The NASA Electronic Parts and Packaging (NEPP) Program – Overview for FY14

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To be published on nepp.nasa.gov previously presented by Kenneth LaBel at the NASA Electronic Parts and Packaging (NEPP) Electronics Technology Workshop (ETW), Greenbelt, MD, June 17-19, 2014.
Outline

• Acronym List
• Overview of NEPP
  – What We Do and Who We Are
  – Working with Others
• Plans for FY14
• Recent Highlights
• Parts “Graveyard”
• Summary

Multi-Layer Ceramic Capacitor (MLCC)

Dielectric Thickness $d$

Average Grain Size $r$

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### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D</td>
<td>Three Dimensional</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog to Digital Converter</td>
</tr>
<tr>
<td>Aero</td>
<td>Aerospace</td>
</tr>
<tr>
<td>AFRL</td>
<td>Air Force Research Laboratory</td>
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<tr>
<td>AFSMC</td>
<td>Air Force Space and Missiles Center</td>
</tr>
<tr>
<td>AMRDEC</td>
<td>Aviation and Missile Research Development and Engineering Center</td>
</tr>
<tr>
<td>ARC</td>
<td>Ames Research Center</td>
</tr>
<tr>
<td>ASU</td>
<td>Arizona State University</td>
</tr>
<tr>
<td>AVSI</td>
<td>Aerospace Vehicle Systems Institute</td>
</tr>
<tr>
<td>BME</td>
<td>Base Metal Electrode</td>
</tr>
<tr>
<td>BOK</td>
<td>Body of Knowledge</td>
</tr>
<tr>
<td>CALCE</td>
<td>Center for Advanced Life Cycle Engineering</td>
</tr>
<tr>
<td>CAVE</td>
<td>Center for Advanced Vehicle and Extreme Environment Electronics</td>
</tr>
<tr>
<td>CBRAM</td>
<td>Conductive Bridging Random Access Memory</td>
</tr>
<tr>
<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
</tr>
<tr>
<td>CNES</td>
<td>Centre National d'Etudes Spatiales</td>
</tr>
<tr>
<td>COP</td>
<td>Community of Practice</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial Off The Shelf</td>
</tr>
<tr>
<td>CSA</td>
<td>Canadian Space Agency</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital to Analog Converter</td>
</tr>
<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DDR</td>
<td>Double Data Rate</td>
</tr>
<tr>
<td>DLA/DSCC</td>
<td>Defense Logistics Agency Land and Maritime</td>
</tr>
<tr>
<td>DMEA</td>
<td>Defense Microelectronics Activity</td>
</tr>
<tr>
<td>DTRA</td>
<td>Defense Threat Reduction Agency</td>
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### Acronym

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>EEE</td>
<td>Electrical, Electronic, and Electromechanical</td>
</tr>
<tr>
<td>ELDRS</td>
<td>Enhanced Low Dose Rate Sensitivity</td>
</tr>
<tr>
<td>EPARTS</td>
<td>NASA Electronic Parts Database</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>ETW</td>
<td>Electronics Technology Workshop</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>FY</td>
<td>Fiscal Year</td>
</tr>
<tr>
<td>G11</td>
<td>Component Parts Committee</td>
</tr>
<tr>
<td>G12</td>
<td>Solid State Devices Committee</td>
</tr>
<tr>
<td>GaAs</td>
<td>Gallium Arsenide</td>
</tr>
<tr>
<td>GaN</td>
<td>Gallium Nitride</td>
</tr>
<tr>
<td>GIDEP</td>
<td>Government Industry Data Exchange Program</td>
</tr>
<tr>
<td>GRC</td>
<td>Glenn Research Center</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
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<tr>
<td>HALT</td>
<td>Highly Accelerated Life Test</td>
</tr>
<tr>
<td>HiREV</td>
<td>High Reliability Virtual Electronics Center</td>
</tr>
<tr>
<td>IARPA</td>
<td>Intelligence Advanced Research Projects Agency</td>
</tr>
<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>ICBM</td>
<td>Intercontinental Ballistic Missile</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual Property</td>
</tr>
<tr>
<td>IPC</td>
<td>(not an acronym)</td>
</tr>
<tr>
<td>JAXA</td>
<td>Japanese Space Agency</td>
</tr>
<tr>
<td>JEDEC</td>
<td>Joint Electron Device Engineering Council</td>
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<tr>
<td>JHU-APL</td>
<td>Johns Hopkins University Applied Physics Laboratory</td>
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# Acronyms (2)

