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

Kenneth A. LaBel
ken.label@nasa.gov
301-286-9936

Michael J. Sampson
michael.j.sampson@nasa.gov
301-614-6233

Co- Managers, NEPP Program
NASA/GSFC
http://nepp.nasa.gov

Unclassified

Acronyms

Acronym	Definition
AEC	Automotive Electronics Council
BME	Base Metal Electrode
BOK	Body of Knowledge
CA	Construction Analysis
CMOS	Complementary Metal Oxide Semiconductor
CNES	Centre National d'Etudes Spatiales
CNT	Carbon Nanotube
CSA	Canadian Standards Association
CSAM	Confocal Scanning Acoustic Microscopy
DC	Direct Current
DoD	Department of Defense
DWV	Dielectric Withstanding Voltage
EEE	Electrical, Electronic, and Electromechanical
ESA	European Space Agency
FOD	Foreign Object Debris
GSFC	Goddard Space Flight Center
IC	Integrated Circuit
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
MIL	Military
NASA	National Aeronautics and Space Administration
NEPAG	NASA Electronic Parts Assurance Group
NEPP	NASA Electronic Parts and Packaging
NPSL	NASA Parts Selection List
SAS	Supplier Assessment System
SEE	Single Event Effect
SiC	Silicon Carbide
SME	Subject Matter Expert
SOC	Systems on a Chip
Tg	glass transition temperature
TRLs	NASA Technology Readiness Levels
VCS	Voluntary Consensus Standard

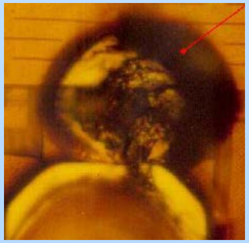
Outline

- Introduction
- 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

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

Electrical overstress failure
in a commercial electronic device



To be presented by Michael J. Sampson to representatives of the Korea Aerospace Research Institute (KARI), January 7-8, 2016.

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

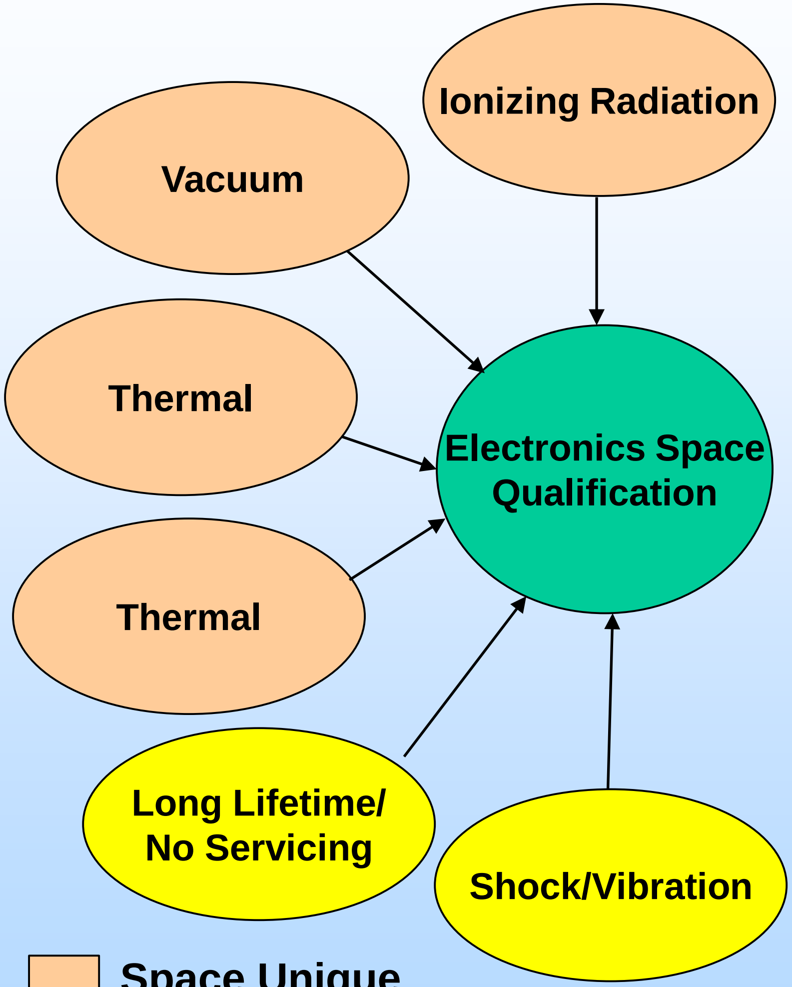
- Science, safety and mission assurance require reliable engineering
  - *NEPP's goal is to provide the infrastructure to allow NASA flight projects to utilize current and next generation electronic technologies in space*
- Prime methods for meeting this goal
  - Focused research on electronic technologies
  - Information infrastructure between all NASA Centers
    - NEPP website, https://nepp.nasa.gov working groups, and weekly telecons
  - Development of qualification guidelines and lessons learned
    - Often jointly developed with other government agencies/industry

