NASA Electronic Parts and Packaging (NEPP) Program
Status and Technology Investments Overview

Responsive Technology Assurance for Civil Space

Peter Majewicz
NEPP Program Manager
peter.majewicz@nasa.gov

Jonathan Pellish
NASA EEE Parts Manager
NEPP Program Deputy Manager
jonathan.pellish@nasa.gov

Michael Sampson
NEPAG Manager
michael.j.sampson@nasa.gov

https://nepp.nasa.gov/

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To be presented by Peter Majewicz at the NEPP Electronics Technology Workshop (ETW) at GSFC, June 17, 2019.
### Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF</td>
<td>Air Force</td>
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<tr>
<td>BGA</td>
<td>Ball Grid Array</td>
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<tr>
<td>BN</td>
<td>Bayesian Network</td>
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<tr>
<td>BoK</td>
<td>Body of Knowledge</td>
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<tr>
<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
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<tr>
<td>COTS</td>
<td>Commercial Off the Shelf</td>
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<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<td>DDR</td>
<td>Double Data Rate</td>
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<td>DLA</td>
<td>Defense Logistics Agency</td>
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<td>DMEA</td>
<td>Defense Microelectronics Activity</td>
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<tr>
<td>DoD</td>
<td>Department of Defense</td>
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<tr>
<td>DoE</td>
<td>Department of Energy</td>
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<tr>
<td>EEE</td>
<td>Electrical, Electronic, and Electromechanical</td>
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<tr>
<td>ETW</td>
<td>Electronics Technology Workshop</td>
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<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array</td>
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<tr>
<td>GaN</td>
<td>Gallium Nitride</td>
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<tr>
<td>GIDEP</td>
<td>Government Industry Data Exchange Program</td>
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<tr>
<td>GPU</td>
<td>Graphics Processing Unit</td>
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<tr>
<td>GRC</td>
<td>Glenn Research Center</td>
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<td>GSFC</td>
<td>Goddard Space Flight Center</td>
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<tr>
<td>GSN</td>
<td>Goal Structuring Notation</td>
</tr>
<tr>
<td>HQ</td>
<td>Headquarters</td>
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<tr>
<td>IC</td>
<td>Integrated Circuit</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
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<td>JSC</td>
<td>Johnson Space Center</td>
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<tr>
<td>LGA</td>
<td>Land Grid Array</td>
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<tr>
<td>MAPLD</td>
<td>Military and Aerospace Programmable Logic Devices (Workshop)</td>
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<tr>
<td>MBMA</td>
<td>Model-Based Mission Assurance</td>
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<tr>
<td>MRAM</td>
<td>Magnetic Random Access Memory</td>
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<tr>
<td>MSFC</td>
<td>Marshall Space Flight Center</td>
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>NEPAG</td>
<td>NASA Electronic Parts Assurance Group</td>
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<td>NEPP</td>
<td>NASA Electronic Parts and Packaging (Program)</td>
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<tr>
<td>NESC</td>
<td>NASA Engineering and Safety Center</td>
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<td>NODIS</td>
<td>NASA Online Directives Information System</td>
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<td>NPR</td>
<td>NASA Procedural Requirement</td>
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<td>NRA</td>
<td>National Reconnaissance Office</td>
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<td>NSREC</td>
<td>Nuclear and Space Radiation Effects Conference</td>
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<tr>
<td>OCE</td>
<td>Office of the Chief Engineer</td>
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<tr>
<td>OGA</td>
<td>Other Government Agency</td>
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<tr>
<td>PIC</td>
<td>Photonic Integrated Circuit</td>
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<tr>
<td>PoC</td>
<td>Point of Contact</td>
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<td>PoF</td>
<td>Physics of Failure</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>RH</td>
<td>Radiation Hardened</td>
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<td>RHA</td>
<td>Radiation Hardness Assurance</td>
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<td>SAPP</td>
<td>Space Asset Protection Program</td>
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<td>SDRAM</td>
<td>Synchronous Dynamic Random Access Memory</td>
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<td>SEE</td>
<td>Single-Event Effects</td>
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<td>SiC</td>
<td>Silicon Carbide</td>
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<td>SMA</td>
<td>Safety and Mission Assurance</td>
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<td>SMC</td>
<td>Space and Missile Systems Center</td>
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<td>SOA</td>
<td>Safe Operating Area</td>
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<tr>
<td>SoC</td>
<td>System on a Chip</td>
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<td>SRAM</td>
<td>Static Random Access Memory</td>
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<tr>
<td>SSAI</td>
<td>Science Systems and Applications, Inc.</td>
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<td>STMD</td>
<td>Space Technology Mission Directorate</td>
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<td>STT</td>
<td>Spin Transfer Torque</td>
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<tr>
<td>SysML</td>
<td>System Modeling Language</td>
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<tr>
<td>TID</td>
<td>Total Ionizing Dose</td>
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<tr>
<td>TSV</td>
<td>Thru-Silicon Via</td>
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Outline

