The NASA Electronic Parts and Packaging (NEPP) Program – Presentation to Korean Aerospace Research Institute

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NASA/GSFC

http://nepp.nasa.gov

Unclassified
## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AEC</td>
<td>Automotive Electronics Council</td>
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<tr>
<td>BME</td>
<td>Base Metal Electrode</td>
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<tr>
<td>BOK</td>
<td>Body of Knowledge</td>
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<tr>
<td>CA</td>
<td>Construction Analysis</td>
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<tr>
<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
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<tr>
<td>CNES</td>
<td>Centre National d'Etudes Spatiales</td>
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<tr>
<td>CNT</td>
<td>Carbon Nanotube</td>
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<td>CSA</td>
<td>Canadian Standards Association</td>
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<tr>
<td>CSAM</td>
<td>Confocal Scanning Acoustic Microscopy</td>
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<tr>
<td>DC</td>
<td>Direct Current</td>
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<tr>
<td>DoD</td>
<td>Department of Defense</td>
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<tr>
<td>DWV</td>
<td>Dielectric Withstanding Voltage</td>
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<tr>
<td>EEE</td>
<td>Electrical, Electronic, and Electromechanical</td>
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<tr>
<td>ESA</td>
<td>European Space Agency</td>
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<tr>
<td>FOD</td>
<td>Foreign Object Debris</td>
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<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
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<td>IC</td>
<td>Integrated Circuit</td>
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<td>JAXA</td>
<td>Japan Aerospace Exploration Agency</td>
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<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
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<tr>
<td>MIL</td>
<td>Military</td>
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<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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<tr>
<td>NEPP</td>
<td>NASA Electronic Parts and Packaging</td>
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<td>NPSL</td>
<td>NASA Parts Selection List</td>
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<tr>
<td>SAS</td>
<td>Supplier Assessment System</td>
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<tr>
<td>SEE</td>
<td>Single Event Effect</td>
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<tr>
<td>SiC</td>
<td>Silicon Carbide</td>
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<tr>
<td>SME</td>
<td>Subject Matter Expert</td>
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<tr>
<td>SOC</td>
<td>Systems on a Chip</td>
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<td>Tg</td>
<td>glass transition temperature</td>
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<tr>
<td>TRLs</td>
<td>NASA Technology Readiness Levels</td>
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<tr>
<td>VCS</td>
<td>Voluntary Consensus Standard</td>
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To be presented by Michael J. Sampson to representatives of the Korea Aerospace Research Institute (KARI), January 7-8, 2016.
Outline

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• NEPP Mission and Goals
• Qualification of Technologies
• Assurance and Technology Focuses
• The NASA EEE Parts Assurance Group (NEPAG)
• Insertion of New Technologies, NEPAG and NEPP
• Technology Challenges
• Collaboration
• Sharing Knowledge
• EEE Parts Challenges and Threats
• NEPP in a Nutshell
• Back-ups
  – Automotive Parts Testing
  – Example of NEPP Roadmap Content

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NEPP Introduction

• The NEPP Program focuses on the reliability aspects of electronic devices
  – Three prime technical areas:
    • Parts (die), Packaging, and Radiation
• These three areas may be viewed as:
  – Lifetime, inherent failure, and design issues related to electronic parts and packaging,
  – Effects of space radiation/environment on electronics, AND
  – Assurance support infrastructure required for NASA mission success.
• NEPP has provided agency support for >20 years
  – 7 NASA Centers and JPL actively participate

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NEPP Program - Mission and Goals

• The NEPP Mission is to:
  – Provide guidance to NASA for the selection and application of microelectronics technologies
  – Improve understanding of the risks related to the use of these technologies in the space environment
  – Ensure that appropriate research is performed to meet NASA mission assurance needs.

