

NASA EEE Parts and NASA Electronic Parts and Packaging (NEPP) Program Update 2018

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Acronyms

- Three Dimensional (3D)
- Air Force (AF)
- Air Force Space & Missile Systems Center (AF SMC)
- Advanced Micro Devices, Inc. (AMD)
- Ames Research Center (ARC)
- AS&D, Inc. (AS&D)
- Marconi Electronic Systems (MES) and British Aerospace (BAe) merged to form BAE Systems (BAE)
- Bayesian Networks (BN)
- Body of Knowledge (BOK)
- Brigham Young University (BYU)
- Capability Leadership Teams (CLTs)
- Complementary Metal Oxide Semiconductor (CMOS)
- Commercial Off-the-Shelf (COTS)
- Cosmic Ray Effects on Micro-Electronics (CRÈME)
- Double Data Rate (DDR)
- Dis-integrated Random Access Memory (DiRAM)
- Defense Logistics Agency (DLA)
- Defense MicroElectronics Activity (DMEA)
- Department of Defense (DoD)
- Department of Energy (DOE)
- Electrical, Electronic, and Electromechanical (EEE)
- Engineering Practices (EP)
- NASA Electronic Parts Database (EPARTS)
- EEE Parts Management and Control Plan (EPMCP)
- Electrostatic Discharge (ESD)
- NEPP Electronics Technology Workshop (ETW)
- Fully Depleted Silicon-on-Insulator (FD-SOI)
- Fin Field Effect Transistor (the conducting channel is wrapped by a thin silicon "fin") (FinFET)
- Field Programmable Gate Array (FPGAs)
- Gallium Nitride (GaN)
- Government-Industry Data Exchange Program (GIDEP)
- Glenn Research Center (GRC)
- Goddard Space Flight Center (GSFC)
- Goal Structuring Notation (GSN)
- Government Working Group (GWG)
- High Bandwidth Memory (HBM)
- High Performance Spacecraft Computing (HPSC)
- Headquarters (HQ)
- Integrated Circuit (IC)
- Internal Gas Analysis (IGA)
- IPC changed its name from Institute for Interconnecting and Packaging Electronic Circuits to IPC
- Infrared (IR)
- Indiana University Cyclotron Facility (IUCF)
- Joint Electron Device Engineering Council (JEDEC)
- Jet Propulsion Laboratories (JPL)
- Johnson Space Center (JSC)
- Los Alamos National Laboratories (LANL)
- Langley Research Center (LaRC)
- Loma Linda University Medical Center (LLUMC)
- Mission Assurance Improvement Workshop (MAIW)
- Model-Based Mission Assurance (MBMA)
- Massachusetts General Hospital (MGH)
- Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET)
- Marshall Space Flight Center (MSFC)
- National Aeronautics and Space Administration (NASA)
- Naval Surface Warfare Center, Crane, Indiana (Navy Crane)
- NASA Electronic Parts Assurance Group (NEPAG)
- NASA Electronic Parts and Packaging (NEPP) Program
- NASA Engineering and Safety Center (NESC)
- Non-Military (Non-Mil)
- United States Navy National Reconnaissance Office (NRO)
- Nuclear and Space Radiation Effects Conference (NSREC)
- NASA Office of the Chief Engineer (OCE)
- NASA Office of Safety and Mission Assurance (OSMA)
- Point of Contact
- Package on Package (PoP)
- Residual Gas Analysis (RGA)
- Radiation Hardened (RH)
- Radiation Hardness Assurance (RHA)
- Society of Automotive Engineers (SAE)
- Space Asset Protection Program (SAPP)
- SCRIPPS Proton Therapy Center (SCRIPPS)
- Systems Engineering and Assurance Modeling (SEAM)
- Single Event Burnout (SEB)
- Single Event Effect (SEE)
- NASA Space Environments Testing Management Office (SETMO)
- Silicon Carbide (SiC)
- Air Force Space and Missile Systems Center (SMC)
- Subject Matter Expert (SME)
- Sandia National Laboratories (SNL)
- NASA Space Technology Mission Directorate (STMD)
- System Modeling Language (SysML)
- Technical Operating Reports (TORs)
- Tri-University Meson Facility (TRIUMF)
- Through Silicon Via (TSV)



Outline

- **NASA Electrical, Electronic, and Electromechanical (EEE) Parts Changes**
 - Why the Change?
 - General Agency EEE Parts Interfaces
 - EEE Parts Manager: A New Role in the Agency
 - NEPP Program Structure
- **NEPP 2018**
 - NEPP Overview
 - Changes in 2018
 - Key efforts, concerns, and status
- **NASA Electronics Parts Assurance Group (NEPAG)**
 - Standards
 - Highlights
 - Concerns
 - Parts Problems
- **Summary**



EEE Parts – Why the Change?

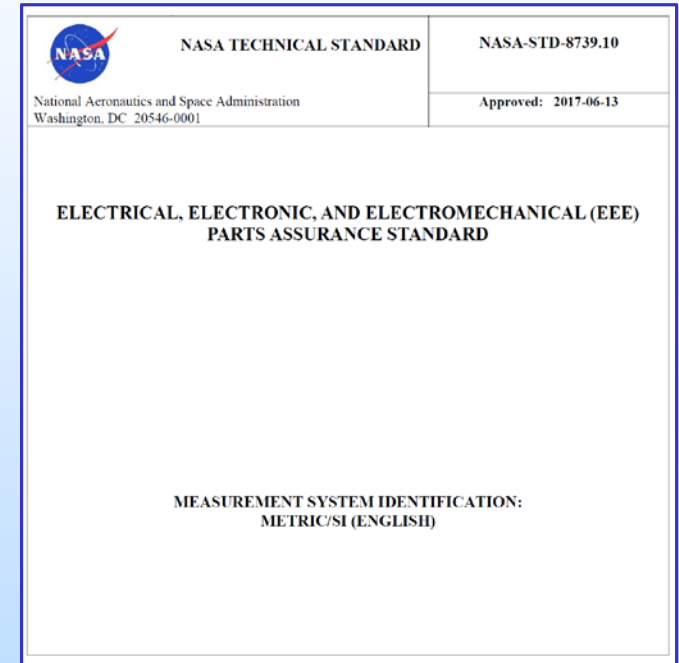


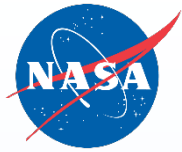
- Capabilities are defined as a combination of technical content, workforce, specialized facilities and infrastructure, as well as unique tools and techniques
- NASA currently has 19 discipline, 7 system, 5 research, and 3 service capabilities
- EEE parts falls under the Avionics discipline within the Capability Leadership Model – EEE parts management function stood up for implementation



NASA EEE Parts – New Structure

- **NASA EEE parts consolidation:**
 - Primary Agency test and analysis activities will be at the Goddard Space Flight Center (GSFC – lead Center) and the Jet Propulsion Laboratory (JPL).
 - **Jonathan Pellish**, the new EEE Parts Manager, will lead.
- **NEPP remains virtually the same:**
 - Owns the EEE parts assurance processes (and related technical efforts)
 - NEPP Management changes with eye to the future
- **New NASA wide documents activities**
 - **NASA Standard 8739.10, Released**
 - First NASA-wide EEE Parts Standard since MIL-STD-975 Canceled May 1998
 - **EEE-INST-002 Unification underway**





General 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**
- Workmanship
- Tech Fellow /
Quality

Capability
Leadership
NESC

Field Centers
Mission
Directorates

Space
Environments
Testing
Management



NASA EEE Parts Manager

- **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, with support from 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**