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

Qualifying Electronic Technologies

NEPP Perspective

- **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**



🟧 **Space Unique**

🟨 **Other Space Challenges**

NEPP Works Two Sides of the Equation

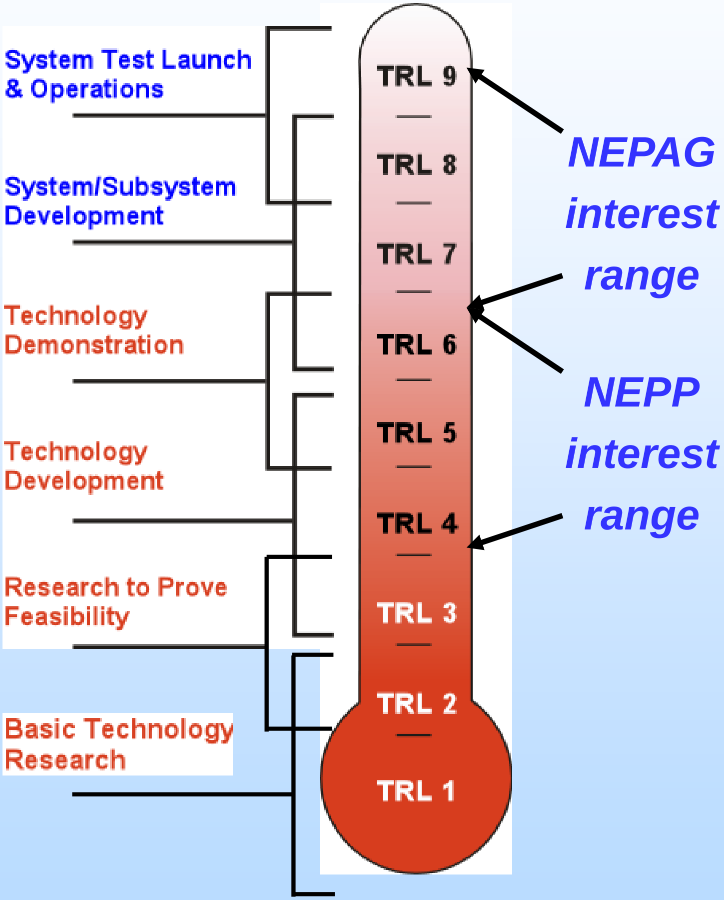
- **Assurance**
  - *Issues applicable to space systems being designed and built (i.e., currently available technologies)*
  - Examples
    - Cracked capacitors
    - Power converter reliability
    - Automotive parts
  - Communication infrastructure
    - NASA Electronic Parts Assurance Group (NEPAG)
  - 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
    - Smallsats/cubesats
  - Collaboration with manufacturers and government programs for test, evaluation, and modeling
  - Development of new tools

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*



NASA Technology Readiness Levels (TRLs)

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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

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

Packages
-Inspection
-Lead free
-How to test generically

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

Passives
-Embedded
-Higher performance
-Hybrids

Power Architectures
-distributed architecture
-thermal modeling
-stability

Board Material
-thermal coefficients
-material interfaces

Related areas (non-NEPP)

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

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

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)

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**

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
- Sensor Technology
- Fiber Optics
- Radio Frequency
- Power Devices
- Scaled CMOS
- Passives
- Interconnects
- Memories
- Lead-free
- SiGe Mixed Signal
- Area Arrays
- Programmable Logic
- Discretes
- Embedded Technologies
- Systems on a Chip (SOC)