• NEPP’s Goals are to:
  – Provide customers with appropriate and cost-effective risk knowledge to aid in:
    • Selection and application of microelectronics technologies
    • Improved understanding of risks related to the use of these technologies in the space environment
    • Appropriate evaluations to meet NASA mission assurance needs
    • Guidelines for test and application of parts technologies in space
    • Assurance infrastructure and support for technologies in use by NASA space systems

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NEPP’s Prime Goal

- Science, safety and mission assurance require reliable engineering
  - **NEPP’s goal is to provide the infrastructure to allow NASA flight projects to utilize current and next generation electronic technologies in space**

- Prime methods for meeting this goal
  - Focused research on electronic technologies
  - Information infrastructure between all NASA Centers
    - NEPP website, [https://nepp.nasa.gov](https://nepp.nasa.gov) working groups, and weekly telecons
  - Development of qualification guidelines and lessons learned
    - Often jointly developed with other government agencies/industry

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NEPP is agency-wide so we do NOT qualify devices, but investigate technology-related failure modes and **HOW** to qualify

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• Electronics for space face hazards well beyond those of terrestrial/commercial
• Qualification requires repeatable and statistically significant testing over relevant environments to ensure mission success
• NEPP provides the basis for understanding the “how to’s” for electronics qualification
NEPP Works Two Sides of the Equation

• Assurance
  – Issues applicable to space systems being designed and built (i.e., currently available technologies)
  – Examples
    • Cracked capacitors
    • Power converter reliability
    • Automotive parts
  – Communication infrastructure
    • NASA Electronic Parts Assurance Group (NEPAG)
  – Audit and review support

• New electronics technology
  – Issues applicable to next generation space systems in conceptualization or preliminary design
  – Examples
    • State-of-the-art commercial
    • High performance electronics
    • Smallsat/satellite electronics
  – Collaboration with manufacturers and government programs for test, evaluation, and modeling
  – Development of new tools

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NASA EEE Parts Assurance Group (NEPAG)

- Formed in 2000
- Weekly Telecons
  - International monthly
  - Typical participation ~ 35
  - Share knowledge and experience
  - Address failures, requirements, test methods
- Audit support
- Coordinate specification and standards changes
Insertion of New Technologies – NEPP/NEPAG Focus

• NASA mission timeframes rarely allow for a technology development path
• For 2016 launch, technology freeze dates are likely in 2013 or earlier
  – May be time to qualify (test) a device, but may not be time to develop/validate a new technology solution!
• Technology development and evaluation programs need to be in place prior to mission design
  – Strategic planning for/by NEPP on technologies is critical

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Sample NEPP Technology Challenges

Can we “qualify” without breaking the bank?

**Device Architectures**
- system on a chip
- interconnects
- power distribution
- high frequencies
- application specific results

**Packages**
- Inspection
- Lead free
- How to test generically

**Silicon**
- <65 nm CMOS
- new materials such as CNT

**Connectors**
- higher-speed, lower noise
- serial/parallel
- ruggedized, electro-optic

**Power Architectures**
- distributed architecture
- thermal modeling
- stability

**Passives**
- Embedded
- Higher performance
- Hybrids

**Board Material**
- thermal coefficients
- material interfaces

**Design Flows/Tools**
- programming algorithms, application
- design rules, tools, simulation, layout
- hard/soft IP instantiation

**Workmanship**
- inspection, lead free
- stacking, double-sided
- signal integrity

**Related areas (non-NEPP)**

**Can we “qualify” without breaking the bank?**

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Collaboration

• “Promote enhanced cooperation with international, industry, other U.S. government agency, and academic partners in the pursuit of our missions.” – Charles Bolden, NASA Administrator

• NEPP has a long history of collaboration. Examples include:
  – US Department of Defense (DoD)
  – Multiple universities
    • Vanderbilt, Georgia Tech, U of MD, Auburn University, …
  – Electronics manufacturers too numerous to mention!
  – International with ESA, JAXA, CNES, CSA, …

• *We work with the NASA flight programs, but do not perform mission specific tasks*
Sharing Knowledge

- NEPP success is based on providing guidance and specialist support to NASA flight projects
  - Interaction with the aerospace community, other government agencies, universities, and flight projects is critical.

- NEPP utilizes
  - NEPP Website:
    - http://nepp.nasa.gov
  - NEPP Annual Electronics Technology Workshop in June (~200 attendees)
  - Standards working groups
  - Regular Telecons
  - Documents such as Guidelines, Lessons Learned, Bodies of Knowledge (BoKs)

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Consortia/Working Groups and Universities

• NEPP utilizes working groups for information exchange and product development
  – External examples:
    • JEDEC Commercial Electronics and GEIA G11, G12 Government Users
  – Internal (NASA) examples:
    • DC-DC Converters, Connectors, Wide Bandgap Semiconductors, Hermeticity, Automotive EEE Parts

