

A Year in the Life of the NASA Electronic Parts and Packaging (NEPP) Program

A NASA Office of Safety and Mission Assurance (OSMA) Program

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Acronyms

AF Air Force (AF) AF SMC Air Force Space and Missile Systems Center (AF SMC) AI Artificial Intelligence (AI) ARC NASA Ames Research Center (ARC) BAE BAE Systems (BAE) BN Bayesian Networks (BN) BOK Body of Knowledge (BOK) BYU Brigham Young University (BYU) CLTs NASA CIO Leadership Teams (CLTs) CMOS Complementary Metal Oxide Semiconductor (CMOS) COTS Commercial Off The Shelf (COTS) CRÈME Cosmic Ray Effects on Micro Electronics Cu Copper DDR Double Data Rate (DDR) [DDR3 = Generation 3; DDR4 = Generation 4] DiRAM Dis-integrated Random Access Memory (DiRAM) DLA Defense Logistics Agency (DLA) DMEA Defense Microelectronics Activity (DMEA) DOD Department of Defense (DoD) DOE Department of Energy (DOE) DRAM Dynamic Random-Access Memory (DRAM) EEE Electrical, Electronic, and Electromechanical (EEE) ESA European Space Agency (ESA) ETW Electronics Technology Workshop (ETW) FD-SOI Fully-Depleted Silicon-On-Insulator (FD-SOI) FinFETs Fin Field Effect Transistors (FinFETs) FPGA Field Programmable Gate Array (FPGA) GaN Gallium Nitride (GaN) GIDEP Government-Industry Data Exchange Program (GIDEP) GPU Graphics Processing Unit (GPU) GSN Goal Structuring Notation (GSN) HBM High Bandwidth Memory (HBM) HFSC High Performance Spacecraft Computing (HPSC) IC Integrated Circuit (IC)	Acronym	Definition
AF SMC Air Force Space and Missile Systems Center (AF SMC) AI Artificial Intelligence (AI) ARC NASA Ames Research Center (ARC) BAE BAE Systems (BAE) BN Bayesian Networks (BN) BOK Body of Knowledge (BOK) BYU Brigham Young University (BYU) CLTs NASA CIO Leadership Teams (CLTs) CMOS Complementary Metal Oxide Semiconductor (CMOS) COTS Commercial Off The Shelf (COTS) CRÈME Cosmic Ray Effects on Micro Electronics Cu Copper DDR Double Data Rate (DDR) [DDR3 = Generation 3; DDR4 = Generation 4] DiRAM Dis-integrated Random Access Memory (DiRAM) DLA Defense Logistics Agency (DLA) DMEA Defense Microelectronics Activity (DMEA) DOD Department of Defense (DoD) DOE Department of Energy (DOE) DRAM Dynamic Random-Access Memory (DRAM) EEE Electrical, Electronic, and Electromechanical (EEE) ESA European Space Agency (ESA) ETW Electronics Technology Workshop (ETW) FD-SOI Fully-Depleted Silicon-On-Insulator (FD-SOI) FinFETS Fin Field Effect Transistors (FinFETs) FPGA Field Programmable Gate Array (FPGA) GaN Gallium Nitride (GaN) GIDEP Government-Industry Data Exchange Program (GIDEP) GPU Graphics Processing Unit (GPU) GSN Goal Structuring Notation (GSN) HBM High Bandwidth Memory (HBM) HPSC High Performance Spacecraft Computing (HPSC)	3D	Three Dimensional (3D)
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IC Integrated Circuit (IC)	HPSC	High Performance Spacecraft Computing (HPSC)
	IC	Integrated Circuit (IC)