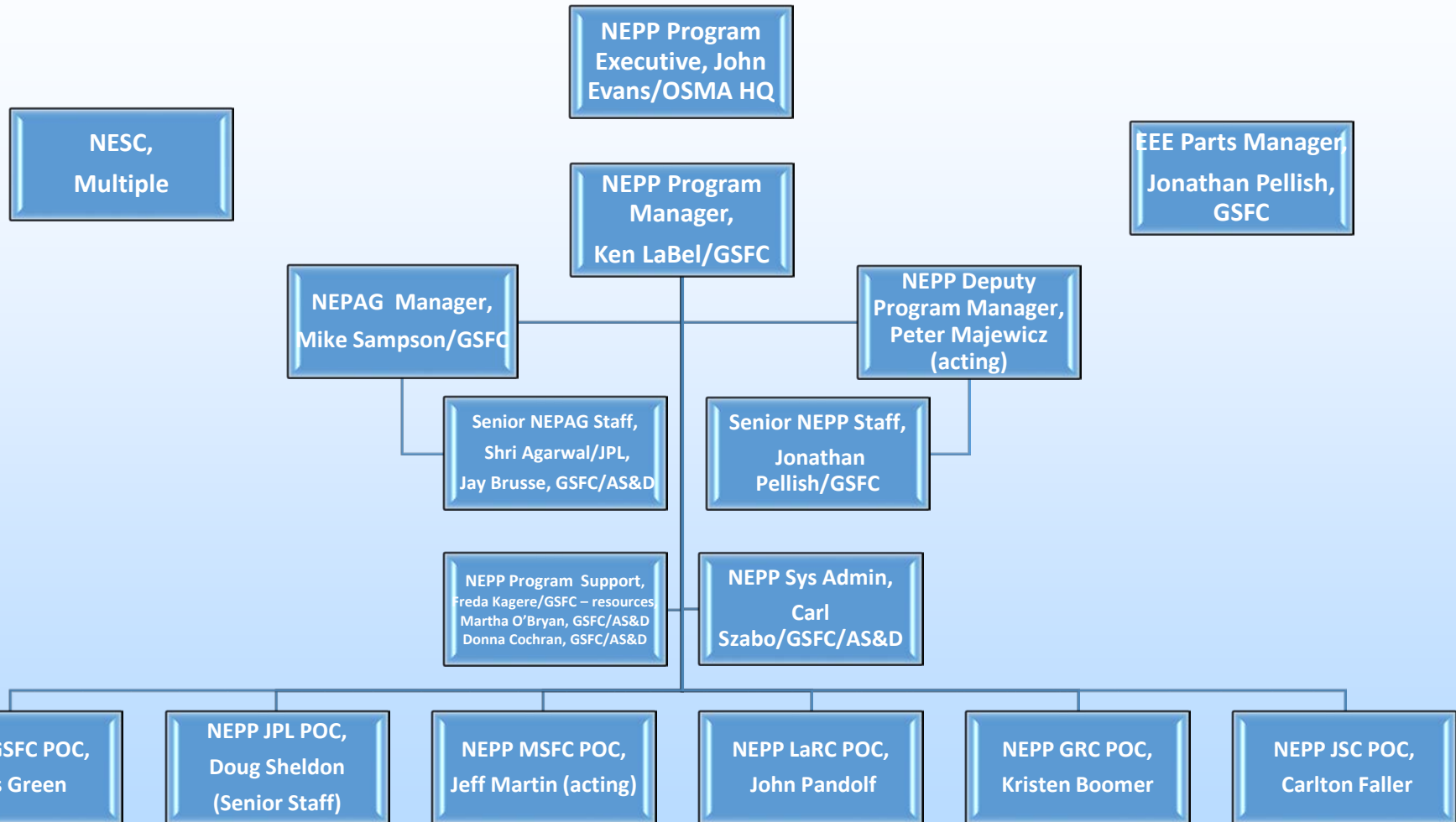
NEPP Mission Statement

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

Note: The NASA Electronic Parts Assurance Group (NEPAG) is a portion of NEPP.



NEPP Program – Organization Chart



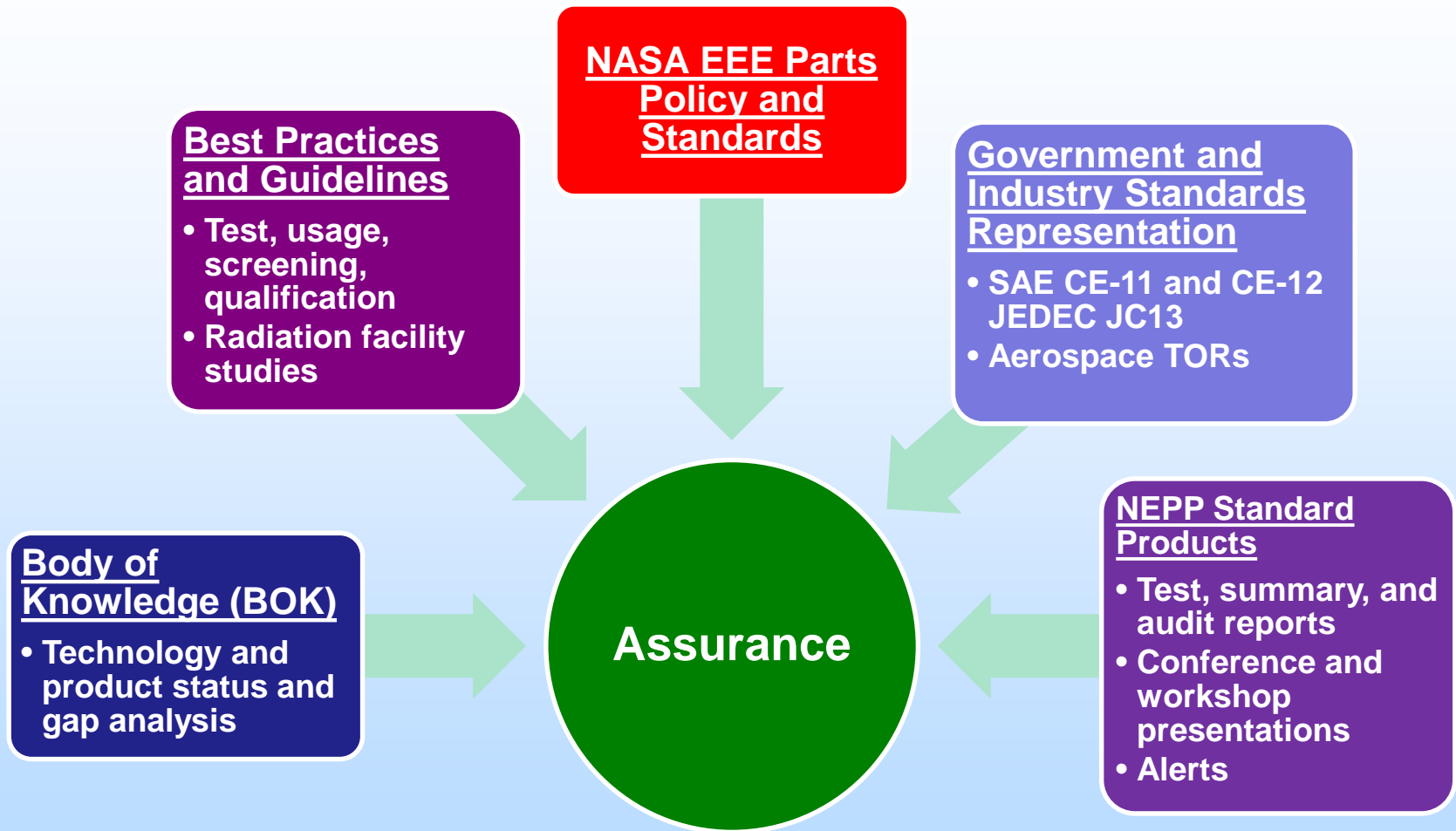


NEPP - Charter



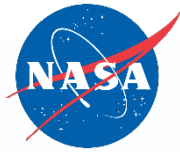


NEPP – Product Delivery



Related task areas:

