

NASA Electronic Parts and Packaging (NEPP) Program – *Resources for SmallSats on EEE Parts*

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Abstract

- From the outside looking in, the NEPP program supports NASA's traditional approach to providing electrical, electronic, and electromechanical (EEE) assurance for space missions. Standards (military and commercial) for EEE parts are based on risk averse methodologies, drive higher costs and schedules, and, in general, provide devices that significantly lag behind commercial devices in performance aspects (speed, power efficiency, etc…). This is NOT the model most small missions realistically can use.
- However, when you look behind the curtain, NEPP has been considering the risk trade space for small missions for over five years and has consistently provided resources that the small mission regime would find useful. In this paper, we provide a brief overview of these resources as well as NEPP's current research/development efforts that are relevant. While we'll primarily discuss radiation assurance related issues such as data availability and usage, assurances processes for not only the radiation effects side, but also the EEE parts reliability will be touched upon.

Acronym List

- Bayesian Networks (BN)
- Complementary Metal Oxide Semiconductor (CMOS)
- Commercial Off-the-Shelf (COTS)
- Cosmic Ray Effects on Micro-Electronics (CRÈME)
- Electrical, Electronic, and Electromechanical (EEE)
- Goal Structuring Notation (GSN)
- Model-Based Mission Assurance (MBMA)
- National Aeronautics and Space Administration (NASA)
- NASA Electronic Parts and Packaging (NEPP) Program
- Radiation Hardness Assurance (RHA)
- Single Event Effect (SEE)
- Single Event Upset (SEU)
- System Modeling Language (SysML)
- Military/Aerospace
- NASA Small Spacecraft Systems Virtual Institute (S3VI)
- Double Data Rate
- IEEE Radiation Effects Data Workshop (REDW)

Outline

- **What's a NEPP?**
  - **Traditional missions versus small missions**
- **NEPP and Small Mission resources**
  - **Philosophy and Approaches**
  - **Guidance**
  - **Tools**
  - **Data**
- **Summary**

NEPP:
NASA's Independent Guidance on Electrical, Electronic, and Electromechanical (EEE) Parts

- **NEPP has been in existence for ~30 years with the prime responsible of leading the Agency's guidance for assurance of EEE parts**
  - ***We are an Agency-wide initiative***
- **From the simple viewpoint, NEPP has a few main areas:**
  - **Agency leadership in standards, guidelines, etc. for NASA documents and those from industry and collaboratively with other government agencies**
    - **NASA policies and standards as well as SAE (MIL/AERO) and JEDEC documents are examples**
  - **Working day-to-day "problems" that may have impacts across the Agency**
  - **Evaluation of new technologies and devices with the goal of gap analysis, determining usability and test guidance**
- ***But what does this have to do with Small Missions?***

NEPP and Small Missions

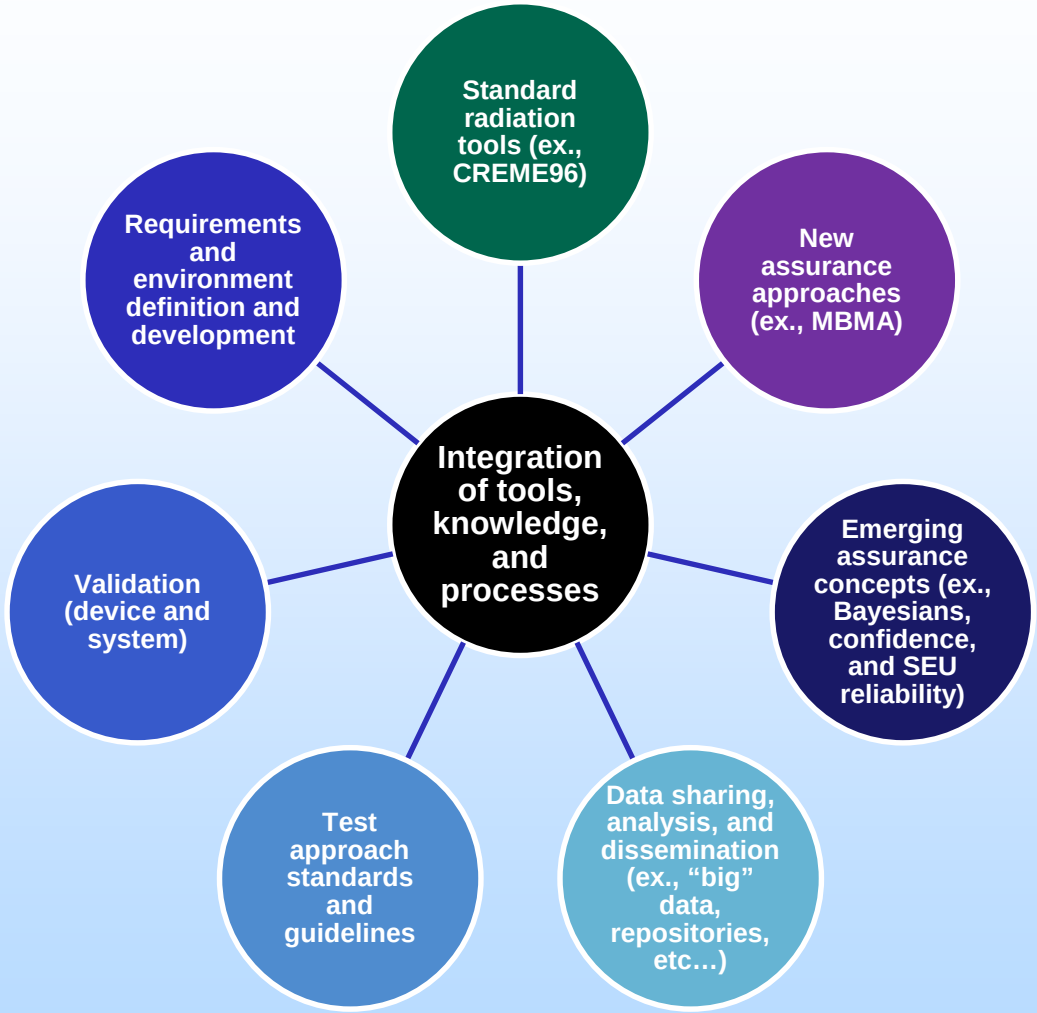
- **While NEPP has always supported small missions, it's only in the last five years that we've been formalizing our support**
- **This includes:**
  - **Thinking beyond mission class on EEE parts choice, test, and risk profiles based on environment exposure, lifetime, and function criticality/risk**
  - **Looking at means of providing "right-size" mission requirements, test and risk profiles, system validation, etc…**
    - ***Radiation Hardness Assurance (RHA) for the future***
  - **Working with Model-Based Mission Assurance (MBMA) approaches for radiation assurance (joint with NASA MBMA program)**
    - **Moving from document-based approaches to model-based approaches**
  - **Developing partnerships and increasing data availability**

