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

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ABSTRACT

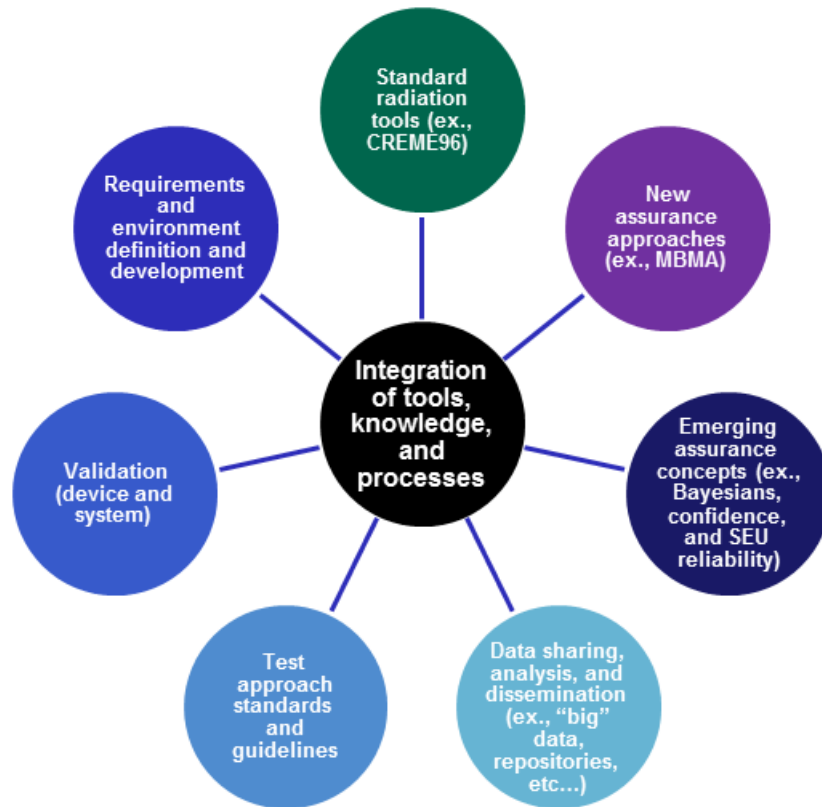
From the outside looking in, the NEPP program supports NASA's traditional approach to providing electrical, electronic, and electromechanical (EEE) assurance for space missions. Standards (military and commercial) for EEE parts are based on risk averse methodologies, drive higher costs and schedules, 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.

INTRODUCTION

The key thing NEPP considers with small missions is an old adage: "when is better the enemy of good enough?" Our traditional mission assurance approaches are based on risk averse techniques – this is appropriate for certain missions such as human presence or deep space. However, following these same approaches for missions that have lesser lifetimes or environment exposure or criticality of mission success, not only would be a struggle to be risk averse in a cost effective manner, but realistically shouldn't even consider the traditional approaches! This is a tenet of NEPP's small mission efforts: provide data, tools, and ideas that are "good enough", in an eyes wide open manner.

Along these lines, NEPP is developing (along with partners) a multi-faceted, integrated approach that will provide a basis both novices and experienced radiation/EEE parts experts will find useful. Figure 1 illustrates the top-level view of this approach with focus on radiation hardness assurance (RHA).



Bottom line goal:
*Provide appropriate and stream-lined approaches for flight projects
 (of all sizes)*

Figure 1: The Future of Radiation Hardness Assurance (RHA).
Highlights of select areas within this Figure will be discussed further.

DATA AND INFORMATION SHARING

Whenever possible, the NEPP Program has always made available the most recent data to the community. This has traditionally been via NEPP’s web platforms as well as presentations/posters accessible at meetings such as the IEEE NSREC. The NEPP website can be found at <https://nepp.nasa.gov>. NEPP’s website provides access not just to data, but other guidance, methods, and information on EEE parts.

A snapshot of the NEPP Radhome entry page is shown in Figure 2. While the data available goes back to the 1980’s, it is updated when test reports on new devices are cleared for release. Like most databases, the data is “caveat emptor”. Use and application of the data needs to be understood and references such as those in IEEE NSREC short courses should be considered. This said, NEPP is supporting entry level tool developments for the novice to aid in simplifying the confusing landscape.