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

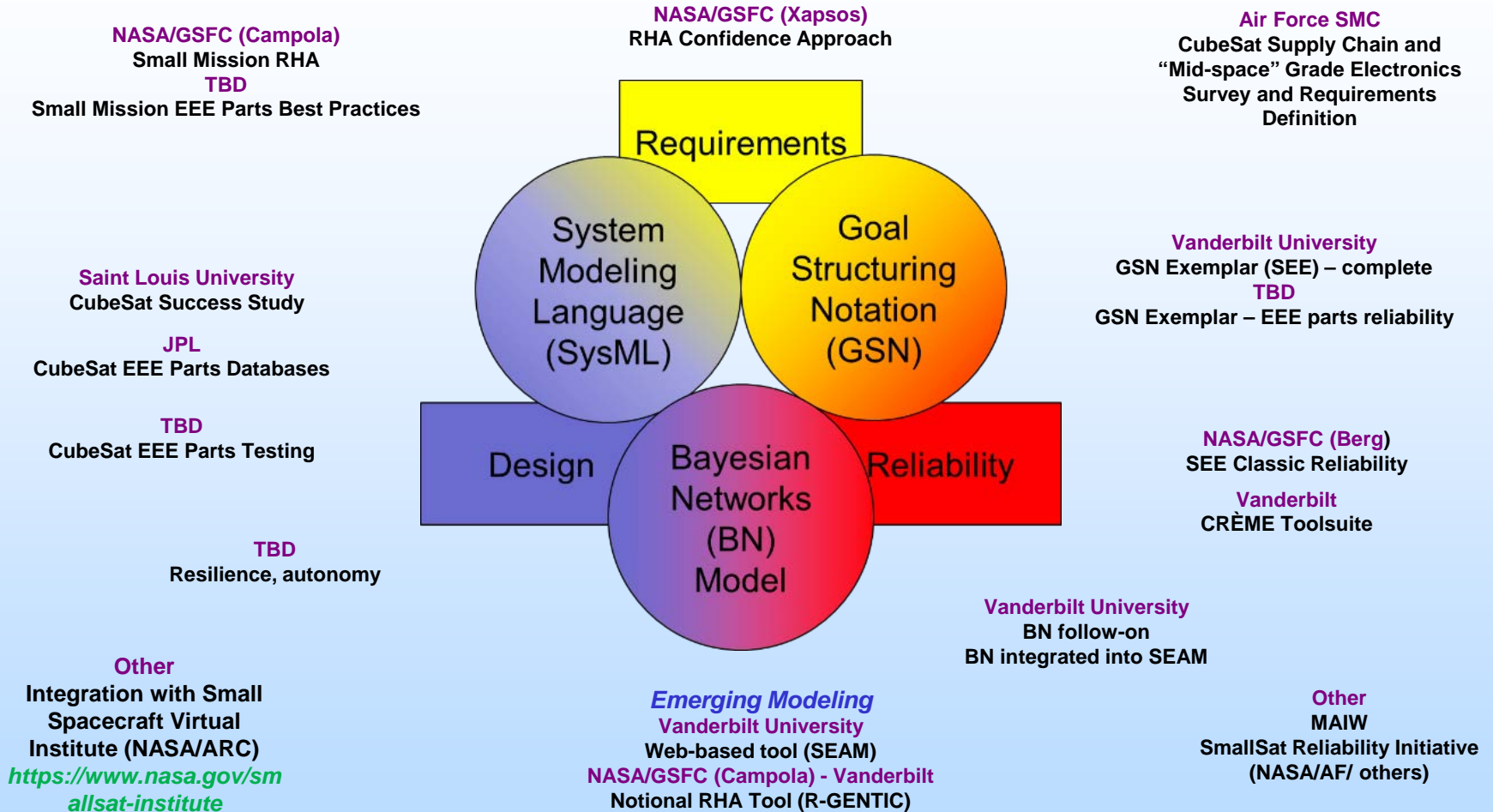


What's New for NEPP in FY18?

- **Agency EEE Parts Manager**
 - Support efforts on workforce, facilities, etc...
- **Increased delivery of assurance products**
 - BOKs, Guidelines, Tools, Information Sharing, Training
 - Unification of NASA documentation (NEPAG)
- **Increased discussion on the role of standardization processes (NEPAG)**
- **Increased emphasis on**
 - Guidance and understanding of small missions such as CubeSats
 - Model-based mission assurance (MBMA) and radiation tool “standardization”
 - Changing EEE parts industry such as the move to “mid-space”
 - Partnering with other NASA organizations, Agencies, and universities
 - Expansion of outreach in all these areas
- **Significant update of the NEPP website planned**
 - Easier to find guidance and search for data
 - New tie-ins to the SmallSat community
- **First look at “big data” analyses...**



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

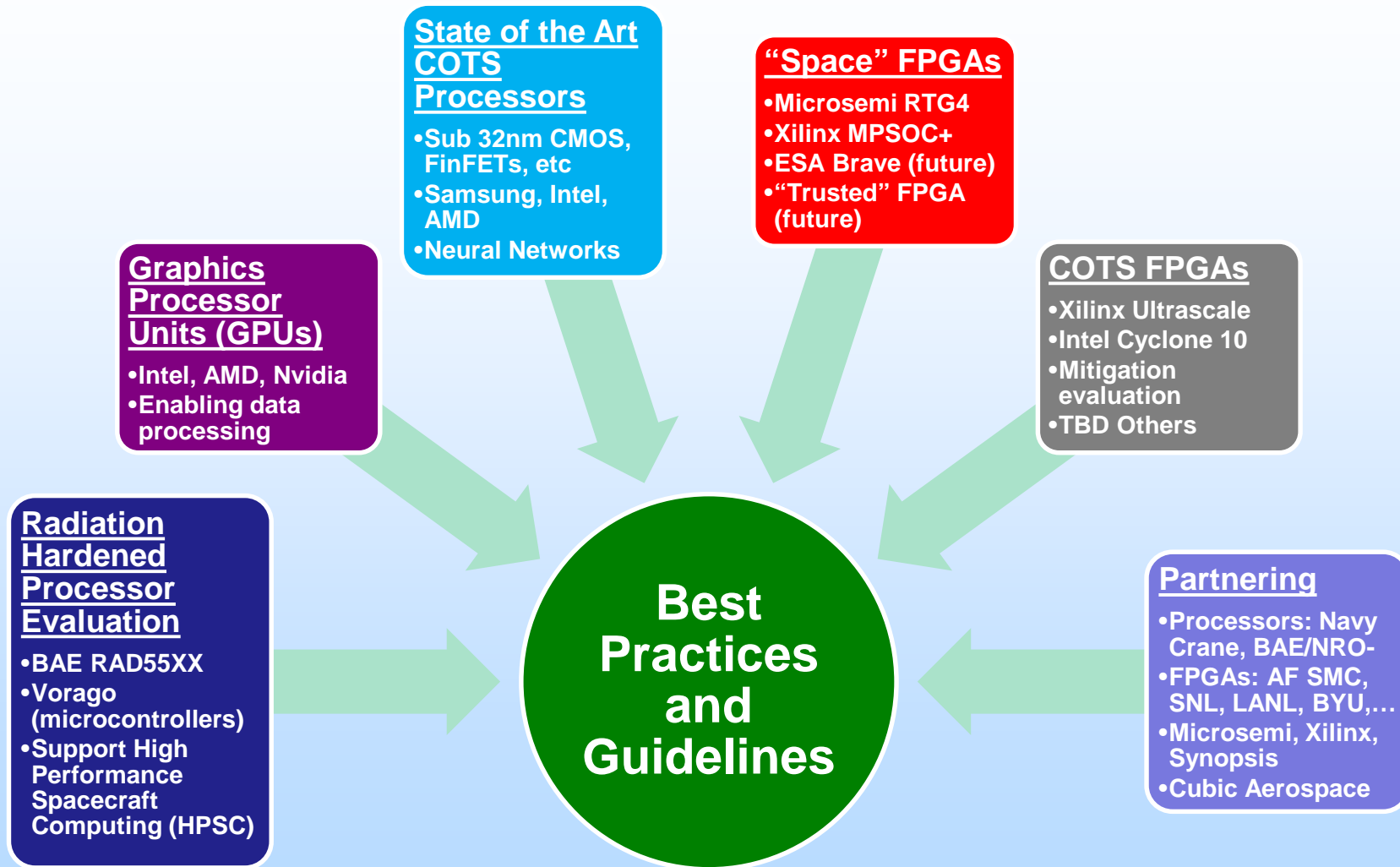


<https://modelbasedassurance.org/>

**Tenet: the best ideas will die on the vine without integration into standard approaches or tools.
It's all about access.**



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



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, Western Digital
- Planar – TBD
- Enabling data storage density

