National Aeronautics and Space Administration



NASA Electronic Parts and Packaging (NEPP) Program Focus, Strategic Collaborations, and Our Path to the Future

Responsive Technology Assurance for Civil Space

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Acronyms



Abbreviation	Definition	Abbreviation	Definition
AF	Air Force	MBMA	Model-Based Mission Assurance
ВоК	Body of Knowledge	MRAM	Magnetic Random Access Memory
BYU	Brigham Young University	MSFC	Marshall Space Flight Center
CLT	Capability Leadership Team	NEPAG	NASA Electronic Parts Assurance Group
CMOS	Complementary Metal Oxide Semiconductor	NEPP	NASA Electronic Parts and Packaging (Program)
DLA	Defense Logistics Agency	NESC	NASA Engineering and Safety Center
DMEA	Defense Microelectronics Activity	NPD	NASA Policy Directive
DoD	Department of Defense	NRO	National Reconnaissance Office
EEE	Electrical, Electronic, and Electromechanical	NSREC	Nuclear and Space Radiation Effects Conference
ESA	European Space Agency	NSWC	Naval Surface Warfare Center
ETW	Electronics Technology Workshop	OCE	(NASA) Office of the Chief Engineer
FPGA	Field Programmable Gate Array	OGA	Other Government Agency
GaN	Gallium Nitride	OSMA	(NASA) Office of Safety and Mission Assurance
GIDEP	Government Industry Data Exchange Program	POC	Point of Contact
GPU	Graphics Processing Unit	RH	Radiation-hardened
GRC	Glenn Research Center	RHA	Radiation Hardness Assurance
GSFC	Goddard Space Flight Center	SAPP	Space Asset Protection Program
IC	Integrated Circuit(s)	SEE	Single-Event Effects
IEEE	Institute of Electrical and Electronics Engineers	SiC	Silicon Carbide
JPL	Jet Propulsion Laboratory	SMC	Space and Missile Systems Center
JSC	Johnson Space Center	SoC	System on a Chip
LANL	Los Alamos National Laboratory	STMD	(NASA) Space Technology Mission Directorate
LaRC	Langley Research Center	STT	Spin-Transfer Torque
MAPLD	Military and Aerospace Programmable Logic Devices (Workshop)	TOR	Technical Operating Report

Outline



- Continued evolution of NASA Electrical, Electronic, and Electromechanical (EEE) parts management
 - EEE Parts Manager: an evolving role in the Agency
 - NEPP Program structure
 - General NASA EEE parts interfaces
- NEPP Program overview for 2019
 - What's new in 2019?
 - Key efforts, concerns, and status
- NASA Electronics Parts Assurance Group (NEPAG)
 - Standards development
- Summary

NASA EEE Parts – Evolving Structure



NASA EEE parts consolidation:

- Primary Agency test and analysis activities will be at the Goddard Space Flight Center (lead Center) and the Jet Propulsion Laboratory
- Jonathan Pellish, the Agency EEE Parts Manager, will lead
- NEPP remains virtually the same:
 - Owns the EEE parts assurance processes and related technical efforts
 - NEPP management evolution
- New NASA-wide documents activities
 - NASA Standard 8739.10, released
 - First NASA-wide EEE parts standard since MIL-STD-975 was canceled in May 1998
 - "EEE-INST-003" / NASA-STD-8739.11 unification underway



https://standards.nasa.gov/

NASA EEE Parts Manager – A Recent and Evolving Role



- Manage EEE parts workforce at the Agency level
 - Radiation effects on EEE parts are in scope, as is management of the Agency radiation facility block buy
 - GSFC is lead Center, supported by JPL
- Provide resources for Centers to acquire EEE parts workforce expertise and a forum to coordinate activities with stakeholders (e.g., OCE, OSMA, etc.) and customers
- Track the state of the Agency EEE parts workforce, including Center expertise, demand, and capacity
- Support Agency policy and technical decision-making processes
- Evolve management functions as needed