• Continued evolution of NASA Electrical, Electronic, and Electromechanical (EEE) parts management
  – EEE Parts Manager & NEPP Program structure
  – General NASA EEE parts interfaces

• NEPP Program overview for 2019
  – What’s new?
  – Key efforts and recent developments
  – NASA Electronics Parts Assurance Group (NEPAG)
    • Audits, community coordination, knowledge dissemination, and standards development

• Summary
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 / NEPAG Standards & Policy Development

• Released NASA-STD-8739.10
  – NASA EEE Parts Assurance Standard
  – Allows projects more flexibility to differentiate between critical/non-critical functions

• Updating EEE-INST-002
  – Instructions for EEE Parts Selection, Screening, Qualification, and Derating
  – Will unify Agency approaches through a single set of documentation
  – 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 EEE Parts – Interfaces

Agency EEE Parts
(NASA Electronic Parts Manager – Steward & Advocate for Capability)

Assurance
Office of Safety & Mission Assurance
- NEPP Program
  - Quality
  - Reliability
  - Workmanship

Development
Office of the Chief Engineer
Capability Leadership
NESC

Facilities
Flight Projects
Field Centers
Mission Directorates
Space Environments Testing Management Office

To be presented by Jonathan Pellish at the Space Parts Working Group (SPWG) in Torrance, CA, May 1, 2019.
**NEPP Charter Breakdown**

**Mission Assurance**

- **Agency Priorities – Independent Support**
  - Commercial Crew
  - Small Mission Reliability
  - Coordination with NASA Consolidation, NESC, STMD, SAPP, and radiation block buy
  - Collaborate with DoD 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

- **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

- **EEE Parts Problem Investigations**
  - Agency/Industry-wide problems
  - GIDEP and NASA Alert development

- **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 OGE/Space Asset Protection)
  - Support DoD RH efforts

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To be presented by Jonathan Pellish at the Space Parts Working Group (SPWG) in Torrance, CA, May 1, 2019.
NEPP Product Delivery

Best Practices and Guidelines
- Test, usage, screening, qualification
- Radiation facility studies

Body of Knowledge
- Technology and product status and gap analysis

NASA EEE Parts Policy and Standards

Government and Industry Standards Representation
- SAE CE11/CE12/JEDEC JC13
- Aerospace TORs

NEPP Standard Products
- Test, summary, and audit reports
- Conference and workshop presentations
- Alerts

Assurance
Selection of NEPP FY2019 Highlights

- Increasing focus on advanced packaging
- Maintaining broad efforts in radiation hardness assurance
- Executing SmallSat industrial base assessment (major support from AF/SMC)
- Supporting evaluation and comparison of Fides vs. Physics-of-Failure (PoF)-based EEE parts reliability assessment – university grant kicked off in April 2019
- Examining opportunities for more significant integration of NEPP documentation into future community-consensus products
- Continuing delivery of standard assurance products / services
- Continuing support of NEPAG and GWG teleconferences.
- Selection of product deliveries:
  - BoKs released: graphics processing units
  - BoKs & guidelines to be released: optoelectronics, 2.5D/3D ICs, board-level proton testing, and SEE testing of system on a chip (SoC) devices
  - Other documents in the works: GaN, Small Mission RHA, SOA for Schottky diodes (radiation), SiC radiation testing, update to general proton testing guideline to include medical facility and low-energy guidance, LGA packages, and ongoing radiation and reliability test reports
## High-Energy Proton Test Facility Availability