Partnering

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

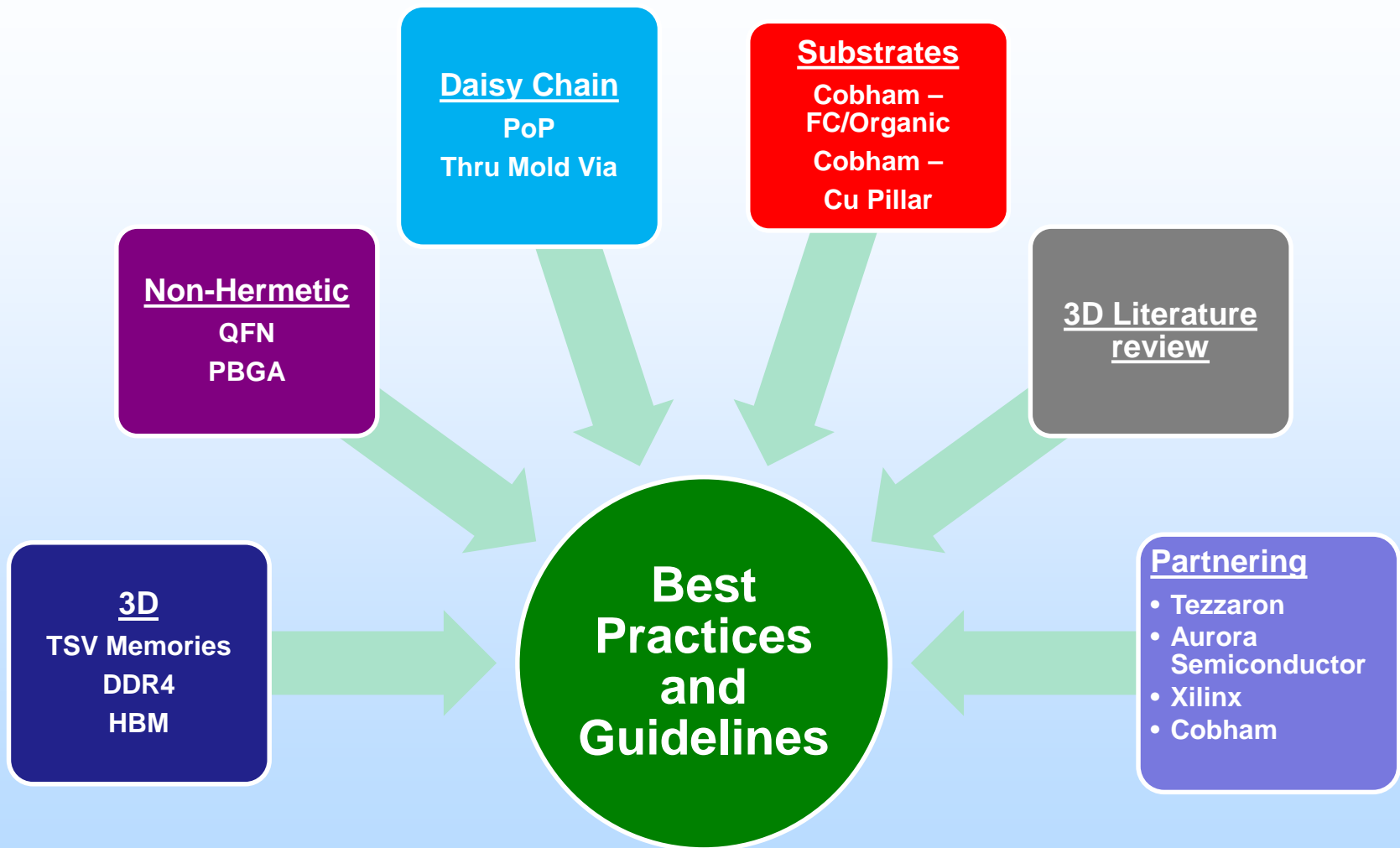
**Best
Practices
and
Guidelines**

Related task areas:

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

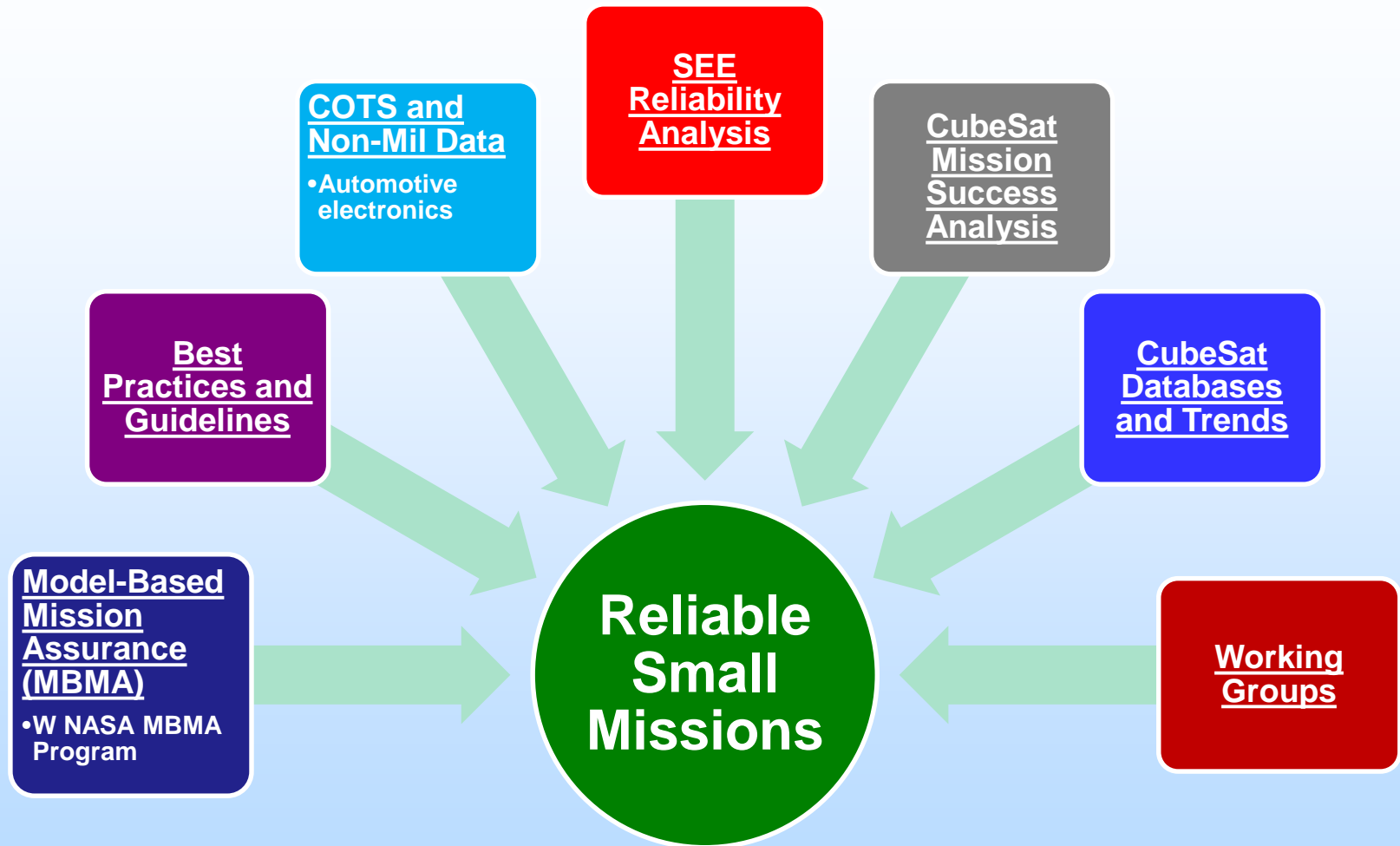


NEPP – Packaging





NEPP - Small Mission and Emerging Architectures Efforts



One goal is working with Vanderbilt University on developing a MBMA toolsuite that encompasses traditional and new radiation hardness assurance (RHA) concepts and tools



“Status” on Proton Test Sites (200 MeV)