NASA EEE Parts – Interfaces



Agency EEE Parts

Assurance

Development

Facilities

Office of Safety & Mission Assurance

Office of the Chief Engineer

Flight Projects

Mission Support

- NEPP

- Quality

- Reliability

- Workmanship

Capability Leadership

NESC

Field Centers

Mission Directorates

Space Environments
Testing Management
Office

NEPP Overview – Mission Statement



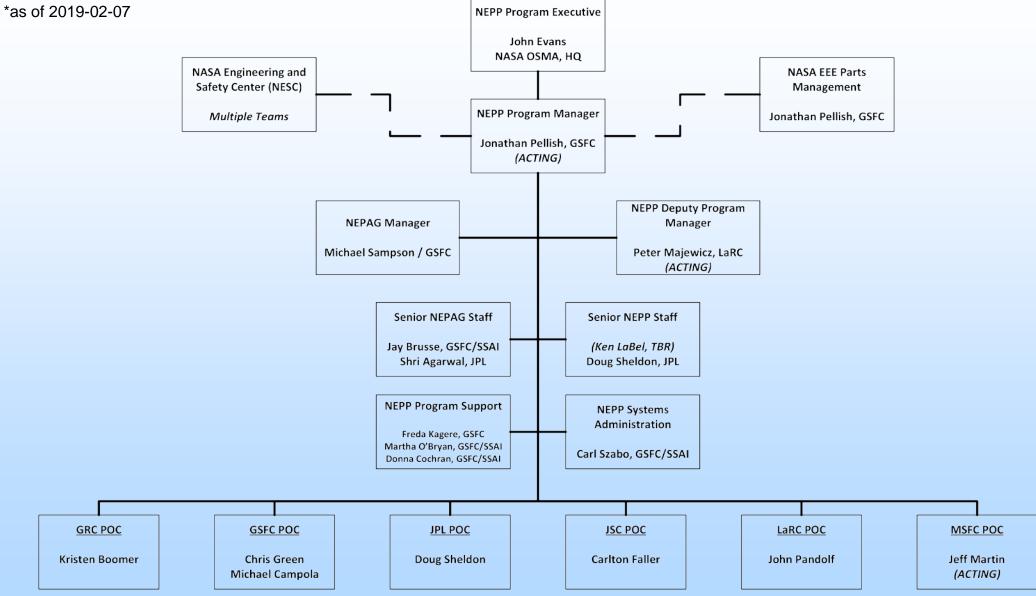
Provide NASA's leadership for developing and maintaining guidance for the screening, qualification, test, and reliable use of EEE parts by NASA, in collaboration with other government agencies and industry.

Accessible & Product-Oriented

Note: the NASA Electronic Parts Assurance Group (NEPAG) is a core portion of NEPP

NEPP Program – Organization Chart*





NEPP Charter



EEE Parts Infrastructure

- •NEPAG Telecons and Working Groups
- •SME Capabilities
- Communication and Outreach within NASA and to the greater aerospace community

Agency Leadership

- •NASA Policies and Procedures
- •Agency Guidelines, Body of Knowledge (BOK) documents, and Best Practices
- •Coordination of Government and Industry Standards
- Audit Coordination with AF, NRO, DLA
- Partnering within NASA and other Agencies, Industry, University, and International

Agency Priorities – Independent Support

- Commercial Crew
- •Small Mission Reliability
- Coordination with NASA Consolidation, CLTs, NESC, STMD, SAPP, and radiation block buy
- Collaborate with DoD/DOE on space radiation test infrastructure

Technology Evaluation

- Advanced /new EEE parts/technologies
- •Ex. Advanced CMOS, GaN, SiC
- Working Groups (NASA, government, aerospace)
- Screening/qualification/ test/usage guidelines
- Partnering: NASA, Government Agencies, Industry, University, International

Trusted and RH Electronics

- Collaboration with NASA and other Agency Supply Chain and Trust/Counterfeit Electronics Organizations
- Support DoD efforts on Trust/Assurance (w/ NASA STMD and OCE/Space Asset Protection)
- Support DoD RH efforts

