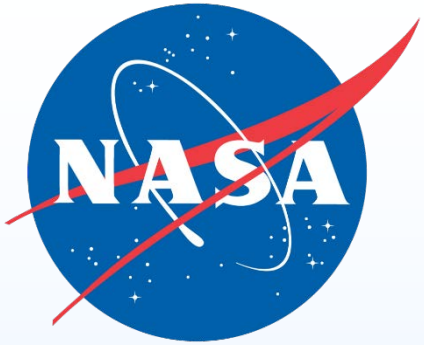

NASA's Changing Electronics Landscape: NEPP Focus, Agency Alignment, and Technology Development

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To be presented by Kenneth A. LaBel and Jonathan A. Pellish at the Microelectronics Reliability and Qualification Working (MRQW) Meeting, El Segundo, CA, February 6-8, 2018.

Acronyms

- Three Dimensional (3D)
- Air Force (AF)
- Air Force Space & Missile Systems Center (AF SMC)
- Advanced Micro Devices, Inc. (AMD)
- Ames Research Center (ARC)
- 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)
- 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)
- Goddard Space Flight Center(GSFC)
- Goal Structuring Notation (GSN)
- High Bandwidth Memory (HBM)
- High Performance Spacecraft Computing (HPSC)
- Integrated Circuit (IC)
- Infrared (IR)
- Indiana University Cyclotron Facility (IUCF)
- Joint Electron Device Engineering Council (JEDEC)
- Jet Propulsion Laboratories (JPL)
- Los Alamos National Laboratories (LANL)
- 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)
- 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)
- NASA Office of the Chief Engineer (OCE)
- NASA Office of Safety and Mission Assurance (OSMA)
- Package on Package (PoP)
- 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

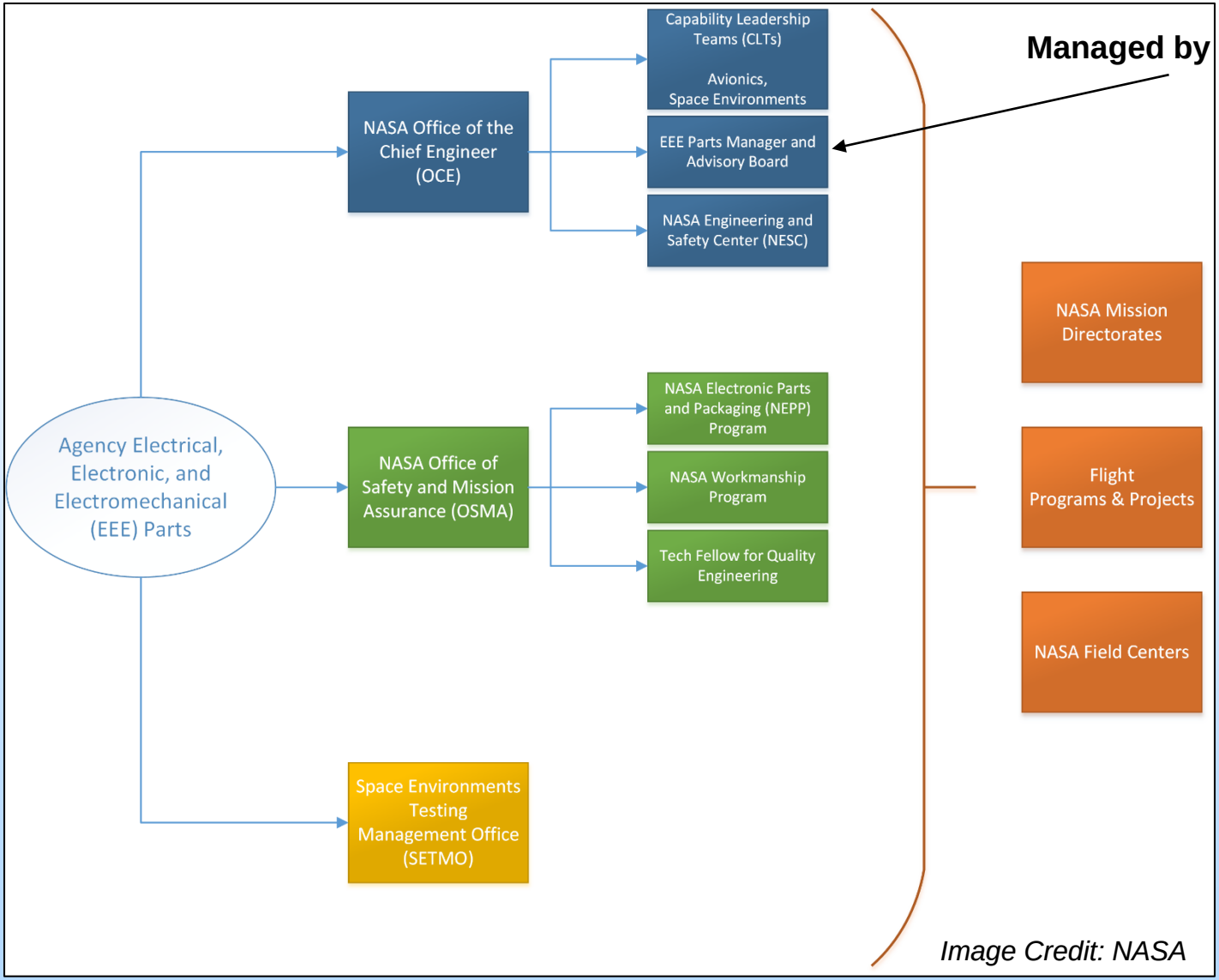
- **NASA Electrical, Electronic, and Electromechanical (EEE) Parts Landscape**
  - **Why the Change?**
  - **General Agency EEE Parts Interfaces**
  - **EEE Parts Manager: A New Role in the Agency**
- **2018 Activities**
  - **NASA Electronic Parts and Packaging (NEPP) Program**
  - **NASA Space Technology Mission Directorate (STMD)**
  - **NASA Space Environments Testing Management Office (SETMO)**
- **Summary**

EEE Parts – Why the Change?