NEPP – Beyond Mission Class

Criticality	Low	Medium	High
High	MIL/Aero EEE parts suggested. COTS upscreening/ testing recommended. Fault tolerant designs for COTS.	MIL/Aero EEE parts , rad hard suggested. Full upscreening for COTS. Fault tolerant designs for COTS.	MIL/Aero EEE parts, rad hard recommended. Full upscreening for COTS. Fault tolerant designs for COTS.
Medium	COTS upscreening/ testing recommended. Fault-tolerance suggested	COTS upscreening/ testing recommended. Fault-tolerance recommended	MIL/Aero EEE parts, rad hard suggested. Full upscreening for COTS. Fault tolerant designs for COTS.
Low	COTS upscreening/ testing optional. Do no harm (to others)	COTS upscreening/ testing recommended. Fault-tolerance suggested. Do no harm (to others)	Rad hard suggested. COTS upscreening/ testing recommended. Fault tolerance recommended

Environment/Lifetime

NEPP Future Approaches – Radiation Hardness Assurance (RHA) Example



NEPP Keys

Key 1:

Define what makes "success" for your mission and risk posture

Key 2:

Identify highest "bang for the buck" tests and analyses using model-based flows that meet mission success criteria

Key 3:

Provide accessible infrastructure for tools, data sharing, etc.

Bottom line goal:

Provide appropriate and stream-lined approaches for flight projects (of all sizes)

MBMA –

Applying Model-Based Systems Engineering (MBSE) Concepts to Assurance



MBMA and RHA

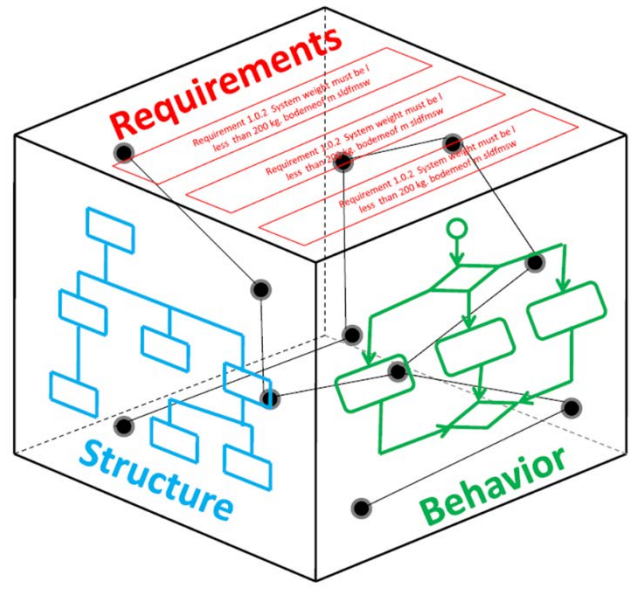
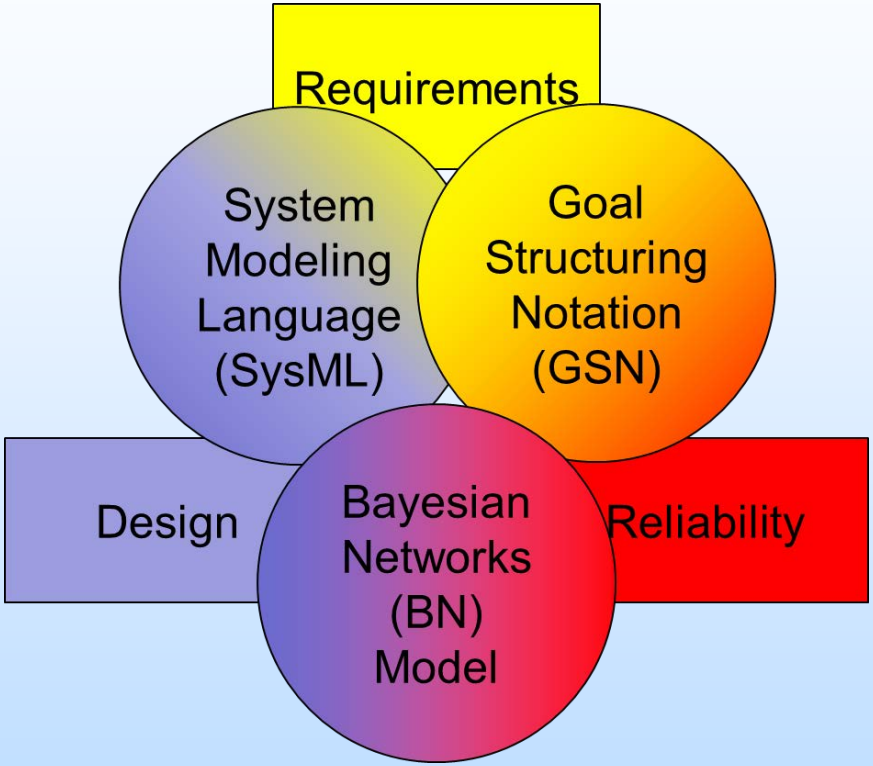