• NEPP fosters university research in electronic parts
  – Examples
    • Radiation effects modeling at Vanderbilt University
    • Ultra-high speed electronics at Georgia Tech
EEE Parts - Challenges and Threats

• NEPP Threat Concerns:
  – Counterfeiting and malware Unpredictable, worldwide supply chain for military, high-reliability and commercial parts, traceability examples:
    • Connector contact defect
    • Capacitor manufacturer branding parts by another manufacturer

• NEPP Challenges:
  – Assurance for commercial parts
  – Balancing parts’ cost, performance and mission
  – Assurance for complex and expensive, advanced technologies
  – Rapid pace of new technology introduction
  – Declining supplier base for military/hi-rel parts, needed for long duration, high importance missions

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Summary - The NEPP Program in a Nutshell

Management

Ken LaBel - 561
Radiation Effects
Advanced Actives
NEPP Events

Mike Sampson - 370
NEPAG
Passives
Packaging

Core Elements

Electronic Parts Reliability
Radiation Effects
Parts Assurance (NEPAG)
Advanced Packaging
Information Dissemination

Focus Technologies

Extreme Environments
Scaled CMOS
Passives
Interconnects
Memories
Discretes
Embedded Technologies
Power Devices
Lead-free
Systems on a Chip (SOC)

SiGe Mixed Signal
Area Arrays
Programmable Logic
Sensor Technology
Fiber Optics
Radio Frequency

Guidelines
Specifications and Standards
Test Methods

Products/Deliverables

Website Content
NASA Parts Selection List
Tools
Data

Technical Reports
Bodies of Knowledge
Conference Papers

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Back Up
## Ceramic Capacitors

**3 Different Mfrs**

**Commodity:** BME, 0805, 0.47uF, 50V

### Test Details
- **Construction Analysis:** Complete
- **Initial Parametric Measurements:** Complete
- **Life Test (2x Vrated, 125°C):** > 7000 Hrs Complete (Progressing to 10k hours)

### Status
- **Ceramic Capacitors**

### Comments
- **At their own discretion a manufacturer supplied devices made with “flexible termination”**
- **No Failures**
- **DWV known to produce negative cap shift**
  - Mfrs recommend bake-out to restore cap
- **1 lot exhibits 6 life test failures (120pc) up to 7500 hrs**
- **2 fail @ 3100 hrs; 3 fail @ 4700 hrs; 1 fail @ 6200 hrs**
- **2 lots exhibit no life test failures up to ~7500 hrs**

## Integrated Circuits

**2 Different Mfrs**

### Test Details
- **Construction Analysis:** In Process
- **Initial Parametric Measurements:** In Process
- **Burn-In & Life Test:** In Process

### Status
- **Integrated Circuits**

### Comments
- **FOD on Terminals “As-Received” (Linear IC)**
- Tg measurements complete
- CSAM complete for digital IC
- C/A to be performed at end of test
- **All digital ICs failed during burn-in. Appears to be a power consumption issue at burn-in temperature. Investigation Pending**
- Linear IC to be tested 04/15

## Discrete Semiconductors

**1 Bipolar transistor (dual transistor)**

### Test Details
- **Construction Analysis:** In Process
- **Initial Parametric Measurements:** In Process
- **Burn-In & Life Test:** In Process Began 03/15

### Status
- **Discrete Semiconductors**

### Comments
- **Tg measurements complete**
- **No Failures for bipolar transistor**
- **Switching diode to be tested 07/15**
- **Bipolar transistor - 1000 hours of life test completed (20 pcs), (1 failure under investigation at 1000 hours)**
- **Bipolar transistor – life test continuing on to 2000 hours**
- **CA to be performed at end of test**
- **Switching diode electrical and life tentatively scheduled to start testing late 07/15 due to parts ordering issue**
NASA Electronic Parts Assurance Group (NEPAG)

Core Areas are Bubbles; Boxes underneath are elements in each core.

NEPAG Focus Areas

Legend

- DoD and NASA Funded
- NASA-only funded
- Overguide

- Investigate
  - Assess NASA Impact
  - Test/Analyze
  - Corrective Action
  - Lessons Learned

- US MIL
  - VCS

- Audits

- National
  - International

- Collaborations

- Parts Support
  - NPSL
    - Technical Expertise Resource
    - Bulletins
    - Connectors

- Consortia
  - CAVE
  - CALCE

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