Acronym	Definition
IR	Infrared (IR)
JEDEC	Joint Electron Device Engineering Council (JEDEC)
LANL	Los Alamos National Laboratories (LANL)
MAIW	Military Al Works (MAIW)
MBMA	Model-Based Missions Assurance (MBMA)
Mil	Military (Mil)
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET)
MPSOC	Multi-Processing System on Chip (MPSOC)
NASA	National Aeronautics and Space Administration (NASA)
Navy Crane	Naval Surface Warfare Center, Crane, Indiana (Navy Crane)
NEPAG	NASA EEE Parts Assurance Group (NEPAG)
NEPP	NASA Electronic Parts and Packaging (NEPP) Program
NESC	NASA National Electric Safety Code (NESC)
NRO	United States Navy National Reconnaissance Office (NRO)
OCE	Office of the Chief Engineer (OCE)
OSMA	NASA Office of Safety and Mission Assurance (OSMA) Program
PBGA	Plastic Ball Grid Array
PoP	Package-on-Package (PoP)
QFN	Quad-Flat No-Leads (QFN)
R&M	Reliability and Maintainability (R&M)
RH	Radiation Hardened (RH)
RHA	Radiation Hardness Assurance
SAE	Society of Automotive Engineers (SAE)
SAPP	Space Asset Protection Program (SAPP)
SEAM	Systems Engineering and Assurance Modeling (SEAM)
SEB	Single Event Burnout (SEB)
SEE	Single Event Effect (SEE)
SiC	Silicon Carbide (SiC)
SME	Small and Medium-sized Enterprises (SME)
SNL	Sandia National Laboratories (SNL)
SOC	Systems on a Chip (SOC)
STMD	NASA's Space Technology Mission Directorate (STMD)
SysML	System Modeling Language (SysML)
TOR	Technical Operating Report (TOR)



NEPP Mission Statement

Provide NASA's leadership for developing and maintaining guidance for the screening, qualification, test, and reliable usage of electrical, electronic, and electromechanical (EEE) parts by NASA, in collaboration with other government Agencies and industry.



NEPP - Charter

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 Trusted Foundries and FPGAs (w/NASA STMD and OCE/Space Asset Protection)
- •Support DoD RH efforts

Agency Leadership

EEE Parts

Infrastructure

NEPAG Telecons and

Communication and

and to the greater

Outreach within NASA

aerospace community

Working Groups

SME Capabilities

- 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

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 G11/G12/ JEDEC JC13
- Aerospace TORs

BOK

 Technology and product status and gap analysis

Assurance

NEPP Standard Products

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

Related task areas:

Technology/parts evaluations lead to new best practices, etc...

Body of Knowledge (BOK) Documents

What goes into a BOK

- An overview of the technology
- An overview of technology applicability to space/aeronautics
- An overview of technology maturity, produceability and/or commercial availability
- Reliability, qualification, and/or radiation knowledge-base
- Technology direction or extent of the reliability issue for the future Identification of experts, technology sources, test houses, etc.
- Facilities/capabilities
- Recommendation for follow-on NEPP task (if applicable)

BODY OF KNOWLEDGE FOR SILICON CARBIDE POWER ELECTRONICS



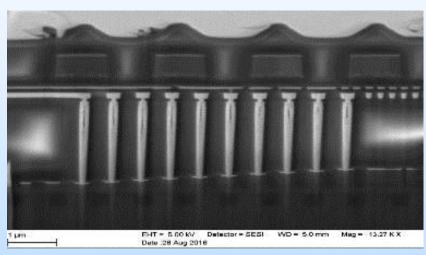
What's New for NEPP in FY18

- Increased emphasis on needs of small missions such as CubeSats and model-based mission assurance (MBMA)
 - Partnering with other NASA organizations, Agencies, and universities
- More assurance products
 - BOKs, Guidelines, Tools, Information Sharing, Training
- Significant update of the NEPP website
 - Easier to find guidance and search for data
 - New tie-ins to the SmallSat community
- Support for Agency efforts for EEE Parts
 Consolidation, Radiation Beam Block Buys, and
 Capability Leadership Teams



Advanced Technologies

 Technology/device evaluations with a nod to developing test methods and user guidance



Hynix 3D Flash Memory



AMD Ryzen Processor

 New: collaboration with DMEA and GlobalFoundries on 22nm FD-SOI and 28nm bulk radiation evaluation

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

State of the Art COTS Processors

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

"Space" FPGAs

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

Graphics Processor Units (GPUs)

- •Intel, AMD, Nvidia
- •Enabling data processing

COTS FPGAs

- Xilinx Kintex+
- Mitigation evaluation
- •TBD: Microsemi PolarFire

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, SNL, LANL, BYU,...
- Microsemi, Xilinx, Synopsis
- Cubic Aerospace

Potential task areas:

artificial intelligence (AI) hardware, Intel Stratix 10



NEPP – Memories

New materials/ architectures

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

DRAMs

- DDR4 test capability (in progress)
- Commercial DDR (various)
- Tezzaron DiRAM (w/HPSC)
- Enabling high performance computing