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>JPL</td>
<td>Jet Propulsion Laboratories</td>
</tr>
<tr>
<td>JSC</td>
<td>Johnson Space Center</td>
</tr>
<tr>
<td>KSC</td>
<td>Kennedy Space Center</td>
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<tr>
<td>LaRC</td>
<td>Langley Research Center</td>
</tr>
<tr>
<td>LEAP</td>
<td>Leading Edge Access Program</td>
</tr>
<tr>
<td>MDA</td>
<td>Missile Defense Agency</td>
</tr>
<tr>
<td>MEMS</td>
<td>Microelectromechanical Structure</td>
</tr>
<tr>
<td>MIL</td>
<td>Military</td>
</tr>
<tr>
<td>MLCC</td>
<td>Multi-Layer Ceramic Capacitor</td>
</tr>
<tr>
<td>MOSFET</td>
<td>Metal Oxide Semiconductor Field Effect Transistor</td>
</tr>
<tr>
<td>MRQW</td>
<td>Microelectronics Reliability and Qualification Working Meeting</td>
</tr>
<tr>
<td>MSFC</td>
<td>Marshall Space Flight Center</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NAVSEA</td>
<td>Naval Sea Systems Command</td>
</tr>
<tr>
<td>NEPAG</td>
<td>NASA Electronic Parts Assurance Group</td>
</tr>
<tr>
<td>NEPP</td>
<td>NASA Electronic Parts and Packaging</td>
</tr>
<tr>
<td>NGC</td>
<td>Northrop Grumman Corporation</td>
</tr>
<tr>
<td>NPSL</td>
<td>NASA Parts Selection List</td>
</tr>
<tr>
<td>NRL</td>
<td>Naval Research Laboratory</td>
</tr>
<tr>
<td>NRO</td>
<td>National Reconnaissance Office</td>
</tr>
<tr>
<td>NSP</td>
<td>National Space Programs</td>
</tr>
<tr>
<td>NSWC</td>
<td>Naval Surface Warfare Center</td>
</tr>
<tr>
<td>PBGA</td>
<td>Plastic Ball Grid Array</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>POC</td>
<td>Point of Contact</td>
</tr>
<tr>
<td>POF</td>
<td>Physics of Failure</td>
</tr>
<tr>
<td>POL</td>
<td>Point of Load</td>
</tr>
<tr>
<td>QML</td>
<td>Qualified Manufacturer List</td>
</tr>
<tr>
<td>RERAM</td>
<td>Resistive Random Access Memory</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SAS</td>
<td>Supplier Assessment System</td>
</tr>
<tr>
<td>SEU</td>
<td>Single Event Upset</td>
</tr>
<tr>
<td>SiC</td>
<td>Silicon Carbide</td>
</tr>
<tr>
<td>SMC</td>
<td>Space and Missile Command</td>
</tr>
<tr>
<td>SNL</td>
<td>Sandia National Laboratories</td>
</tr>
<tr>
<td>SOC</td>
<td>Systems on a Chip</td>
</tr>
<tr>
<td>SST</td>
<td>Silicon Space Technologies</td>
</tr>
<tr>
<td>STS</td>
<td>Silicon Turnkey Solutions</td>
</tr>
<tr>
<td>SW</td>
<td>Southwest</td>
</tr>
<tr>
<td>SwRI</td>
<td>Southwest Research Institute</td>
</tr>
<tr>
<td>TI</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>TMR</td>
<td>Triple Modular Redundancy</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
</tr>
<tr>
<td>US</td>
<td>United States</td>
</tr>
<tr>
<td>USAF</td>
<td>United States Air Force</td>
</tr>
<tr>
<td>USASMDC</td>
<td>United States Army Space and Missile Defense Command</td>
</tr>
<tr>
<td>USN</td>
<td>United States Navy</td>
</tr>
<tr>
<td>VCS</td>
<td>Voluntary Consensus Standards</td>
</tr>
<tr>
<td>VNAND</td>
<td>Vertical NAND</td>
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NEPP - Frame of Reference

• EEE (electrical, electronic, and electromechanical) parts are:
  – All the things that are on printed circuit boards (PCB) inside of electronics boxes.