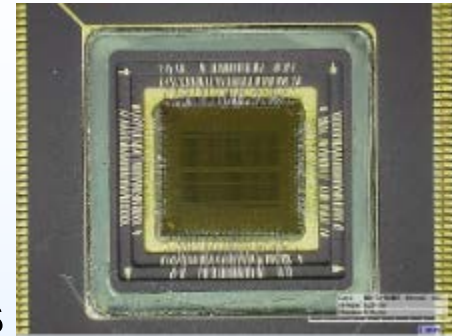
- **The long-time facilities (used prior to IUCF shutdown)**
 - Massachusetts General Hospital (MGH) Francis H. Burr Proton Therapy Center
 - Tri-University Meson Facility (TRIUMF) – Vancouver, CAN
 - James M. Slater, M.D. Proton Treatment and Research Center at Loma Linda University Medical Center (LLUMC)
- **Newer locations that are/were selling or will sell time**
 - California Protons Cancer Therapy Center (formerly SCRIPPS Proton Therapy Center) – unclear if any change of policy or not
 - Northwestern Medicine Chicago Proton Center
 - Mayo Clinic Proton Beam Therapy Program, Rochester, Minnesota and Scottsdale, AZ
 - NASA currently discussing contract options
- **Coming “soon” – either currently willing or planning on access**
 - ProVision (Knoxville) – successful shakeout test held in March
 - Cincinnati Children’s Proton Therapy Center
 - Discussing near-term shakeout test
 - Hampton University Proton Therapy Institute, Hampton, Virginia
 - Building a dedicated research room with planned June/July readiness
- **Possibilities**
 - Oklahoma City’s ProCure Proton Therapy Center
 - The Roberts Proton Therapy Center at University of Pennsylvania Health System
 - Maryland Proton Treatment Center, Baltimore, Maryland – on hold
 - M.D. Anderson Cancer Center's Proton Center, Houston

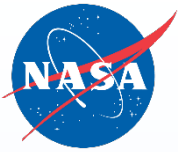
Always open to discussions with ANY location



Content of NASA-STD-8739.10

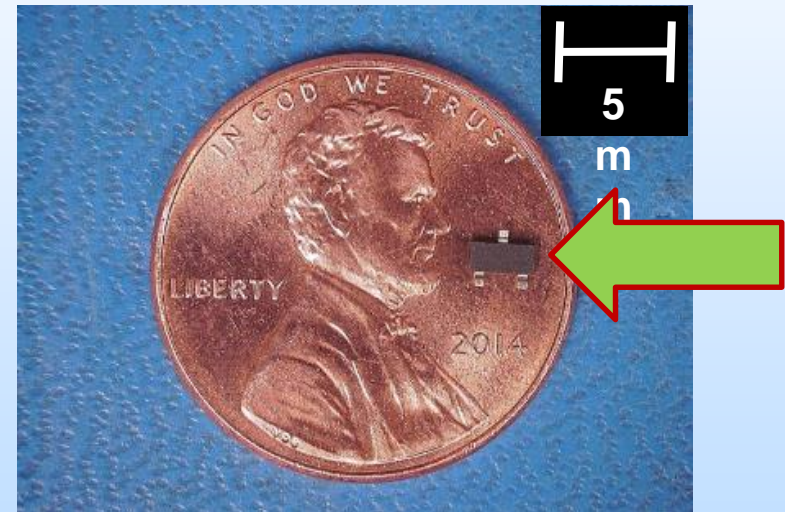
1. Scope
 2. Applicable Documents
 3. Acronyms and Definitions
 4. EEE Parts Classification
 5. EEE Parts Selection Requirements
 6. EEE Parts Assurance and Control Requirements (**Plan**)
 1. Scope
 2. Qualification – Environmental and life testing (includes radiation)
 3. Screening – 100% test for burn-in and parametrics
 4. Government Industry Data Exchange Program (GIDEP) Review
 5. Receiving Inspection
 6. Environmental Control and Storage Requirements (**Plan**)
 7. Electrostatic Discharge (ESD) Control (**Plan**)
 8. Re-use of EEE Parts
 7. EEE Parts Procurement, Obsolescence and Counterfeit Avoidance (**Plans**)
 8. EEE Parts Documentation and Organization (**Plans**)
- Lists of Appendices and Tables





Documentation

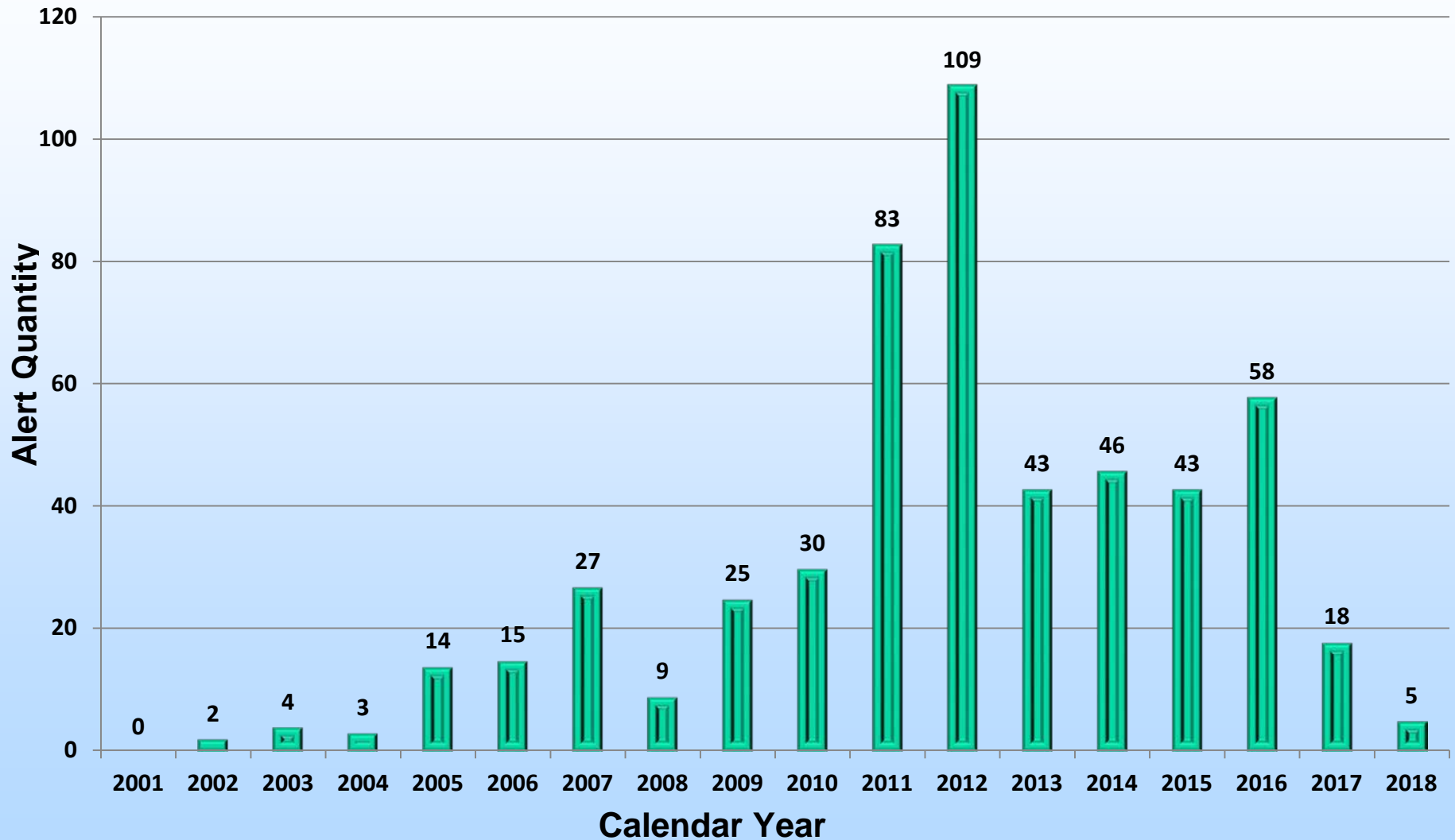
- **Program/Project EEE Parts Management and Control Plan (EPMCP)**
 - Plan can be stand-alone documents or part of Project Product Assurance Plan
 - Specific Issue Plans may be contained in EPMCP or stand-alone documents
- **Parts Lists**
 - (EPARTS recommended)
 - As Designed, As Built Parts Lists
- **Analyses**
 - Derating, Parts Obsolescence
- **Specific Issue Plans**
 - Radiation Hardness Assurance Plan
 - Counterfeit Control Plan
 - Restricted Materials Plan
 - NASA-STD-6016 - Standard Materials and Processes Requirements for Spacecraft
 - Red Plague Control Plan
 - IPC J-STD-001 ES - Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies



Sn, Hg, Zn, Cd ...