Mission Assurance

EEE Parts Problem Investigations

- Agency/Industry-wide problems
- GIDEP and NASA Alert development

NEPP Product Delivery



Best Practices and Guidelines

- Test, usage, screening, qualification
- Radiation facility studies

NASA EEE Parts
Policy and
Standards

Government and Industry Standards Representation

- SAE CE11/CE12/ JEDEC JC13
- Aerospace TORs

Body of Knowledge

Technology and product status and gap analysis

Assurance

NEPP Standard Products

- Test, summary, and audit reports
- Conference and workshop presentations
- Alerts

New for NEPP in FY2019



- Released <u>GPU BoK</u> (E. Wyrwas et al.)
- Kicked off SmallSat industrial base assessment (major support from AF/SMC)
 - Components and systems; production and procurement
- Increasing focus on advanced packaging
- Radiation Hardness Assurance
 - Building board-level proton test guideline
 - Developing proton electronics testing best practices at medical facilities
 - Examining best practices for test planning and data collection / sharing
 - Planning to release GaN and SiC RHA testing best practices
 - Starting non-volatile FPGA and STT-MRAM radiation evaluation via interagency agreement between NASA and DoD/NSWC Crane
- Examining opportunities for more significant integration of NEPP documentation into future community-consensus products/standards
- Continuing delivery of assurance products (lots more going on here)
 - BoKs, guidelines, tools, information sharing, and training
 - Unification of NASA documentation (NEPAG)

Field Programmable Gate Arrays (FPGAs), Processors, Systems on a Chip (SOC)



State of the Art COTS **Processors**

- •Sub-32nm CMOS, FinFETs, etc
- ·Samsung, Intel, AMD
- Neural Networks

"Space" FPGAs

- Microsemi RTG4
- •Xilinx MPSOC+
- •ESA Brave (TBR)
- •"Trusted" FPGA (TBR)

COTS FPGAs

- Microsemi **PolarFire**
- Xilinx Ultrascale
- •Intel Cyclone 10
- Mitigation evaluation
- •TBD Others

Graphics Processor Units (GPUs)

- •Intel, AMD, Nvidia
- Enabling data processing

Radiation Hardened Processor

- **Evaluation** •BAE RAD55XX
- Vorago (microcontrollers)
- Support High **Performance** Spacecraft **Computing (HPSC)**

Best **Practices** and Guidelines

Partnering

- Processors: Navy Crane, BAE/NRO
- FPGAs: AF/SMC. Navy Crane SNL, LANL, BYU
- Microsemi, Xilinx, **Synopsis**
- Cubic Aerospace

Potential task areas: artificial intelligence (AI) hardware, Intel Stratix-10, Xilinx Versal

Memory Devices



New materials/ architectures

- Resistive
- Fujitsu/Panasonic
- Spin transfer torque magnetoresistive
- Avalanche, Everspin
- 3-D Xpoint
 - Intel, Micron
- Enabling "universal" memories

DRAMs

- DDR4 test capability
- Commercial DDR (various)
- Enabling high performance computing

Commercial Flash

- 3-D
- Samsung, Hynix, Micron, Western Digital
- Planar TBD
- Enabling data storage density

Best
Practices
and
Guidelines

Partnering

- Navy Crane
- NASA STMD
- Avalanche
- University of Padova

Related task areas: deprocessing for single event testing (also w/processors, FPGAs,...)