Image Credit: NASA

- **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**

General NASA EEE Parts Interfaces



NASA EEE Parts Manager

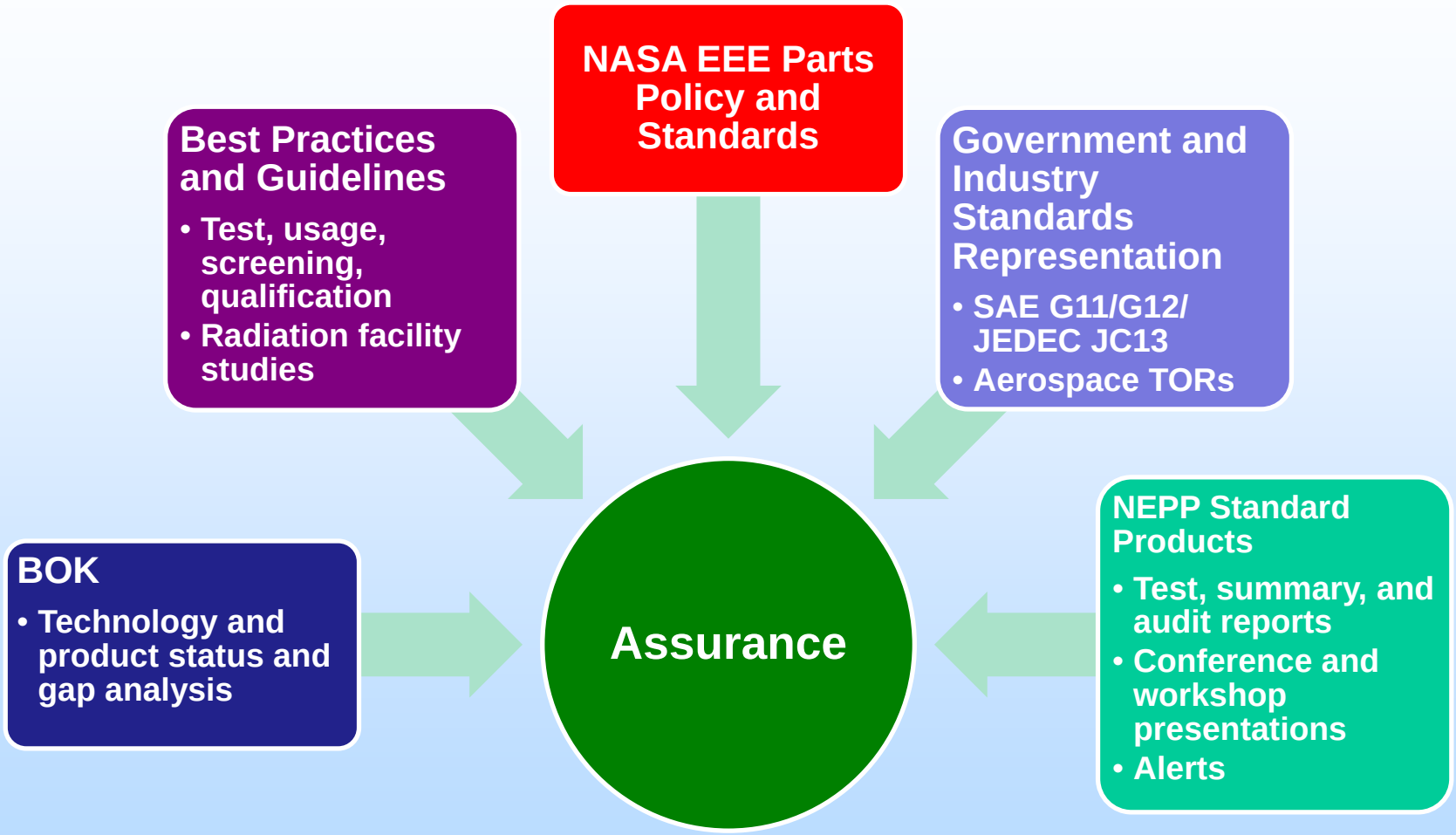
- **Manage consolidation and centralization of EEE parts workforce**
  - **Radiation effects on EEE parts are in scope, as is management of the Agency radiation facility block buy**
  - **GSFC is lead Center, with support from JPL**
- **Provide resources for Centers to acquire EEE parts workforce expertise and a forum to coordinate activities with stakeholders (e.g., OCE, OSMA, SETMO, 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 usage of electrical, electronic, and electromechanical (EEE) parts by NASA, in collaboration with other government Agencies and industry.