CLEAR SEARCH and RESET TABLE to Display Everything							Page 1 of 135	Record 1 - 10 of 1,344
Part Number	Function	Manufacturer	Date(s)	File(s)	Test Type	Category		
011640 OPTIC-70	4Mx4 DRAM	IBM	5/4/1995;7/15/1996	d050595.htm random6a.htm	SEE	RAM (Random Access Mem...		
0116400J1B-70	4Mx4 DRAM	IBM	9/11/1997	DRAM296.HTM	SEE	RAM (Random Access Mem...		
0116400J1C-70	160 MB Stack DRAM	Irvine Sensors	9/5/95;7/15/96;9/11/97	i090595.htm random6a.htm DRAM296.HTM	SEE	RAM (Random Access Mem...		
0116400J1D Luna-ES2	4Mx4 DRAM	IBM	7/12/1997	Random97a.html	SEE	RAM (Random Access Mem...		
0116400J1C-70	4Mx4 DRAM	IBM	5/4/1995;7/15/1996	D050595.htm random6a.htm	SEE	RAM (Random Access Mem...		
0116400PT1C-70	4Mx4 DRAM	IBM	9/11/1997	DRAM296.HTM	SEE	RAM (Random Access Mem...		
1020B	Gate array	Actel	8/24/1995;03/16/1994	tid/PPM-95-167.pdf tid/PPM-95-130.pdf tid/PPM-94-005.pdf	TID	Programmable Device		
120720A	Schottky Diode	Crane Aerospace & Engineer...	11/14/2012;5/6/2013	nsrec2013_W8_SEE.pdf	SEE	Si		
1280A	Gate array	Actel	8/24/1995;05/20/1994	tid/PPM-95-168.pdf tid/PPM-95-131.pdf tid/PPM-94-012.pdf	TID	Programmable Device		

Figure 2: Snapshot of NEPP Radhome.

Three newer efforts have also begun. The first is tying the NEPP data in an easier to access way to the NASA Small Spacecraft Virtual Institute [1]. The second is working on better means of EEE parts data sharing across the community, both domestically as well as internationally. The third is performing “big data” analysis of existing radiation data [2].

The authors would also like to point out that NEPP holds an annual workshop (Electronics Technology Workshop – ETW). This multi-day meeting is available for both local and remote participation and past workshop presentations are posted on the NEPP website whenever allowed by the presenters’ organizations. Details beyond the scope discussed here may be available there.

Guidance Documents

NEPP provides guidance to the small mission community in several forms. These range from what we call “body of knowledge” (BOK) documents that are snapshot of available information on a EEE parts technology to guidelines on mission EEE parts assurance flows. The latter has two documents under development: one for EEE parts and one for radiation on EEE parts, with both discussing rational flows for missions to consider for proper risk handling [3].

These are based on Figure 3 – a view of tailoring general EEE parts assurance to the actual function and criticality of its usage as well as the exposure it’ll have to the space environment. We’ll note that both needs for long term reliability (operating over intended lifetime) and availability (operating flawlessly during an exact time period) need to be considered under criticality.

Criticality	High	Level 1 or 2 suggested. COTS upscreening/ testing recommended. Fault tolerant designs for COTS.	Level 1 or 2, rad hard suggested. Full upscreening for COTS. Fault tolerant designs for COTS.	Level 1 or 2, 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	Level 1 or 2, 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
		Low	Medium	High
		Environment/Lifetime		

Figure 3: Providing Guidance Based on Function and Exposure since 2014.

TOOLS AND METHODS

NEPP is focusing on three separate efforts that are planned for integration. The first is leveraging off of model-based systems engineering (MBSE) approaches [4] for assurance purposes. The goal is to provide a flexible framework to develop and validate assurance for a mission. This is called model-based mission assurance (MBMA).

The second tool effort is to integrate tool access between the MBMA flow and standard radiation tools such as CRÈME96. In an assurance case, you might have a goal to have single event upset (SEU) rates be under a certain value. CRÈME96 could be the tool used to demonstrate meeting that requirement (with appropriate test data).

However, the third leg of the triangle is key: new methods that have been developed in the radiation community that can aid both realistic requirement definition, but also system level reliability/availability constraints. Two such efforts to be integrated relate to confidence levels [5] and SEU reliability analysis [6].

The latter focuses on moving information away from the transistor and tying into real system operating constraints (i.e. taking the discussion of SEUs from the rate prediction (upsets per day) to a mission success window (example, 99.4% success during a specific timeframe)).

Beyond these three efforts, a staple for NEPP is evolving test methods. Whether this is for emerging EEE parts technologies or for general methods such as performing radiation evaluation on circuit boards with protons [7], NEPP is engaged with providing the most current approaches to the community.

RADIATION TEST INFRASTRUCTURE

NEPP is also involved in ensuring the future access of the space community as a whole to appropriate test facilities. NEPP supported a key study by the National Academies of Science [8] and is actively tracking current and future options for both proton and heavy ion domestic test sites. We're always willing to share the latest status [9].

SELECTED OTHER TOPICS

There are two final topic areas NEPP is supporting and/or collaborating on. The first is supporting the extremely useful work on CubeSat success and classification by Prof. Swartwout [10]. This is an ongoing effort.

The last topic is reviewing the status of the EEE parts supply chain with focus on the evolving “mid-space” regime. This new area involves parts screened and qualified to lesser levels than the traditional military grade.

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