  - Impact of Sample Size on Radiation Testing and Analysis



RHA Lifecycle

- The RHA process is laid out with interdependent activities that span assurance and engineering design
- Each program or project should have a single point of contact or lead who is responsible for overall system RHA
- A RHA program should be planned and implemented for all flight programs and projects to verify and validate component- and system-level radiation hardness by key decision points associated with the final design



RHA Guidelines – Application to COTS Electronics

- This study was not designed to focus specifically on COTS technologies, but there are general RHA considerations for COTS that parallel statements in NESC-RP-19-01490 (Recommendations on Use of COTS Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions)
- Radiation effects issues with COTS electronic parts are the same as with other parts (e.g., MIL-SPEC) – the work published in these guidelines is applicable to COTS electronic parts
- COTS electronic parts pose special challenges for radiation effects due to lack of process / material traceability, testability, etc. – this work includes more guidance on robust methods to handle increased unit-to-unit variability that may be present in COTS electronic parts
- COTS electronic parts are almost always designed without accounting for space radiation effects; engineers are also unlikely to find (any) relevant data in an accessible database, which tends to drive more radiation testing, which may be more complex and time-consuming – this work includes more guidance on test and evaluation to help address COTS electronic parts challenges
- SEECA was developed, in part, as a means of better addressing the use of COTS electronic parts in space systems – this work includes guidance on a refreshed SEECA methodology for the same reasons

Summary and Future Work

- RHA guidelines are not radiation requirements
  - Public technical memorandum is not a directive / technical standard (no “shalls”)
  - Guidelines do, however, discuss derivation of radiation requirements, implementation of best practices, and how these things fit into the overall RHA flow
  - Not meant as a cover-to-cover read – consider it a desk reference
- As a result of this NESC study, NASA will be pursuing the development of an Agency technical standard for RHA
  - Companion to existing policies and standards
    - NASA Procedural Requirement 8705.4A: Risk Classification for NASA Payloads
    - NASA Technical Standard 8739.10: Electrical, Electronic, and Electromechanical (EEE) Parts Assurance Standard
    - NASA Technical Standard 8739.11 (forthcoming): Electrical, Electronic, Electromechanical, and Electro-Optical (EEEE) Parts Selection, Testing, and Derating Standard
  - Also considering the parallel development of a TID analog to SEECA and a radiation risk assessment handbook

Acronyms

Abbreviation	Definition
AMA	Analytical Mechanics Associates, Inc.
CCA	Circuit Card Assembly
CME	Coronal Mass Ejection
COTS	Commercial Off The Shelf
DDD	Displacement Damage Dose
DSNE	(Cross-Program) Design Specification for Natural Environments
EEE	Electrical, Electronic, and Electromechanical
EEEE	Electrical, Electronic, Electromechanical, and Electro-optical
ESA	European Space Agency
FMECA	Failure Mode, Effects, and Criticality Analysis
GCR	Galactic Cosmic Rays
GEO	Geosynchronous Equatorial Orbit / Geostationary Orbit
GSFC	Goddard Space Flight Center
GSN	Goal Structuring Notation
HEOMD	Human Exploration and Operations Mission Directorate
IRCP	Ionizing Radiation Control Plan
ISS	International Space Station
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KBR	KBRwyle
KSC	Kennedy Space Center
LaRC	Langley Research Center
LASCO	Large Angle and Spectrometric Coronagraph

Abbreviation	Definition
LEO	Low Earth Orbit
LET	Linear Energy Transfer
MBMA	Model-Based Mission Assurance
MSFC	Marshall Space Flight Center
MTSO	Management and Technical Support Office
NASA	National Aeronautics and Space Administration
NASA-STD	NASA Technical Standard
NEA	Near-Earth Asteroid
NESC	NASA Engineering and Safety Center
NRB	NESC Review Board
RDM	Radiation Design Margin
RHA	Radiation Hardness Assurance
SBU	Sensitive But Unclassified
SEE	Single-Event Effects
SEECA	Single-Event Effects Criticality Analysis
SLS	Space Launch System
SOHO	Solar and Heliospheric Observatory
SPE	Solar Particle Events
SPEC	Specification
SSAI	Science Systems and Applications, Inc.
TID	Total Ionizing Dose
TNID	Total Non-Ionizing Dose
U.S.	United States

Additional References

- Guidelines for Verification Strategies to Minimize Risk Based on Mission Environment, Application, and Lifetime, 2018
  - https://ntrs.nasa.gov/citations/20180007514
- Recommendations on Use of Commercial-Off-The-Shelf Electrical, Electronic, and Electromechanical Parts for NASA Missions, 2020
  - https://ntrs.nasa.gov/citations/20205011579