Products/ Deliverables

Guidelines
Specifications and Standards
Test Methods

Website Content
NASA Parts Selection List
Tools
Data

Technical Reports
Bodies of Knowledge
Conference Papers

Back Up

Testing Summary: NEPP Evaluation Automotive Parts

Purchased as Automotive Electronics Council (AEC) Q-"XXX" Qualified

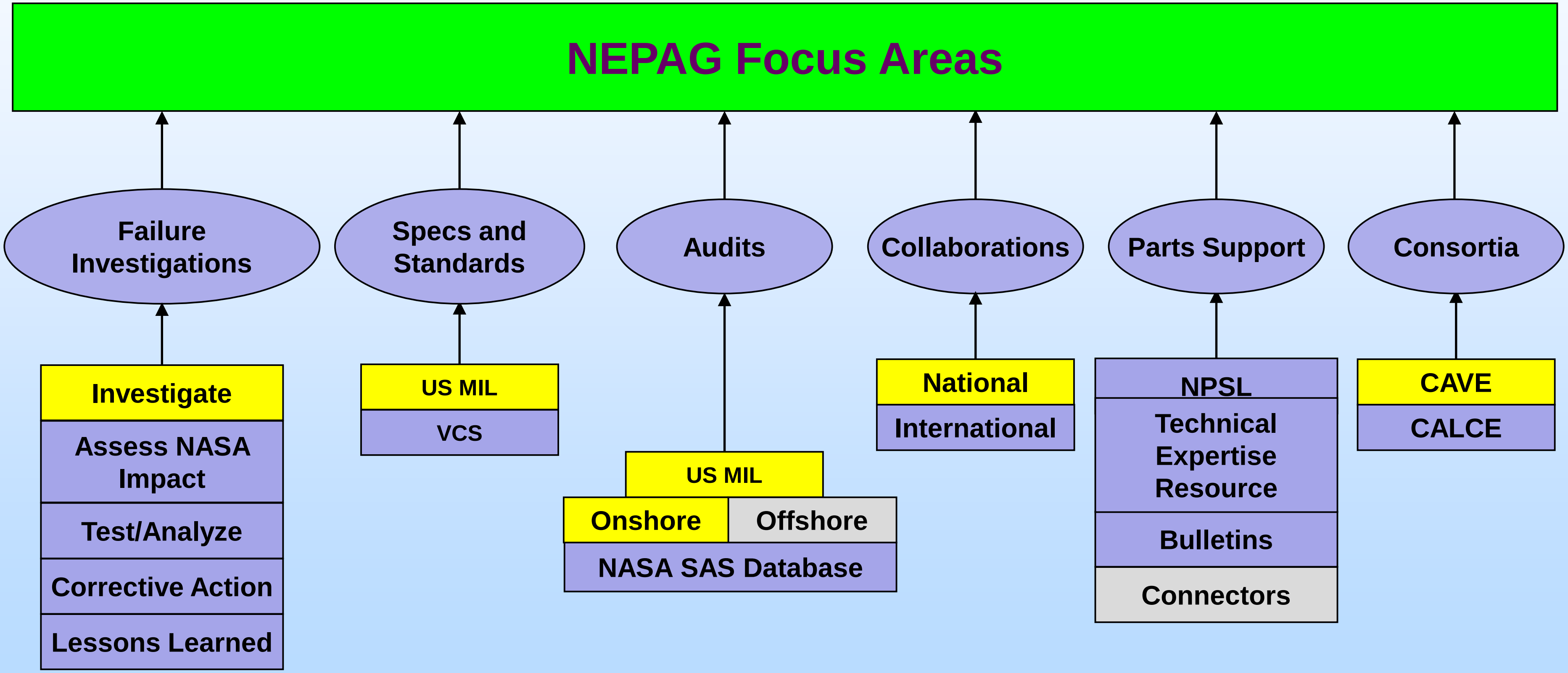
Commodity	Test	Status	Comments
Ceramic Capacitors 3 Different Mfrs BME, 0805, 0.47uF, 50V	Construction Analysis	Complete	• *At their own discretion a manufacturer supplied devices made with "flexible termination"*
	Initial Parametric Measurements	Complete	• No Failures • *DWV known to produce negative cap shift* • *Mfrs recommend bake-out to restore cap*
	Life Test (2x Vrated, 125°C)	> 7000 Hrs Complete (Progressing to 10k hours)	• *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 1 digital IC (Diff Bus Driver); 1 linear IC (Comparator)	Construction Analysis	In Process	• *FOD on Terminals "As-Received" (Linear IC)* • Tg measurements complete • CSAM complete for digital IC • C/A to be performed at end of test
	Initial Parametric Measurements	In Process	• No Failures for digital IC • Linear IC to be tested 04/15
	Burn-In & Life Test	In Process	• All digital ICs failed during burn-in. Appears to be a power consumption issue at burn-in temperature. Investigation Pending
Discrete Semiconductors 1 Bipolar transistor (dual transistor) 1 Switching diode 1 Transient Voltage Suppressor 1 Schottky Diode	Construction Analysis	In Process	• Tg measurements complete
	Initial Parametric Measurements	In Process	• No Failures for bipolar transistor • Switching diode to be tested 07/15
	Burn-In & Life Test	In Process Began 03/15	• 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

Legend

- 🟨 DoD and NASA Funded
- 🟪 NASA-only funded
- ⬜ Overguide



NEPAG Focus Areas

- Failure Investigations
  - Investigate
  - Assess NASA Impact
  - Test/Analyze
  - Corrective Action
  - Lessons Learned
- Specs and Standards
  - US MIL
  - VCS
- Audits
  - US MIL
  - Onshore
  - Offshore
  - NASA SAS Database
- Collaborations
  - National
  - International
- Parts Support
  - NPSL
  - Technical Expertise Resource
  - Bulletins
  - Connectors
- Consortia
  - CAVE
  - CALCE