Commercial Flash

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

Best
Practices
and
Guidelines

Partnering

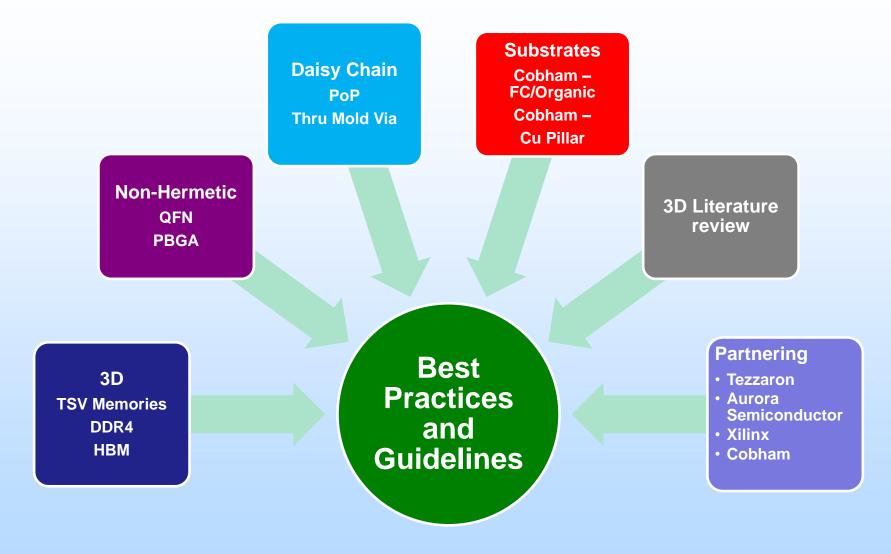
- Navy Crane
- NASA STMD
- Avalanche
- University of Padova

Related task areas:

Deprocessing for single event testing (also w/processors, FPGAs,...)