NEPP - Charter

NEPP – Product Delivery



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)**

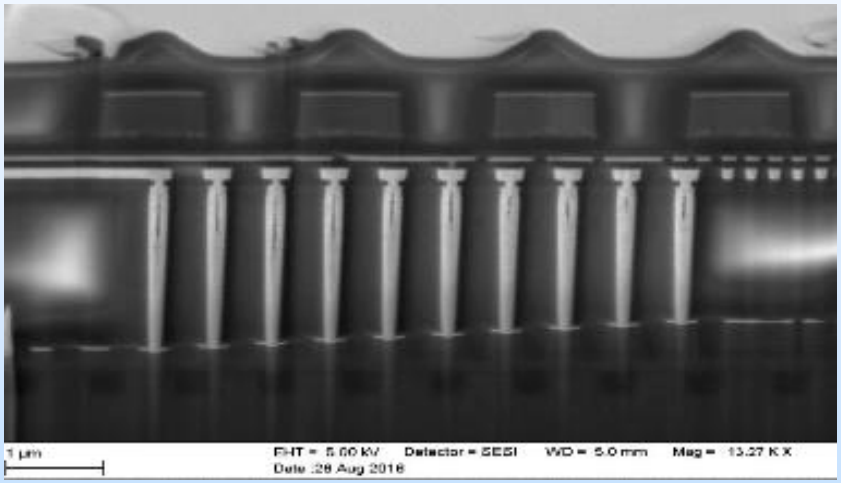
BODY OF KNOWLEDGE FOR SILICON CARBIDE POWER ELECTRONICS

What's New for NEPP in FY18

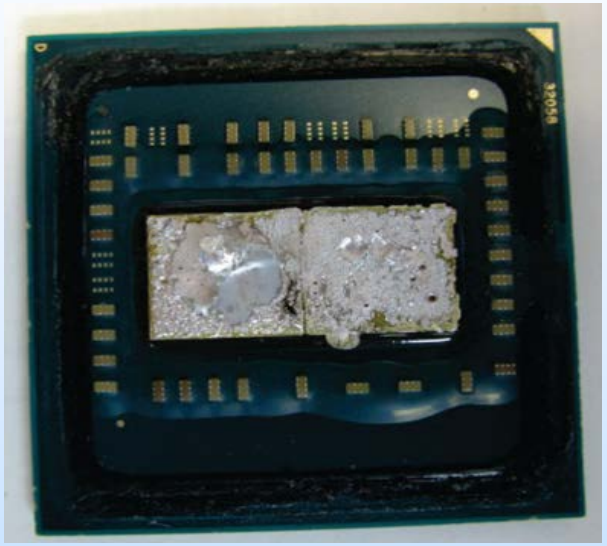
- **Increased emphasis on needs of small missions such as CubeSats and model-based mission assurance (MBMA)**
  - **Partnering with other NASA organizations, Agencies, and universities**
  - **Expansion of outreach in this area**
- **More assurance products**
  - **BOKs, Guidelines, Tools, Information Sharing, Training**
- **Significant update of the NEPP website planned**
  - **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**



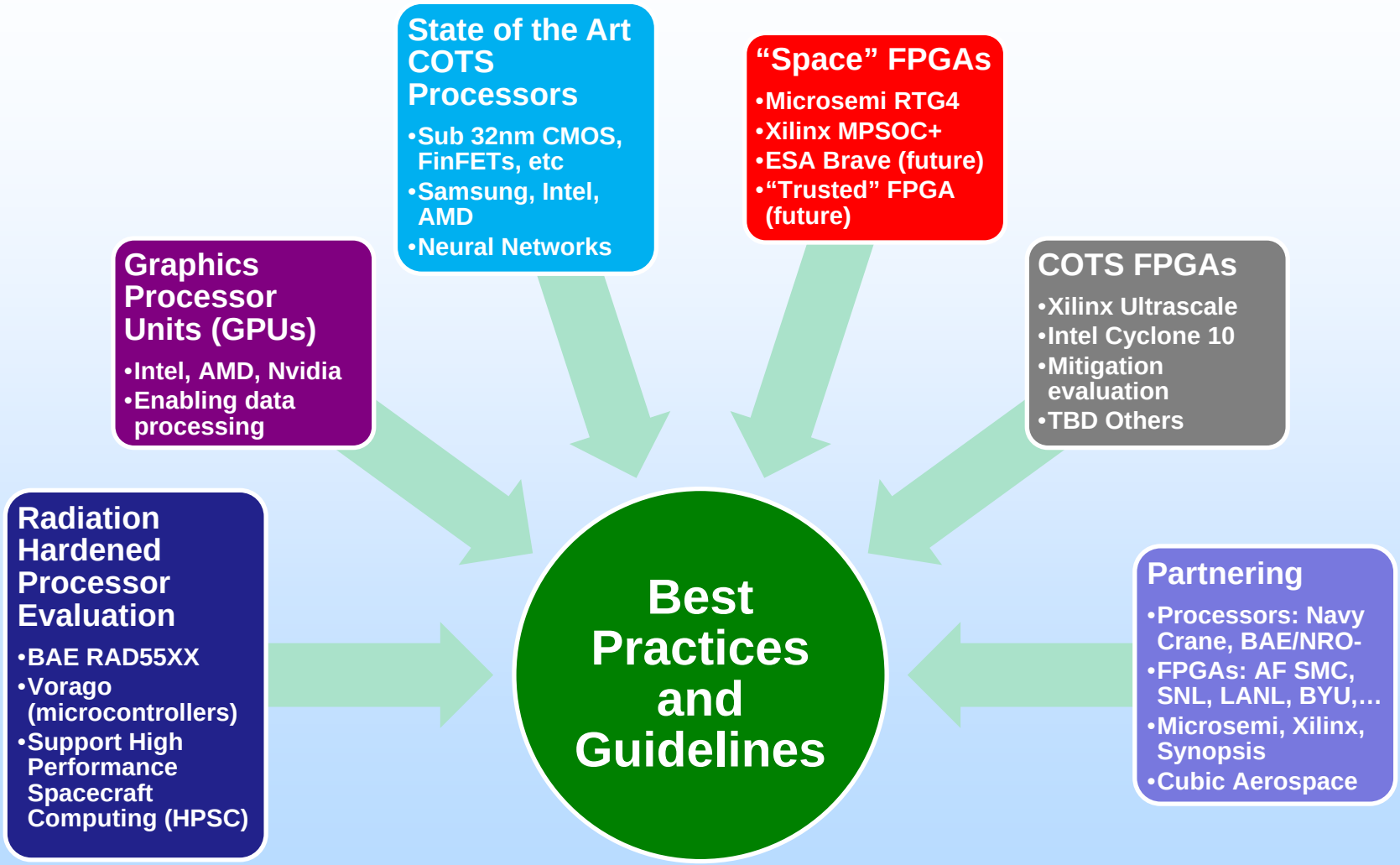
Hynix 3D Flash Memory



AMD Ryzen Processor

- **New: collaboration with DMEA and GlobalFoundries on 22nm FD-SOI and 28nm bulk radiation evaluation**
  - **Discussion with other government Agencies as additional partners**