• This includes:
  – Integrated Circuits (ICs or chips) like processors and memories as well as passives such as capacitors and resistors,
  – Hybrid devices or multi-chip modules: Small packages that house multiple chips internally that are placed on the PCB, and,
  – Connectors and wires used to send electrical or power signals between boards, boxes, or systems.

• This does not include:
  – The PCB - NASA Workmanship Program responsibility.

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EEE Parts and Space

• EEE parts are available in “grades”
  – Designed and tested for specific environmental characteristics.
    • E.g., Operating temperature range, vacuum, radiation exposure,…
  – Examples: Aerospace, Military, Automotive, Medical, Extended-Temperature-Commercial, and Commercial.

• Aerospace Grade is the traditional choice for space usage, but has relatively few available parts and their performance lags behind commercial counterparts (speed, power).
  – Designed and tested for radiation and reliability for space usage.

• NASA uses a wide range of EEE part grades depending on many factors (technical, programmatic, and risk).
  – *NEPP is the Agency’s independent view for understanding “safe” usage.*
NEPP provides the Agency infrastructure for assurance of EEE parts for space usage.

Qualification guidance
To flight projects on how to qualify

Standards
Ensures NASA needs are represented

Manufacturer Qualification
Support of audits and review of qualification plans/data

Information Sharing
Lessons learned, working groups, website, weekly telecons

Technology Evaluation
Determine new technology applicability and qualification guidance

Test/Qualification Methods
Evaluate improved or more cost-effective concepts

Risk Analysis
For all grades of EEE parts (commercial, automotive, military/aerospace, …)

Subject Matter Expertise
SMEs for NASA programs, other agencies, industry

NEPP and its subset (NASA Electronic Parts Assurance Group – NEPAG) are the Agency’s POCs for reliability and radiation tolerance of EEE parts and their packages.

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Notional NEPP View of EEE Parts Needs Diversity

Focus on fail-safe architecture/electronics

Focus on cost-consciousness and low power electronics

Focus on reliability and radiation tolerance

Overlap is critical assurance infrastructure (NEPAG)

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NASA EEE Parts Assurance Group (NEPAG)

- **Subset of NEPP, formed in 2000.**
- **Weekly telecons,**
  - Typical participation ~25
  - Share knowledge and experience
  - Address failures, requirements, test methods
  - Monthly international
- **Audit support,** and
- **Coordinate specification and standards changes.**

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Sharing NEPP Knowledge

• NEPP success is based on providing appropriate guidance 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),
  – Annual Electronics Technology Workshop (ETW),
  – NEW: EEE Parts for Small Missions, Sep 10-11, 2014,
  – Standards working groups,
  – Telecons (NEPAG weekly and monthly international), and
  – Documents such as Guidelines, Lessons Learned, Bodies of Knowledge (BOKs), and, Technical Papers.
EEE Parts for Small Missions

• Meeting Dates: Sep 10-11, 2014.
• Location: NASA/GSFC Greenbelt, MD Bldg. 3 auditorium and via web participation. On-site participation will be limited to US/green card participants as well as auditorium capacity.
• As a follow-on to an internal NASA EEE parts workshop held in FY13, the NEPP Program will be hosting an open workshop entitled “EEE Parts for Small Missions.” The focus of this workshop is two-fold:
  – Provide small mission designers (and new designers) exposure to reliable use of EEE parts in small missions (i.e., “rules of thumb” for parts usage, testing/qualification, and design), and,
  – Provide a forum for discussion of recent efforts, plans, and accomplishments. This will include, for example, a discussion on the use of automotive electronics.
• While there is not a formal “call for presentations,” we seek participation from industry, universities, and other government agencies. Volunteers are welcome.

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NEPP Partnerships

- Collaboration with other U.S. Government Agencies,
  - Co-funding of radiation effects efforts with Defense Threat Reduction Agency (DTRA) and National Reconnaissance Office (NRO),
  - In-kind efforts and information exchange with DTRA, AFSMC, AFRL, NAVSEA, DMEA, MDA, DARPA, NRL, DLA, USASMD, SNL, and
    • HiREV is included in this category.
  - We occasionally provide subject matter expertise (SME) to other agencies on point issues (FCC, State Department, IARPA, FAA, and NSA).
- Information exchange with international space agencies (JAXA, ESA, CNES, and CSA),
- Collaboration with industry via in-kind efforts (review, test, samples),
  - Long list ranging from capacitors to FPGAs
- Collaboration with universities, and
  - Currently unfunded due to budget cuts
- Formal consortia and working group participation.