Quantity of Counterfeit EEE Parts Alerts per Year





Working Groups – Typical Topics

NASA EEE Parts Assurance Group (*NEPAG)

- DLA Wafer Fab Audit Moratorium
- ITT Cannon Connector Status
- Using IGA Results for Lot Acceptance
- IGA Hybrid Failure Experiences – Recent Example
- Copper Bond Wire EP Study
- IGA Lot Acceptance Discussion
- New Trends in Building Rad Hard Space ICs
- ESD Harmonization Status
- Comments on NSREC Paper re Rad Implications of Kr-85 Leak Testing
- RGA Requirement Changes

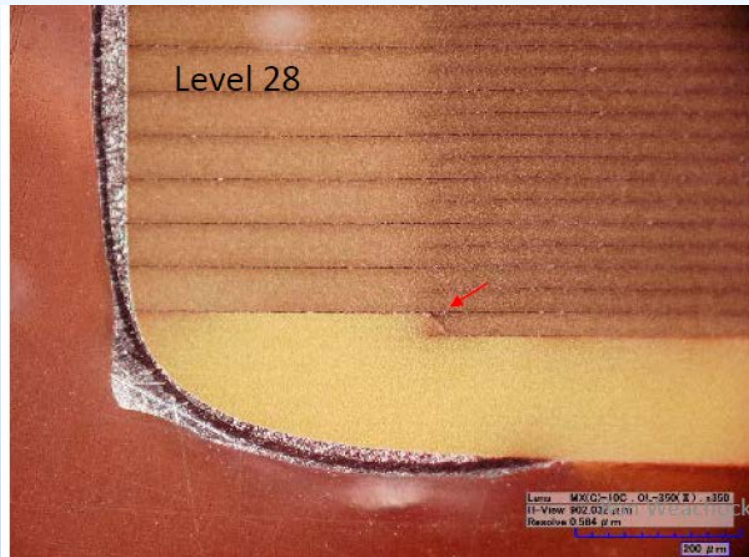
Government Working Group (GWG)

- JEDEC Proposal to Change X-ray Voiding Criteria
- MIL-STD-1580 Changes
- Standardization of Manufacturer Record Retention Requirements
- Proposed Changes to MIL-PRF-19500
- Standardization of Connector Specifications to Reduce SCDs
- Review MIL-STD-883 TM 5004
- Review MIL-STD-202 test methods
[Some methods last revised in the 1950s!](#)
- M19500 Burn-in/Life Test Sample Size
- EP (Engineering Practices) Study Cu Bond Wire Test Requirements

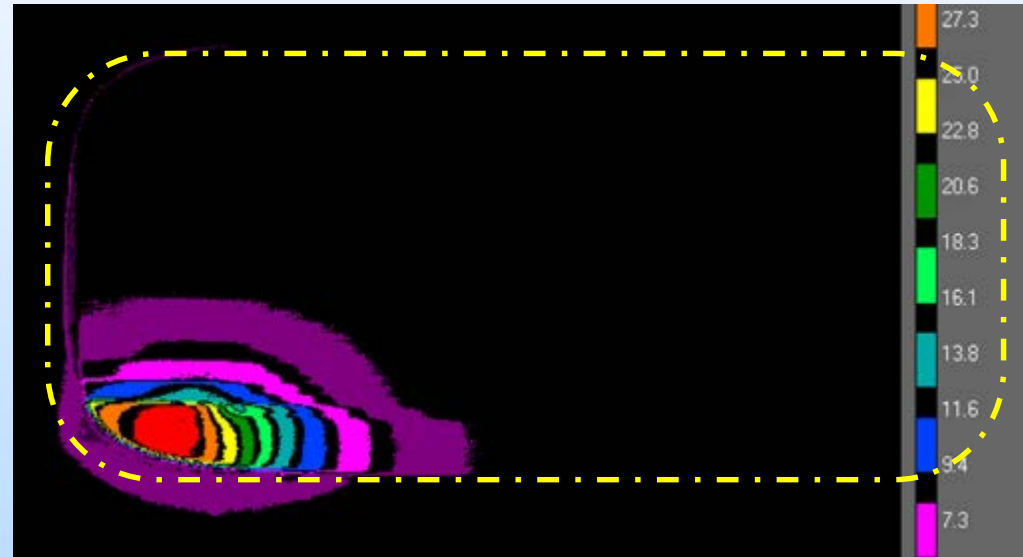


Recent Capacitor Issues

- NASA GSFC Report J17537
- Cross Section of ceramic chip capacitor that has developed internal low resistance path



- NASA GSFC Report J17537
- Infrared Image to detect high leakage current path inside of ceramic chip cap





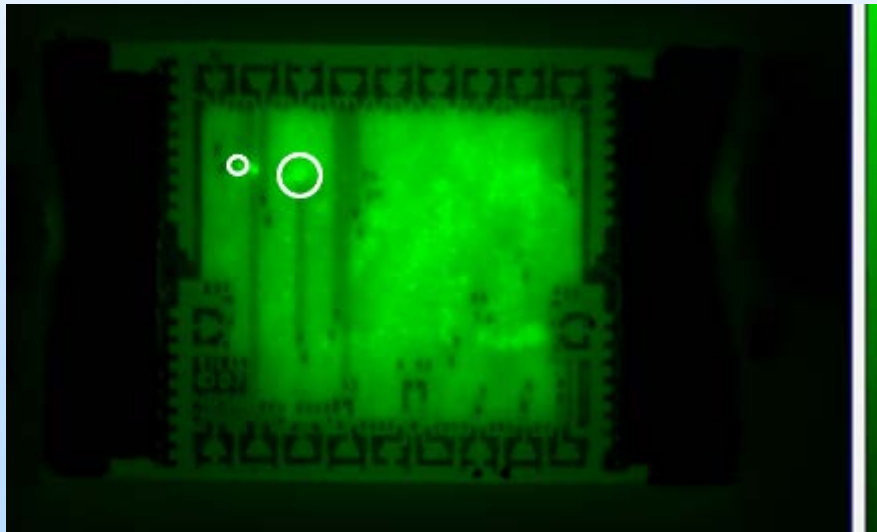
NEPP-Developed Improved Screening Technique for Foil (and other) Resistors