*(NEPP Program Continues to Monitor and Update)*

Organizations Selling Time Now – More Details Presented at SEE Symposium/MAPLD Workshop & NEPP ETW

<table>
<thead>
<tr>
<th>Organization</th>
<th>Location</th>
<th>Notes</th>
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<tbody>
<tr>
<td>James M. Slater MD Proton Treatment &amp; Research Center</td>
<td>Loma Linda, CA</td>
<td>BUSY! Booked well in advance at this time.</td>
</tr>
<tr>
<td>Northwestern Medicine Chicago Proton Center</td>
<td>Warrenville, Il</td>
<td>Fairly busy, but some weekend time still available throughout the year.</td>
</tr>
<tr>
<td>Proton Therapy at University of Cincinnati Medical Center</td>
<td>Liberty Township, OH</td>
<td>Dedicated research room with plans for access during days (interleave w/ 5-10 minutes/hour for user) and in evenings &amp; weekends. A few folks have gone here, but biological experiments have had a higher load than expected. TBD on how many yearly hours, but time is currently available.</td>
</tr>
<tr>
<td>Provision CARES Proton Therapy Center</td>
<td>Knoxville, TN</td>
<td>Customers started. Have taken multiple customers (government, industry). Up to 1000/hrs a year planned. Currently have open bandwidth for access.</td>
</tr>
<tr>
<td>MGH Francis H. Burr Proton Beam Therapy Center</td>
<td>Boston, MA</td>
<td>BUSY! Booked through 2019. 3 out of 4 weekends a month access.</td>
</tr>
<tr>
<td>TRIUMF Proton Irradiation Facility</td>
<td>Vancouver, CAN</td>
<td>Several cycles of access a year with two beam lines</td>
</tr>
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This is a moving target - new facilities, changes in management, changes in operational loads, etc. all play into access. We reach out to the facilities regularly as a community service.
Current Technology Focus Areas

- **NEPP Program**
  - Advanced CMOS
  - Memory
  - Part and Supply Chain Data Science
  - Packaging
  - Crosspoint, Discrete & Embedded STT-MRAM, NAND / NOR, & SDRAM
  - Supply Chain Studies, Web Scraping, Metadata Analysis, Formal Methods
  - 2.5D / 3D solutions, Evolving Market Considerations, Support for Qualification Efforts

- **Other**:
  - data conversion, optical/PIC, etc.

- **Current Technology Focus Areas**
  - Capacitors and resistors
  - Wide Bandgap Power
  - SoCs (e.g., CPUs, GPUs, FPGAs)
  - AMD, Intel, Microsemi, Nvidia, Qualcomm, Xilinx
  - GaN (enhancement mode & RF) and SiC
  - <=14nm, 14nm, 22nm, 32nm, & 45nm

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Advanced Technology Evaluation Examples

Select Radiation Test Efforts

- ARM processor evaluation
- COTS power modules for smallsat applications (various vendors)
- FPGA collaboration – 20nm Xilinx XCKU040 testing (SEE & TID)
- Snapdragon processor evaluation

G. Allen, S. Guertin, et al., NASA JPL-Caltech

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

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

GF 22FDX TID testing March 2019;
more SEE May 2019

Image Credit: NASA

AMD e9173 Discrete GPU (14nm Global)
Board without heatsink and cold plate adapter
E. Wyrwas et al., NASA GSFC
Advanced Packaging Highlights

Selected Task Areas

- 2.5D packaging guidance
- BGA underfill selection and application guideline
- LGA interposer development
- Underfill technology assessment BoK
- Wafer-level 3D package reliability guidance
Evolving Landscape for SmallSat Assurance Support

Multiple Collaborations
- Academia
- Industry
- OGAs

Accessible

Product-Focused

Linking Program Tasks to Community Focus Areas / Needs

Continued focus on Model-Based Mission Assurance (MBMA)

Data Sharing
- Data standards
- Web access
- Firewalls

Data Science
- Data scraping
- Metadata analysis

Vendors
- Assemblies/ICs
- Supply chain
- Grades / approaches

Reliability
- Assurance approaches
- Heritage
- Tools

Databases
- Conferences
- Web
- Repositories

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As Always, Partnering is Essential

• Within:
  – NASA

• With:
  – Academia
  – Government agencies
  – Industry
  – International

Image Credit: NASA