Packaging

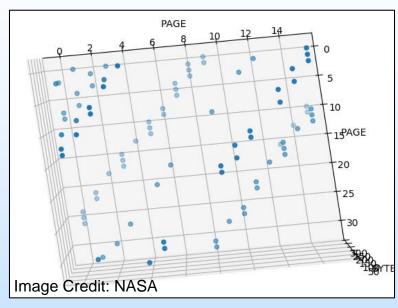




A NEPP Program task area that will see increased attention in FY19+

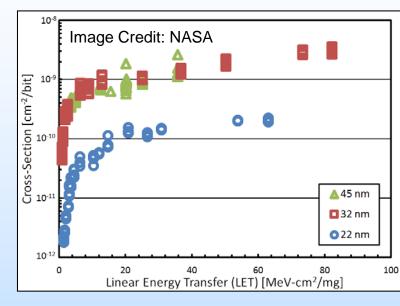
Advanced Technology Evaluation Examples





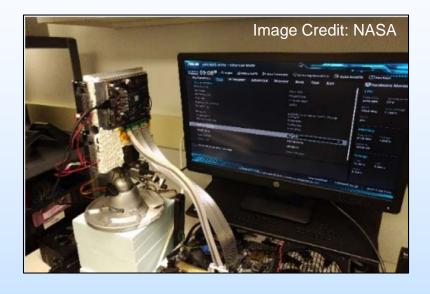
Angled heavy ion tracks in 3-D NAND Flash
Micron MT29F1T08CMHBB
256Gb die, MLC, 32 layers, piece-part testing

T. Wilcox et al., SEE/MAPLD 2018.



Heavy ion cross sections
GlobalFoundries 45 & 32 nm PDSOI, 22 FDSOI
Static Random Access Memories (SRAMs)

M. Casey et al., IEEE NSREC 2018. Collaboration with DMEA, Sandia, and GlobalFoundries



400 W cooling on bare NVIDIA GTX 1050

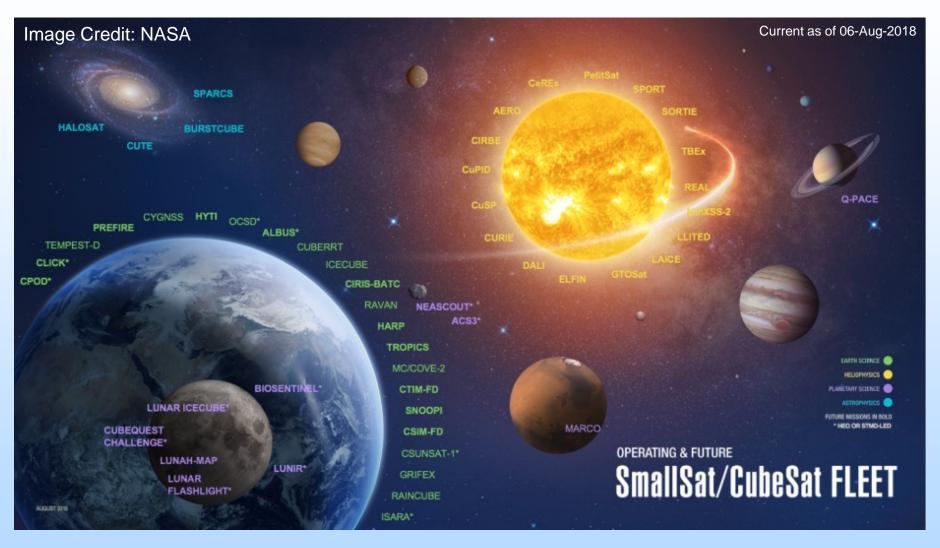
E. Wyrwas, <u>2018 NEPP GPU BOK</u>.

Pace of technology evolution and growth of evaluation requirements continue to generate new demands:

1) diversified subject matter expertise; 2) more access to a wider variety of radiation test facilities

NASA Bolsters SmallSat Science Programs





NASA SMD 06-Aug-2018: SmallSats are the focus of a new initiative that'll grant \$\frac{\$100M/yr}{2}\$ to targeted science, tech developments & educational opportunities to enrich the already impressive NASA science SmallSat mission portfolio.