One Resistor that Exhibited Two Delta R Changes During Life Test

Failure Mode = +10440 ppm @ 250 hours; +11365 ppm @ 2k hours

BEFORE Life Test

Multiple “Hot Spots” Detected
Indicating Local Bridge Type Defects



AFTER Life Test

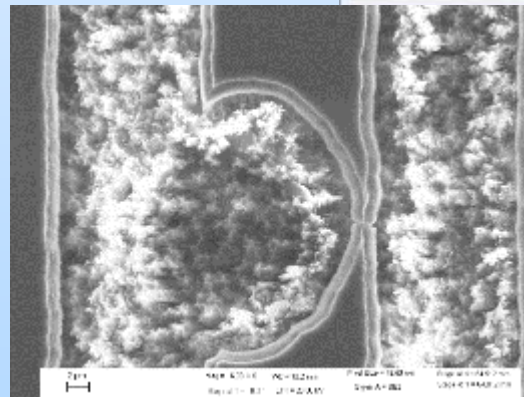
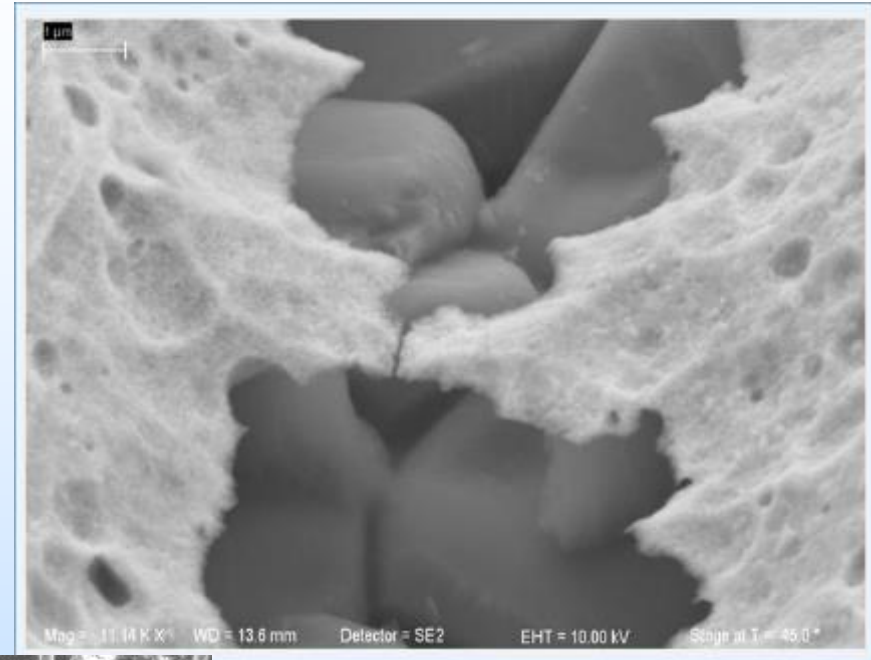
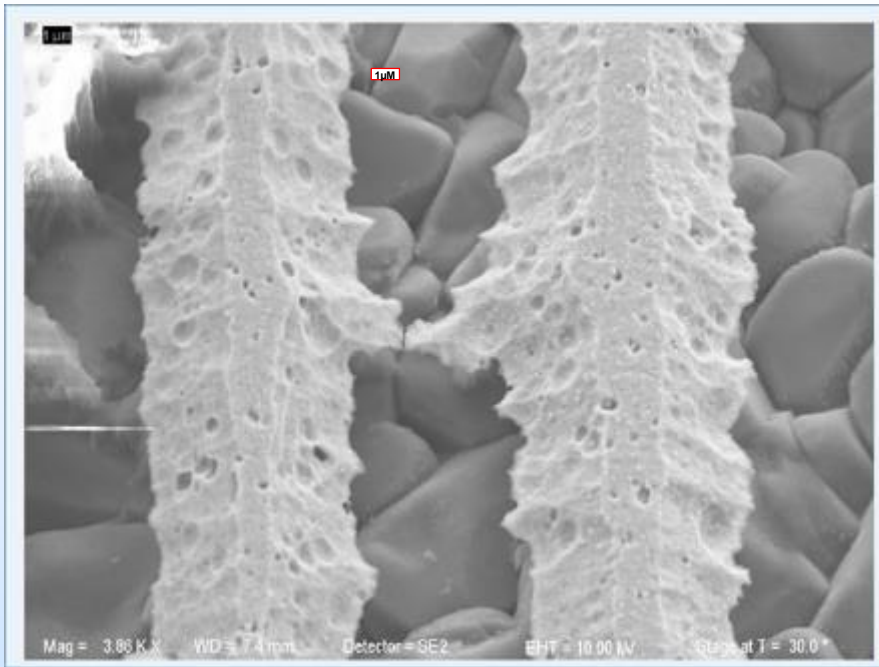
Two “Hot Spots” are Gone
Indicating Fracture of Bridge Type Defects

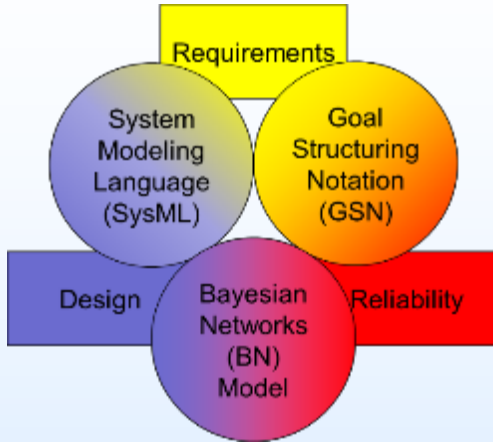


Apply brief power pulses while examining for “hot spots” using high-resolution infrared thermography



Broken "Bridge" Between Gridlines



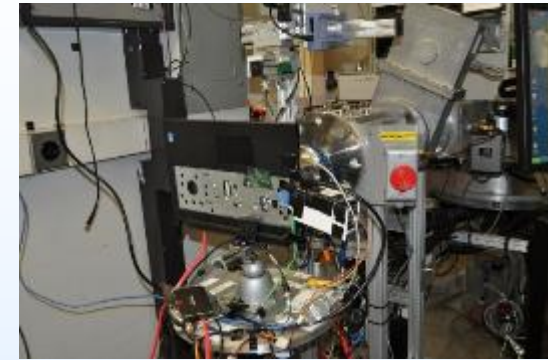


Emerging Assurance Methods
(Witulski, Vanderbilt University, NEPP ETW 2017)

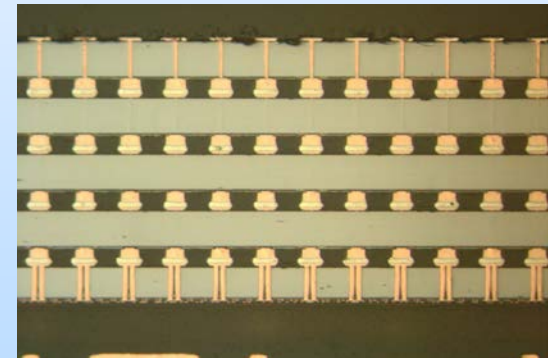
9th Annual NEPP Electronics Technology Workshop (ETW)

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

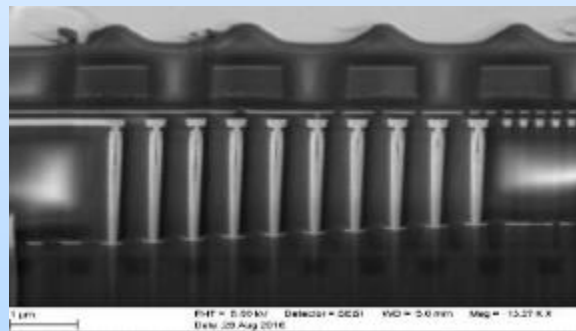
Special sessions on:
Small Mission Success
PEMS/Cu Wirebonds
2.5/3D ICs
Discussion on audit utility



Radiation Testing



Commercial IC Packaging



Advanced Technology Reliability



Summary

- ***“The only constant is change”***
 - However, NEPP’s responsibilities to mission assurance remain the same
- **An overview has been presented of:**
 - NASA’s EEE Parts structure
 - NEPP Program and it’s NEPAG subset
 - Selected highlights and recent part issues
- **NEPP’s bigger concerns (only touched on)**
 - Radiation test/facility infrastructure
 - Manufacturer audits
 - Semiconductor fab closures and consolidations
 - Changing space industry
- ***Join us at NEPP ETW to discuss these and others!***

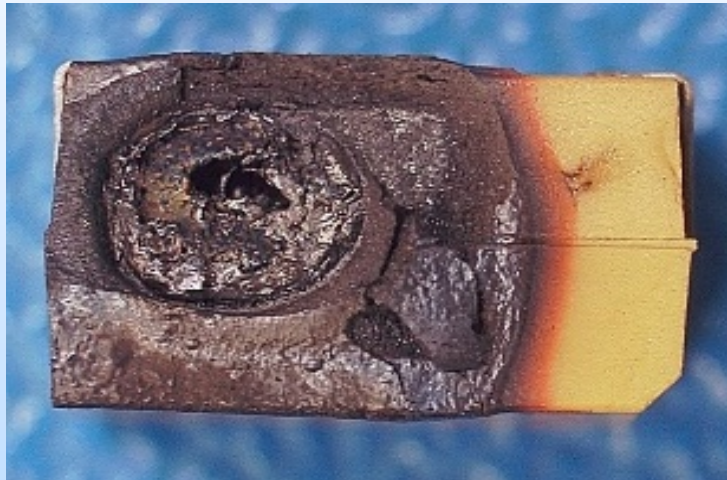
Questions?