Image Credit: MBSE Connects the Dots (U.S. Army)
http://armytechnology.armylive.dodlive.mil/index.php/2015/07/01/15-3/



Austin, NEPP ETW 2018

It's All About the Data and Partnering

- **NEPP's been a leader in sharing data since its inception**
  - **NEPP's Goddard hosted websites**
    - **https://nepp.nasa.gov and https://radhome.gsfc.nasa.gov – now in its 21st year of public access!**
  - **Tasks related to data scraping and metadata analysis**
    - **Ways of digging into the data for determining risk of usage or test needs**
  - **Collaborations on wider data availability**
    - **Partnering with NASA Small Spacecraft Systems Virtual Institute (S3VI) – visit their booth!**
    - **Working with other agencies on data sharing standards and increasing overall data access**

Example of NEPP Data Sharing -
Single Event Effects (SEE) Annual Compendia

Table V: Summary of SEE Test Results

Part Number	Manufacturer	LDC or Wafer#, (REAG ID#)	Device Function	Technology	Particle: (Facility/Year/Month) P.I.	Test Results: LET in MeV•cm^2/mg, σ in cm^2/device, unless otherwise specified	Supply Voltage	Sample Size (Number Tested)
Memory Devices:								
AS008MA12A	Avalanche Technology	5216 (17-011)	Non-Volatile Memory	CMOS, MRAM	H: (TAMU2017Mar) DC; (TAMU2017Oct) TW	SEL LET_{th} > 85.4; SEU LET_{th} > 120.7; 1.3 < SEFI LET_{th} <1.84; SEFI σ $3.2x10^{-8}$ cm^2 [17-011]	1.8 and 2.0 V	2
MT46V128M8P	Micron	0830 (16-019), 1012 (16-020)	DDR SDRAM	CMOS	H: (TAMU2017June) MJC	SEL LET_{th} > 34.9; SEFI LET_{th} < 1.3; SEFI σ ~ $5x10^{-4}$ cm^2 [16-019]	2.5 V	2
MT29F128G08AJAA AWP-ITZ	Micron	1504 (16-013)	Flash	CMOS	H:(TAMU 2017Mar) MJC	Page Program Failure LET < 3.5	3.3 V	5
MT29F4G08ABADA WP-IT:D	Micron	1644 (17-012 or 17-040)	Flash	CMOS	H: (TAMU2017Mar) MJC	SEU LET_{th} < 2.8; SEU σ ~ 2 x 10^{-10} cm^{-2}/bit; SEFI LET_{th} < 2.8; SEFI σ ~ $5x10^{-5}$ cm^{-2}.	3.3 V	3

Other NEPP Tasks Underway on RHA

- **Provide guidance for Small Mission RHA**
  - **Notional RHA methods**
  - **Detailed RHA Small Mission Guideline**
- **New methods of viewing risk from single event upsets (SEUs)**
  - **Putting SEUs into the reliability domain as opposed to a SEU rate**
- **COTS radiation testing**
  - **Processors, memories, power devices, and more!**
  - **Data made available via IEEE Radiation Effects Data Workshop (REDW) records as well as hosted on NEPP websites**
    - **As stated earlier, working on more universal data sharing approaches and hosting options**

Summary

- **The future learns from the past, but charts a new course**
- **Utilize newer engineering methods to streamline decision processes and connect the dots between mission success and the steps for radiation assurance**
- **Make sure data and new tools are available for the greater good of the community**