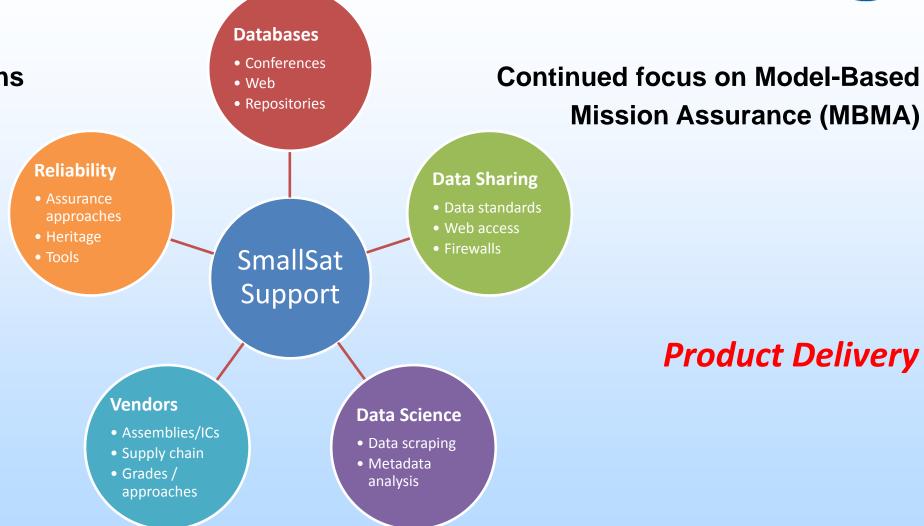
Evolving Landscape for SmallSat Assurance Support





- Academia
- Industry
- OGAs

Accessibility



Linking Program Tasks to Community Focus Areas / Needs

NEPP Program / NEPAG Standards & Policy Development



- Released NASA-STD-8739.10
 - NASA EEE Parts Assurance Standard
- Updating EEE-INST-002
 - Instructions for EEE Parts Selection, Screening, Qualification, and Derating
 - Will become new Agency standard, NASA-STD-8739.11
 - Goal is to modernize and synthesize existing Agency documents
 - Ongoing throughout FY19
- Updating NPR-8705.4
 - Risk Classification for NASA Payloads
 - Appendix C Recommended SMA-Related Program Requirements for NASA Class A-D Payloads
 - Goal for EEE Parts is a mapping that recommends parts with respect to payload class (A-D), mission criticality (critical/noncritical) and part grade level (space, military, industrial, COTS, etc.)

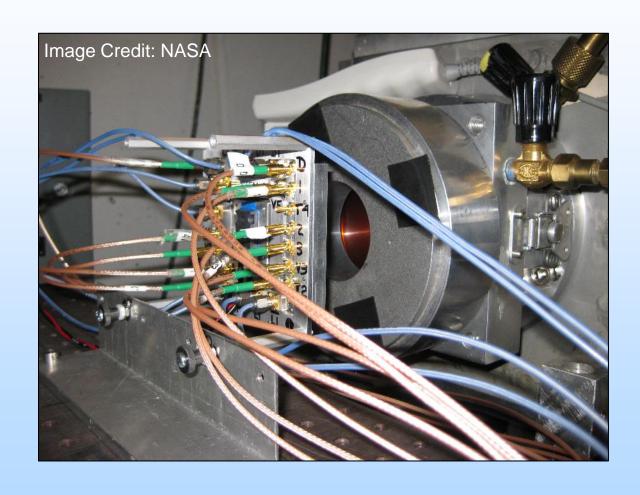
NASA Technical Standards: https://standards.nasa.gov/

NASA Online Directives Information System (NODIS): https://nodis3.gsfc.nasa.gov/

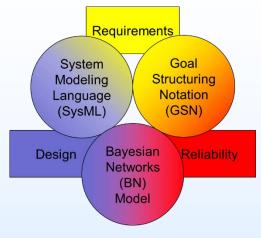
As Always, Partnering is Essential



- Within:
 - NASA
- With:
 - Academia
 - Government agencies
 - Ex.: Strategic Radiation-Hardened Electronics Council Working Groups
 - Test & Evaluation (member)
 - Workforce Development (lead)
 - Industry
 - International







Emerging Assurance Methods (Witulski, Vanderbilt University, NEPP ETW 2017)

Image credit: Vanderbilt / NASA



Advanced Technology Reliability

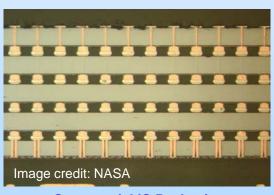
10th Annual NEPP Electronics Technology Workshop (ETW)

Scheduled dates: June 17-20, 2019 NASA/GSFC and on-line

https://nepp.nasa.gov/



Radiation Testing



Commercial IC Packaging