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



Potential task areas:

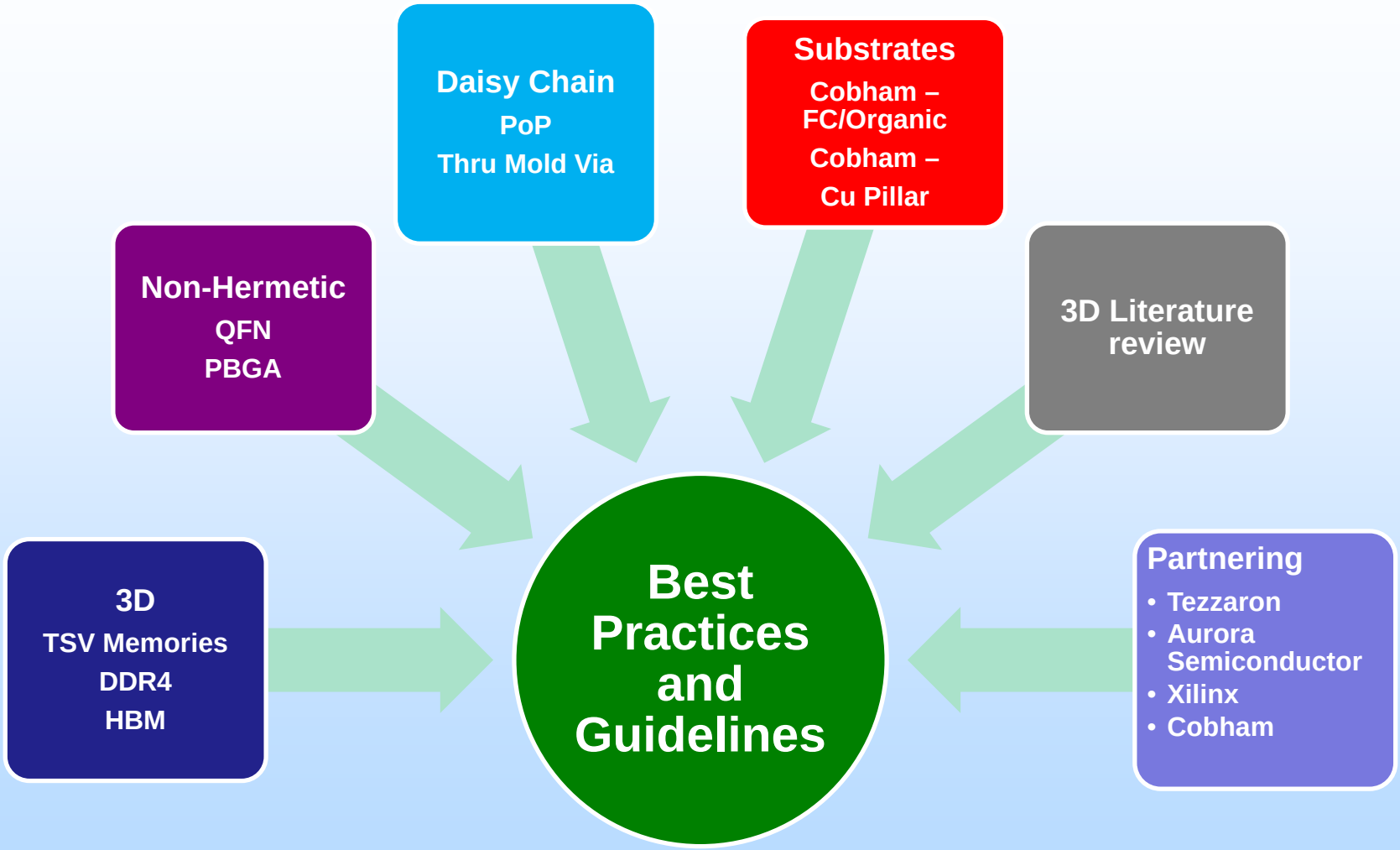
artificial intelligence (AI) hardware, Intel Stratix 10