<https://nepp.nasa.gov>

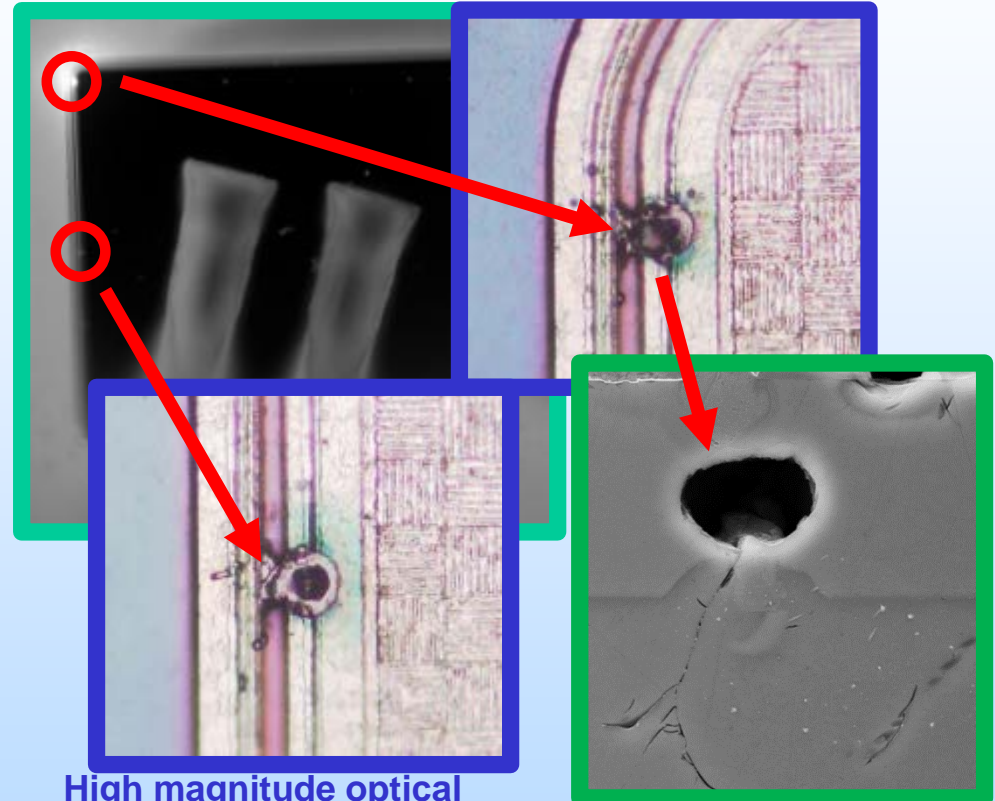


NEPP - Working Industry/Agency-Wide Concerns



Tantalum capacitor failure

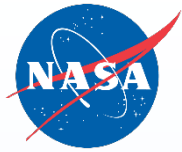
Thermal Image of failure locations



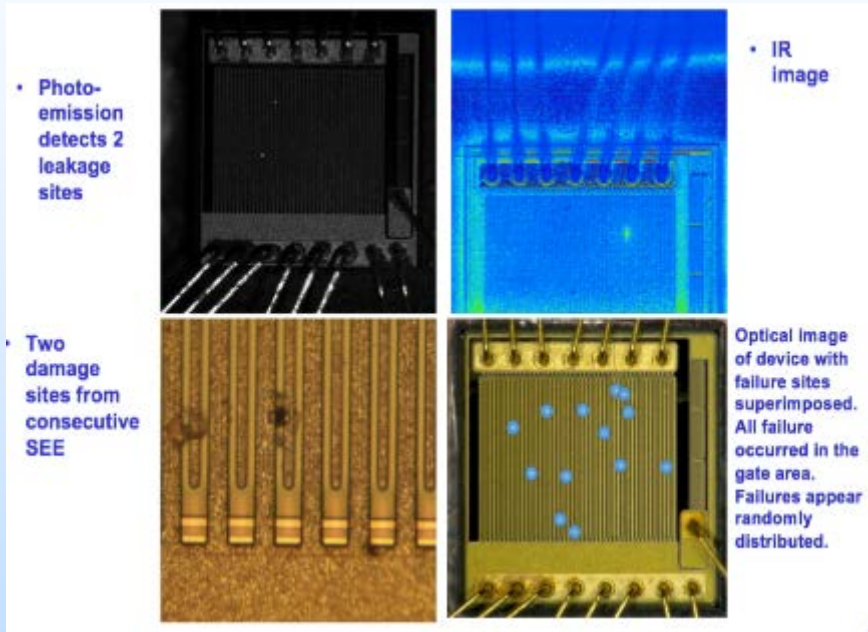
High magnitude optical images of failure locations

Cross-section of failure location

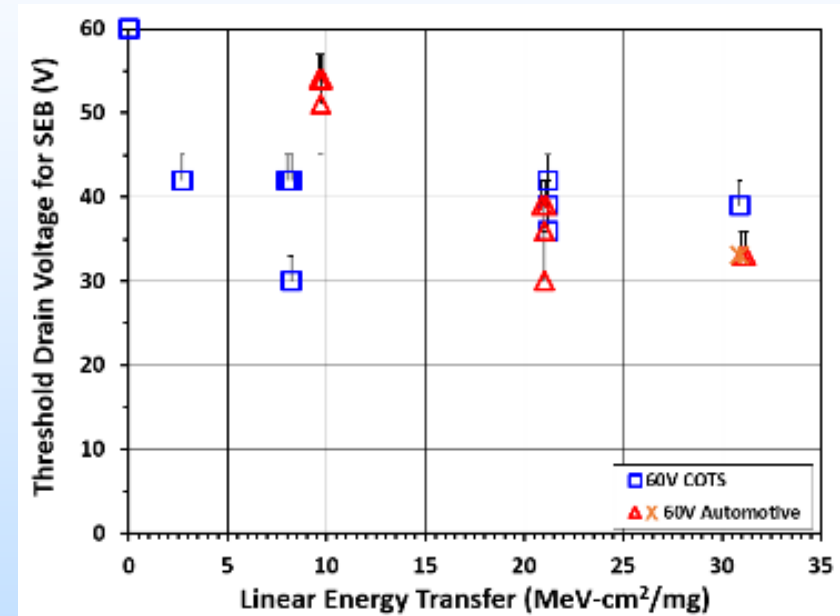
Failure analysis of Schottky diode radiation damage



Vendor Validation Tests



GaN IC – radiation test analysis

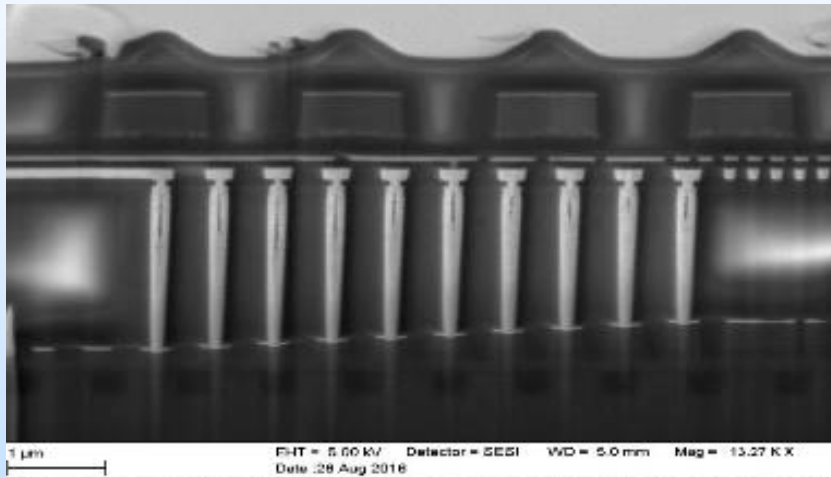


Comparison of n-type 60V trench MOSFET SEB thresholds

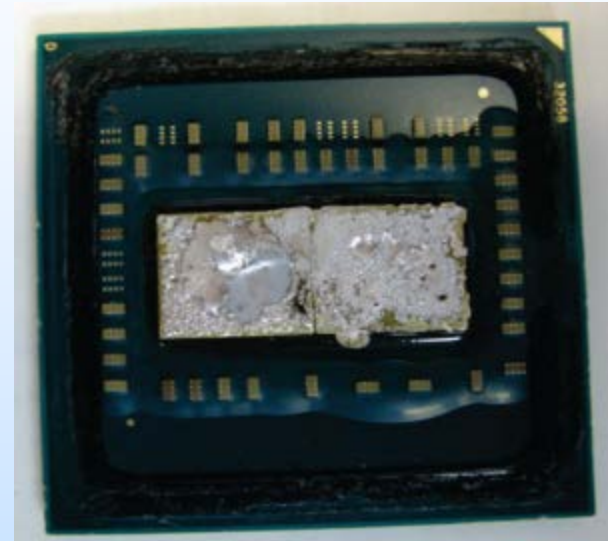


Advanced Technologies

- 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
 - Discussion with other government Agencies as additional partners



Infrastructure Challenges



*Using Proton Cancer Therapy Centers
for electronics testing*