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Other U.S. Government Agency Partners – Information Exchange and In-Kind

- DLA
- AFRL
- DTRA
- NRO
- DARPA
- NRL
- NSP
- MDA
- USASMDC
- AF SMC Aerospace Corp
- NAVSEA
- AFRL
- SNL
- JHU-APL
- HiREV
- Multiple locations:
- DMEA

Direct co-funding: DTRA*, NRO

*This is expected to be the last FY DTRA provides co-funding due to their budget realignment

Limited collaboration:
- NSA, IARPA, State Dept., FCC, FAA

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NEPP – International Agencies

Information Exchange Partners

CSA
ESA
CNES
JAXA

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Example U.S. Industry Partners – In-Kind

In-kind:
Usually this is reviewing their qualification plans or obtaining samples for evaluation

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NEPP: Universities and Consortia – Budget Cuts Have Impacted Participation

• NEPP retains a leadership role in JEDEC and SAE G11/G12 working groups:
  – Develop standards for qualification.

• NEPP budget cuts over the last 5 years have reduced NEPP’s ability to fund agency participation in consortia:
  – CAVE (Auburn),
  – CALCE (U of MD), and,
  – AVSI (Aerospace Industry).

• University research no longer funded at:
  – Vanderbilt University,
  – Georgia Tech,
  – Auburn,
  – Arizona State University, or
  – University of Maryland.
HiREV

- Technology forecasting (US Government needs)
- POF tools for Si and III-V electronics
- Pre-qualification efforts on
  - Base Metal Electrode (BME) Capacitors
  - Class Y packages
  - 45 and 90 nm CMOS trusted foundry technology
- Reliability science
  - GaN technology
- Reliable Electronics
  - Electronic technology Physics of Failure (PoF)
- Radiation Reliability of Electronics
  - Modeling PoF in new technologies

NEPP

- Body of Knowledge (BOK) documents on new technologies
- Guideline on testing/qualification of FPGAs, memories, BME capacitors
- Evaluation of commercial products
  - BME capacitors
  - GaN/SiC devices
  - FPGAs
  - Automotive-grade electronics
- Reliable Electronics
  - Applying PoF to qualification/usage guidance
- Radiation Reliability
  - Testing for PoF on new Technologies
  - Support modeling/tools on new technologies
  - Qualification/usage guidance

HiREV utilizes test structures for detailed knowledge (model first).
NEPP utilizes commercial product for general knowledge (test first).

HiREV PoF on early TRL’s feeds NEPP focus on insertion/qualification.
FY14 - NEPP Evaluation of Automotive Electronic Parts

• Questions to be answered:
  – *What are automotive grade parts, who makes them, what standards exist, and can NASA leverage them for reliable use in space?*

• NEPP objectives:
  – Develop a BOK on automotive grade parts,
  – Test a range of electronic parts (capacitors to transistors to processors), and
  – Develop a guideline for NASA usage.

• Testing will be performed by NASA and NSWC Crane.

• Early results on selected automotive grade capacitors indicate aging/de-aging behavior variance.
  – This behavior could be due to dielectric differences between military-grade parts and the selected test articles (higher volumetric efficiency).

http://www.aecouncil.com/AECDocuments.html

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FY14 NEPP Core – Automotive/Commercial Electronics (Small Missions)

Core Areas are Bubbles; Boxes underneath are variable tasks in each core

NEPP Research Category – Automotive/Commercial Electronics

- Automotive Electronics
  - Body of Knowledge on specs, standards, and vendor approaches
  - Reliability evaluation of ceramic capacitors, discrete transistors, and microcircuits
  - Work performed by NAVSEA Crane in collaboration

- Alternate Test Approaches
  - Effectiveness of Board Level Testing for Piecpart Qualification
    (will utilize boards with processors and microcontrollers)

- Mobile Processors
  - Intel Atom, Qualcomm Snapdragon Processors
    (radiation only)

- Microcontrollers
  - Freescale Automotive Microcontroller
    (+ board)
  - CubeSat vendor Microcontrollers:
    Tyvak (TI microcontroller), Pumpkin (Atmel microcontroller)
    (radiation only)

- Advanced Processors
  - Freescale P5040 Network Processor
    (+ board)
    (IP for next generation BAE Systems Rad Hard Processor)

- Guidance, Documents
  - Rule of thumb documents
  - Policy, Guidelines
  - Microcontroller recommendations
  - CubeSat Parts Database
  - COP