NEPP – Memories

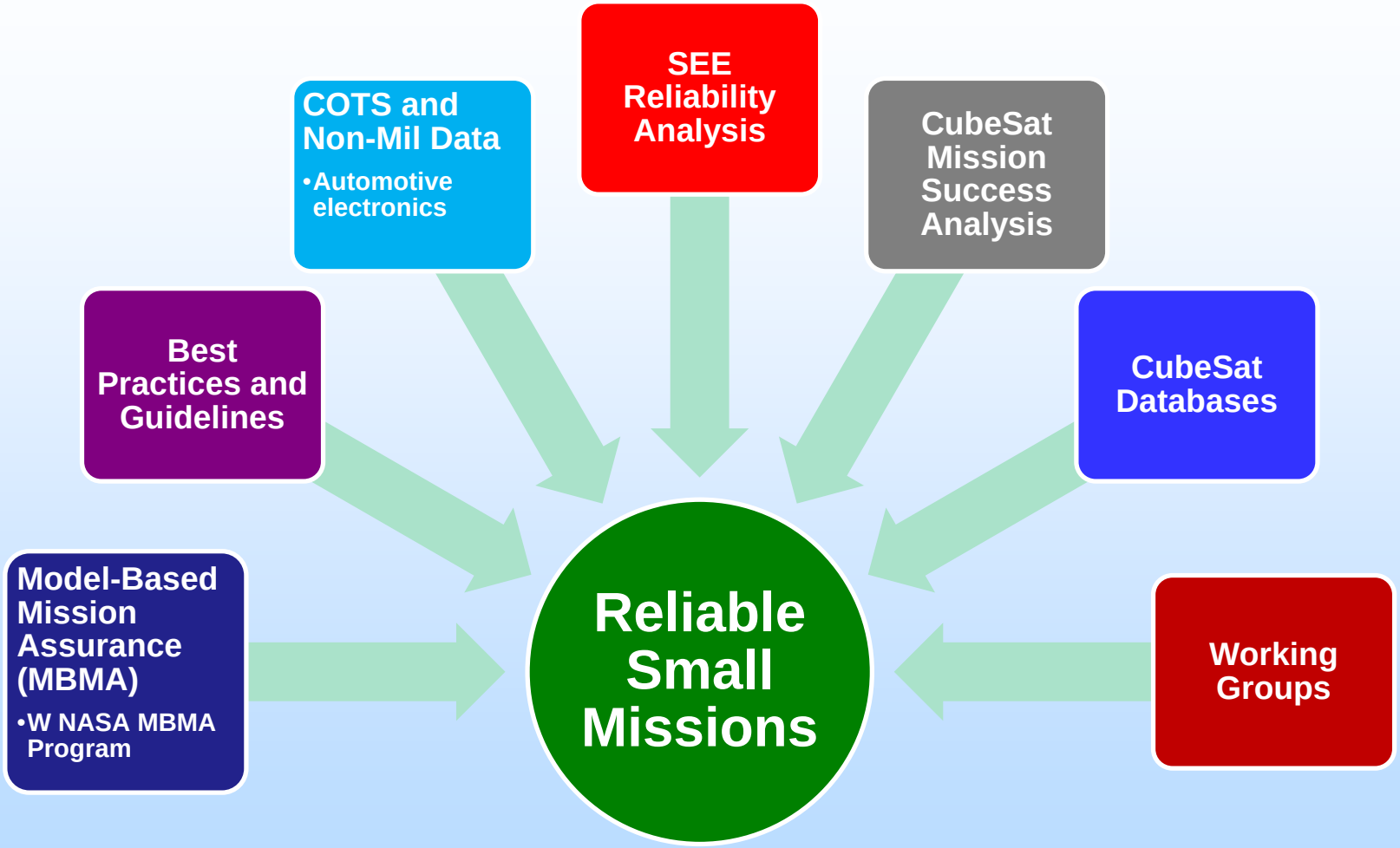
Related task areas:

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

NEPP – Packaging



NEPP - Small Mission and Emerging Architectures Efforts



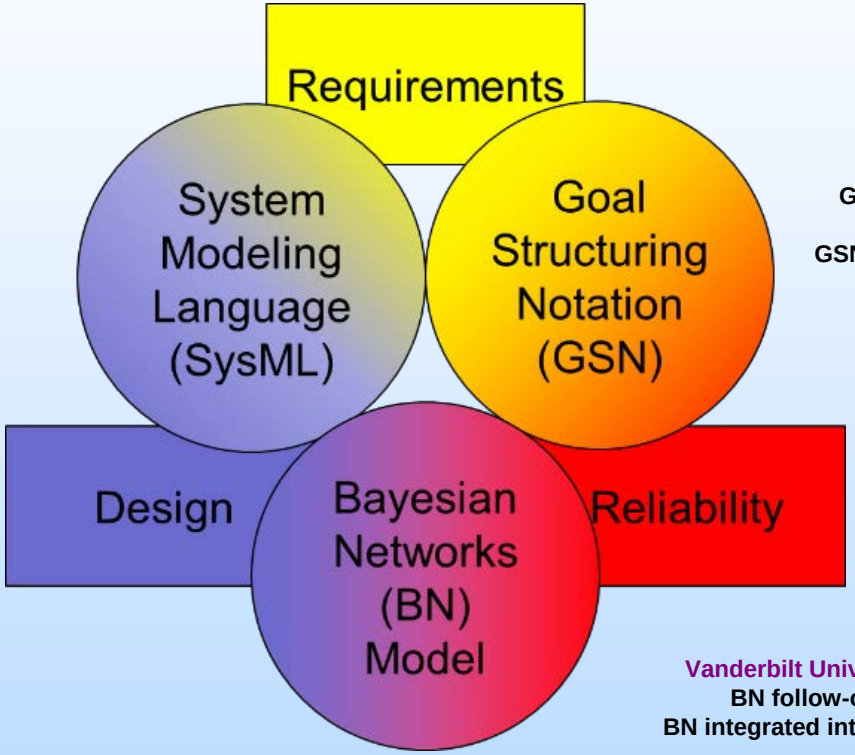
Big goal is working with Vanderbilt University on developing a MBMA toolsuite that encompasses traditional and new radiation hardness assurance (RHA) concepts and tools

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

Air Force SMC
CubeSat Supply Chain and "Mid-space" Grade Electronics Survey and Requirements Definition