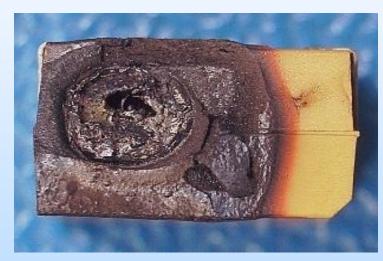
NEPP – Packaging



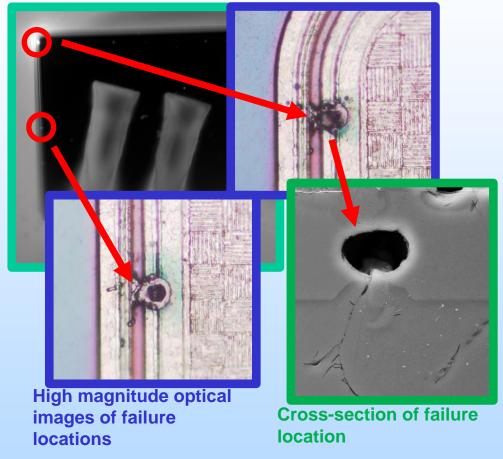


Working Industry/Agency-Wide Concerns

Thermal Image of failure locations



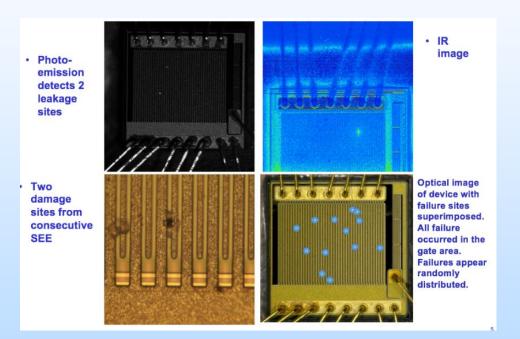
Tantalum capacitor failure



Failure analysis of Schottky diode radiation damage



Vendor Validation Tests



GaN IC - radiation test analysis

Comparison of n-type 60V trench MOSFET SEB thresholds



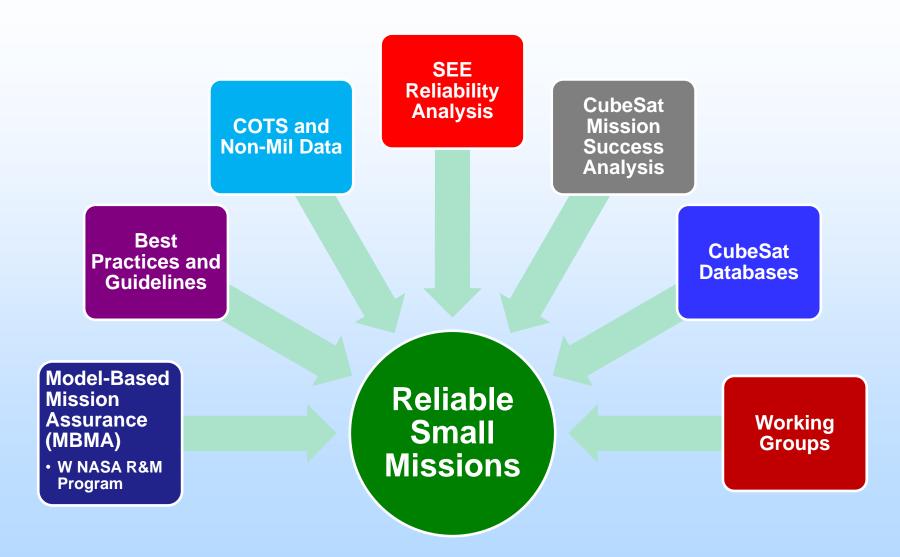
Infrastructure Challenges



Using Proton Cancer Therapy Centers for electronics testing



NEPP - Small Mission Efforts



Potential future task areas: automotive and avionics resilience



NEPP Small Mission Efforts and MBMA (w/ NASA MBMA Program)

NASA/GSFC (Campola)
Small Mission RHA
TBD
Small Mission EEE Parts Best Practices

NASA/GSFC (Xapsos)
RHA Confidence Approach

Requirements

Aerospace (proposed)

CubeSat Kit Vendor Survey "Mid-space" Grade Survey and Requirements Definition

Saint Louis University CubeSat Success Study

JPL

CubeSat EEE Parts Databases

TBD

CubeSat EEE Parts Testing

System Modeling Language (SysML)

Goal
Structuring
Notation
(GSN)

Vanderbilt University
GSN Exemplar (SEE) – complete
TBD
GSN Exemplar – EEE parts reliability

Design

Bayesian Networks (BN) Model Reliability

Vanderbilt University
BN follow-on
BN integrated into SEAM

NASA/GSFC (Berg)
SEE Classic Reliability
Vanderbilt

CRÈME Toolsuite

TBD

Resilience, autonomy

Other

Integration with Small Spacecraft Virtual Institute (NASA/ARC)

https://www.nasa.gov/small sat-institute

Emerging ModelingVanderbilt University

Web-based tool (SEAM)
NASA/GSFC (Campola) - Vanderbilt
Notional RHA Tool (R-GENTIC)

https://modelbasedassurance.org/

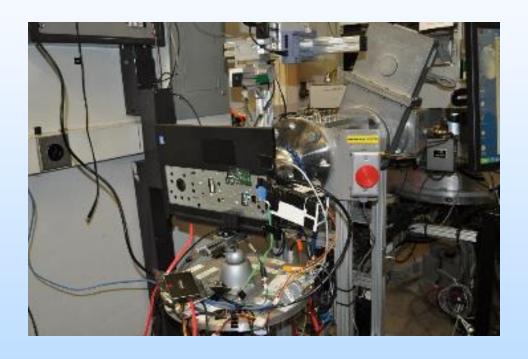
Other

MAIW SmallSat Reliability Initiative (NASA/AF/ others)

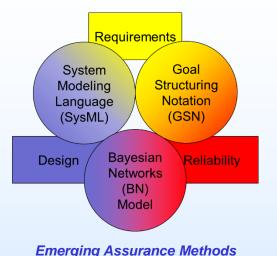


Partnering is key

- Within
 - NASA
- With
 - Othergovernmentagencies
 - Industry
 - University
 - International

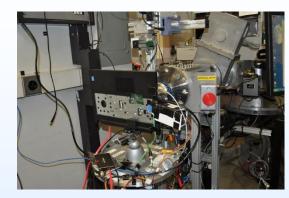




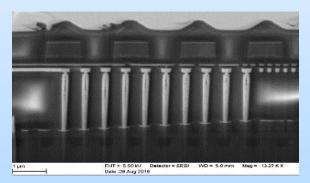


(Witulski, Vanderbilt University, NEPP ETW 2017)

9th Annual NEPP Electronics Technology Workshop (ETW)

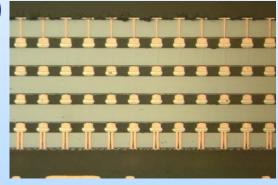


Radiation Testing



Advanced Technology Reliability

Scheduled dates:
June 18-21, 2018
NASA/GSFC and on-line



Commercial IC Packaging



http://nepp.nasa.gov