Legend
- NEPP Ongoing Task
- FY14 Proposed New Start

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FY14 NEPP Core - Complex Devices

Core Areas are Bubbles; Boxes underneath are variable tasks in each core

NEPP Research Category – Complex Devices

- **FPGAs – Radiation**
  - Xilinx Virtex 5QV
  - Commercial
  - Xilinx 28nm Virtex-7, Kintex-7
  - FPGA SOCs: Xilinx Zynq, Microsemi SmartFusion 2
  - New Microsemi and ATMEL Embedded Coldfire™

- **FPGAs – Reliability**
  - Xilinx Virtex 5QV
  - Daisy Chain Package Evaluation
  - FPGA SOCs: Xilinx Zynq, Microsemi SmartFusion 2

- **Area Array Packages**
  - Class Y QML
  - Class Y and IPC
  - HALT for PBGA
  - Thermal Interface Materials
  - Solder Bump Comparison
  - Flip Chip Interconnect

- **Memory Devices**
  - Resistive Memory (RERAM, CBRAM)
  - Radiation, Reliability
  - 3D Structure
  - FLASH Memory
  - Samsung VNAND Radiation, Reliability
  - DDR3 Memory Radiation, Reliability

- **Advanced CMOS**
  - IBM trusted foundry
  - 14-32 nm Radiation
  - Intel 14 nm Radiation
  - DARPA LEAP Program (32 nm) Radiation

- **Assurance**
  - Memory Fault Coverage
  - SOC Radiation
  - Synopsys TMR Tool Evaluation

Legend:
- NEPP Ongoing Task
- FY14 Proposed New Start

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FY14 NEPP Core - Power Devices

Core Areas are Bubbles; Boxes underneath are variable tasks in each core

NEPP Research Category – Power Devices

- Power Converters
  - DC-DC Converter Working Group
  - POL SEU Susceptibility

- Power MOSFETS – Silicon
  - New Mil/Aero Product Evaluation (Radiation)
  - (CubeSat) Commercial Power MOSFET Evaluation (Radiation)

- Widebandgap Power and RF
  - Widebandgap Working Group
  - GaN Radiation Test
  - SiC Radiation Test
  - Combined Effects Reliability

- Assurance
  - Standards Support

Legend
- NEPP Ongoing Task
- FY14 Proposed New Start

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FY14 NEPP Core - Assurance

Core Areas are Bubbles; Boxes underneath are variable tasks in each core.

NEPP Research Category – Assurance

- Radiation
  - Hydrogen Effects
  - Ultra-ELDRS
  - Board level proton testing BOK

- Parts
  - Hermeticity
  - BME Capacitors
  - Ceramic Capacitors
  - Tantalum Capacitors

- Packaging
  - NEPP Roadmap Update
  - Leadless Package Trends

- Assurance
  - Connector Working Group
  - Low Proton Energy Test Guideline
  - NASA Parts Policy Update
  - Radiation Assurance Policy/Guidance
  - Long term Storage BOK

Legend
- NEPP Ongoing Task
- FY14 Proposed New Start

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NASA Electronic Parts Assurance Group (NEPAG)

Core Areas are Bubbles, Boxes underneath are elements in each core

NEPAG Focus Areas

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

Legend
- NEPP Ongoing Task
- FY14 Proposed New Start

To be published on nepp.nasa.gov previously presented by Kenneth LaBel at the NASA Electronic Parts and Packaging (NEPP) Electronics Technology Workshop (ETW), Greenbelt, MD, June 17-19, 2014.
Sample Overguide Task Areas

- Fiber Optics,
- Sensor Technologies (IR, visible, etc...),
- SiGe Advanced Mixed Signal,
- ADCs/DACs,
- GaAs Electronics,
- Connector Evaluation,
- 3D Packages,
- Flexible Electronics,
- MEMS,
- University Research, and
- CAVE/CALCE Memberships.

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Summary

- NEPP is an agency-wide program that endeavors to provide added-value to the greater aerospace community.
  - Always looking at the big picture (widest potential space use of evaluated technologies),
  - Never forgetting our partners, and
  - Attempting to do “less with less” (static budget versus rising costs).
- We invite your feedback and collaboration. Please visit our website (http://nepp.nasa.gov).
- Join us at our new “EEE Parts for Small Missions Workshop” in September.
- Questions?