Saint Louis University
CubeSat Success Study

JPL
CubeSat EEE Parts Databases

TBD
CubeSat EEE Parts Testing

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

NASA/GSFC (Berg)
SEE Classic Reliability

Vanderbilt
CRÈME Toolsuite

TBD
Resilience, autonomy

Vanderbilt University
BN follow-on
BN integrated into SEAM

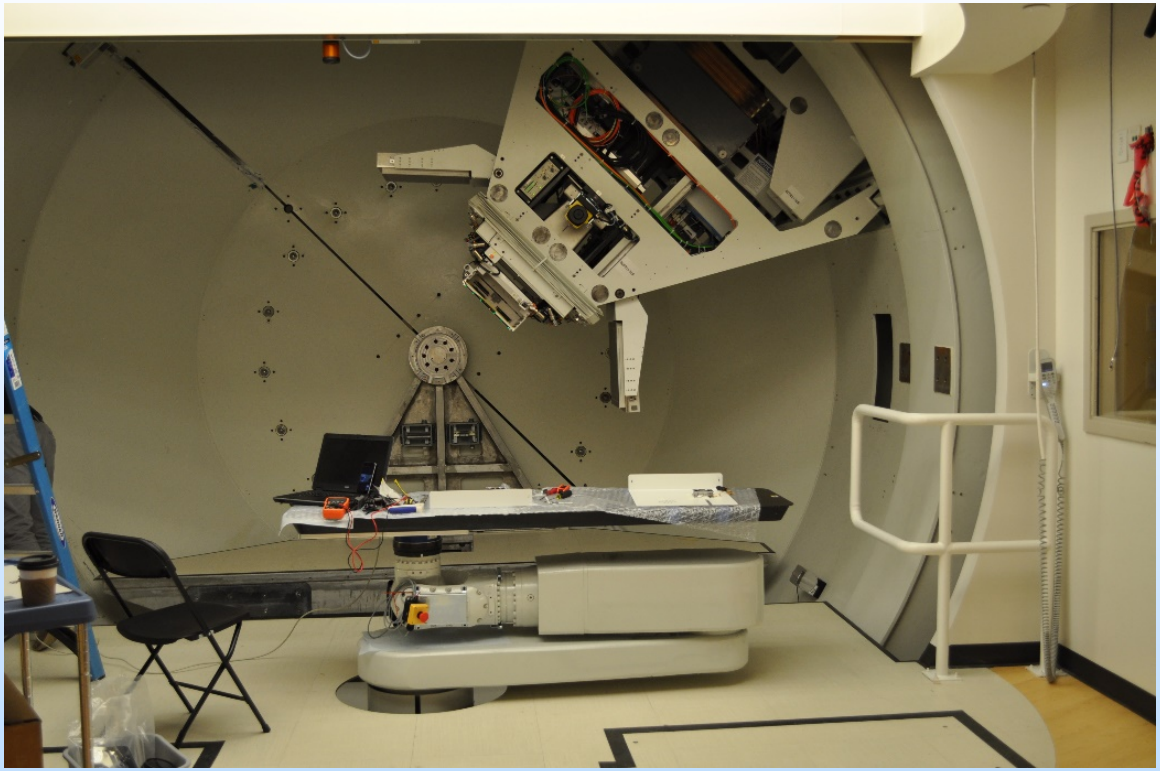
Other
Integration with Small Spacecraft Virtual Institute (NASA/ARC)
https://www.nasa.gov/smallsat-institute

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

Other
MAIW
SmallSat Reliability Initiative (NASA/AF/ others)

https://modelbasedassurance.org/

Infrastructure Challenges



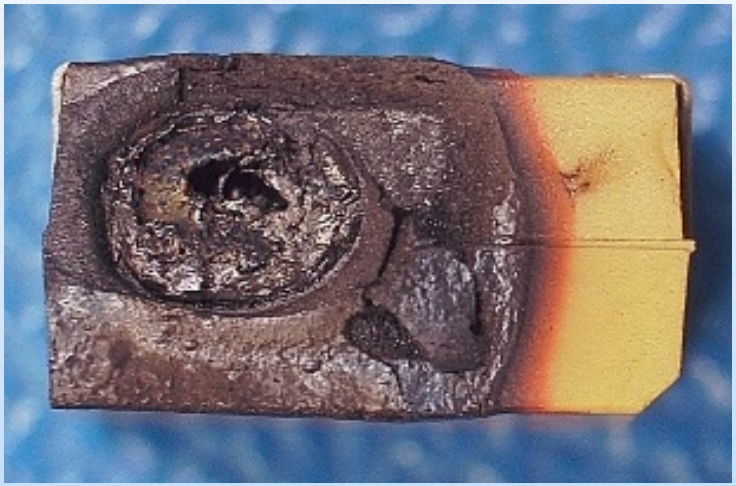
Using Proton Cancer Therapy Centers for electronics testing

"Status" on Where We Test

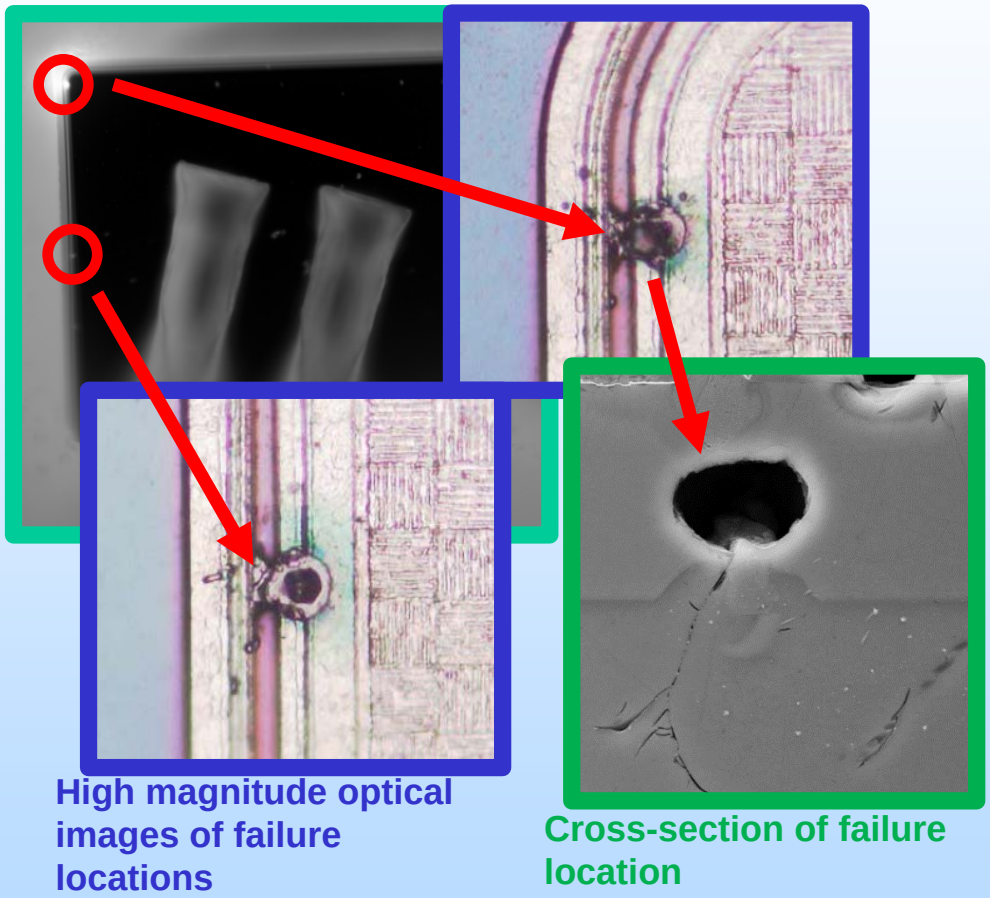
- The long-time facilities (used prior to IUCF shutdown
  - Massachusetts General Hospital (MGH) Francis H. Burr Proton Therapy Center
  - Tri-University Meson Facility (TRIUMF) – Vancouver, CAN
  - James M. Slater, M.D. Proton Treatment and Research Center at Loma Linda University Medical Center (LLUMC)
- Newer locations that are selling time
  - California Protons Cancer Therapy Center (formerly SCRIPPS Proton Therapy Center) – unclear if any change of policy or not
  - Northwestern Medicine Chicago Proton Center
- Coming "soon" – either currently willing or planning on access
  - Mayo Clinic Proton Beam Therapy Program, Rochester, Minnesota and Scottsdale, AZ
    - NASA currently discussing contract options
  - Cincinnati Children's Proton Therapy Center
    - Load by patients/internal research has been higher than anticipated slowing down external user access
  - 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
    - Renegotiating new contract with Varian services – outcome will determine access
  - M.D. Anderson Cancer Center's Proton Center, Houston

Always open to discussions with ANY location

Working Industry/Agency-Wide Concerns

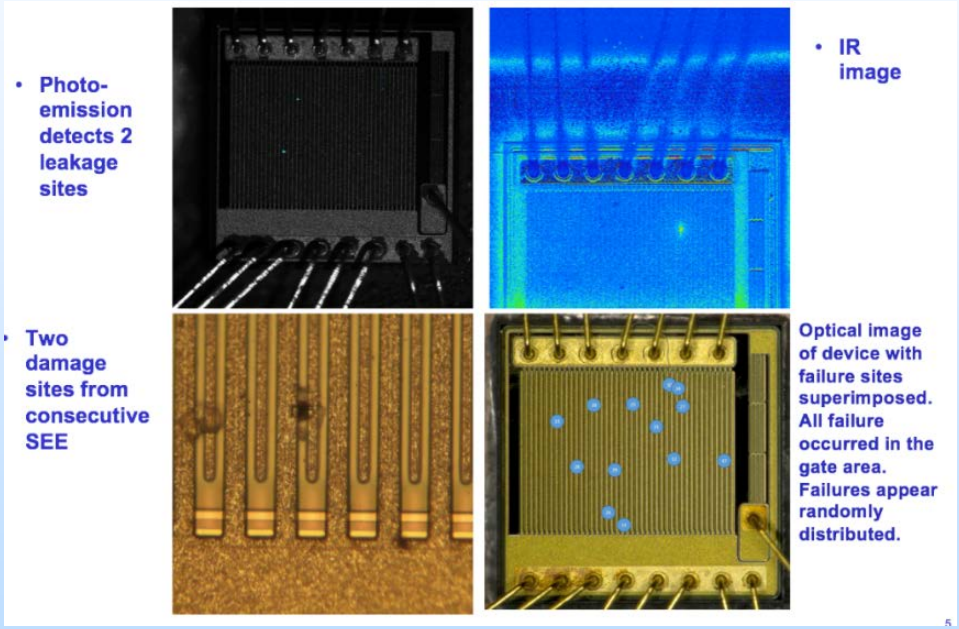


Tantalum capacitor failure

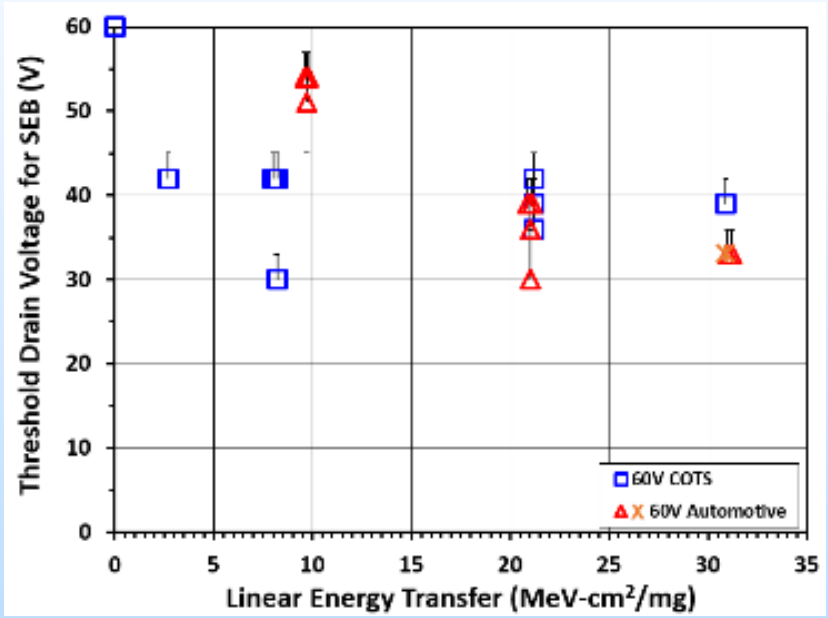


Failure analysis of Schottky diode radiation damage

Vendor Validation Tests



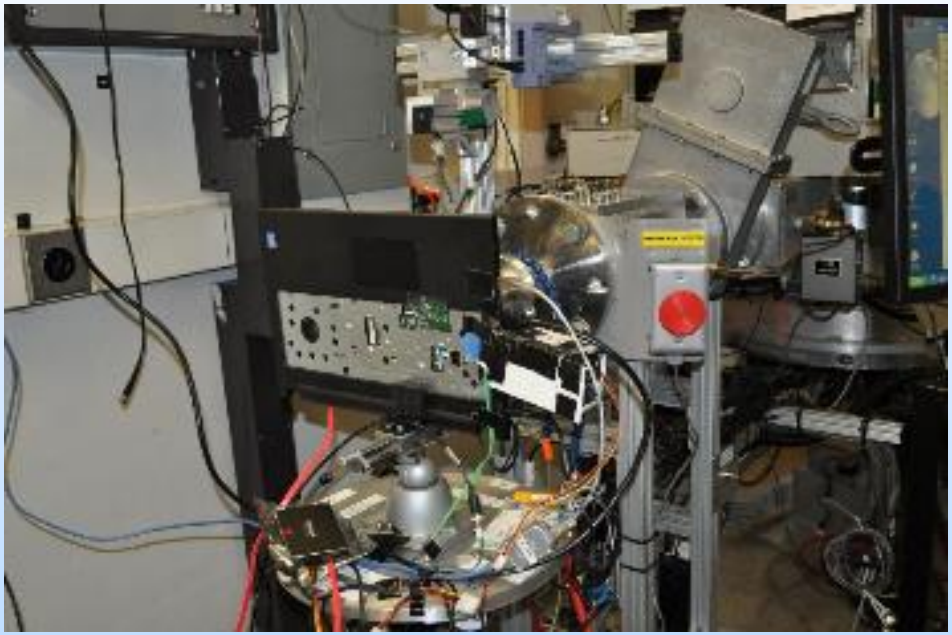
GaN IC – radiation test analysis

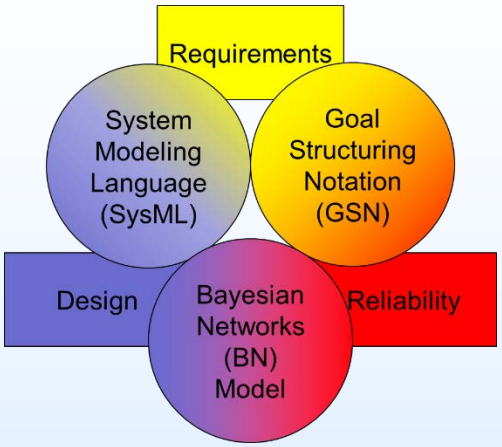


Comparison of n-type 60V trench MOSFET SEB thresholds

Partnering is key

- **Within**
  - **NASA**
- **With**
  - **Other government agencies**
  - **Industry**
  - **University**
  - **International**





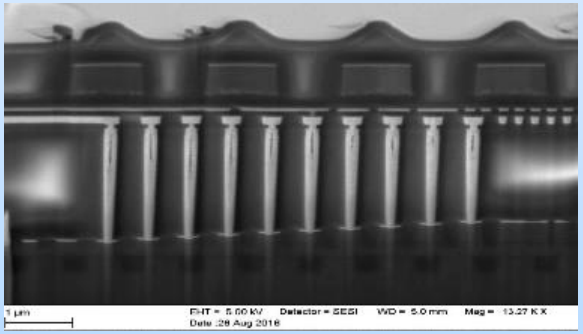
Emerging Assurance Methods
(Witulski, Vanderbilt University, NEPP ETW 2017)

9th Annual NEPP Electronics Technology Workshop (ETW)

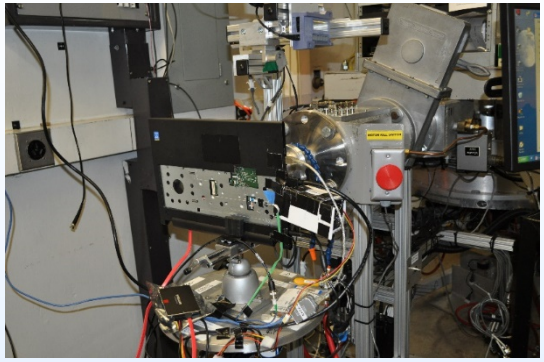
Scheduled dates:

June 18-21, 2018

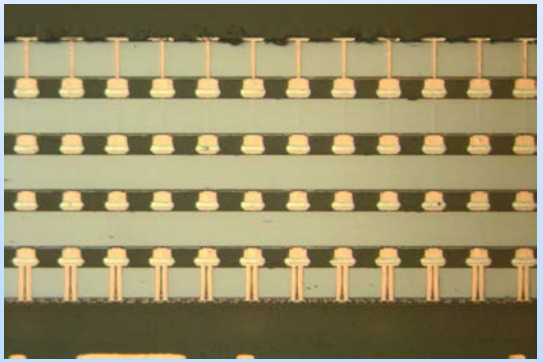
NASA/GSFC and on-line



Advanced Technology Reliability



Radiation Testing



Commercial IC Packaging

NASA STMD

- **Relevant efforts**
  - **High Performance Spacecraft Computing (HPSC)**
    - **“The goal of the HPSC activities is to develop a significantly improved spaceflight computing capability for NASA missions.This will be achieved by addressing the computational performance, energy management, and fault tolerance needs of NASA missions through 2030.”**
    - **ARM chiplet approach selected with Boeing as prime**
    - **https://gameon.nasa.gov/projects-2/high-performance-spaceflight-computing/**
  - **Advanced Memory Technology**
    - **Initial manufacturing status and usage studies for advanced memory technologies relevant to HPSC needs**
      - **Focus on DDRX style interface devices for performance needed**
    - **Collaborative testing with NEPP Program**

NASA SETMO

- **NASA SETMO**
  - **Along with EEE Parts Manager, NEPP, and others have been given approval to develop “radiation common block buys” (i.e., single contracts between NASA and external radiation facilities)**
  - **This may allow NASA to**
    - **Internally prioritize access**
    - **Schedule regular access**
    - **Provide support to critical facilities**
    - **Aid working with new facilities (e.g., proton therapy sites, etc…)**

https://nepp.nasa.gov