NASA Electronic Parts and Packaging (NEPP) Program Preliminary Update for FY15

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

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Acronyms

3D	Three Dimensional
ADC	Analog to Digital Converter
Aero	Aerospace
ARC	Ames Research Center
ASIC	Application Specific Integrated Circuit
CMOS	Complementary Metal Oxide Semiconductor
COTS	Commercial Off The Shelf
CSLI	CubeSat Launch initiative
DIP	Dual Inline Package
DNL	Differential Non-Linearity
DSP	Digital Signal Processor
EDAC	Error Detection and Correction
EEE	Electrical, Electronic, and Electromechanical
ENOB	Effective Number of Bits
EPI	Epitaxial
ESSP	Earth System Science Pathfinder
FCBGA	Flip Chip Ball Grid Array
FPGA	Field Programmable Gate Array
GAS can	GetAway Special can
Gb	Gigabit
Gbps	Gigbits per Second
GHz	Gigaherz
GSFC	Goddard Space Flight Center
HST	Hubble Space Telescope
IC	Integrated Circuit
INL	Integral Non-Linearity
IO	Input Output
ISS	International Space Station
JIMO	Jupiter Icy Moons Orbiter
JPL	Jet Propulsion Laboratories
JWST	James Webb Space Telescope
k	Kilo
kb	Kilobit
LCC	Leadless Chip Carrier

M	Meg
MER	Mars Exploration Rover
MHz	Megaherz
MIDEX	Medium-Class Explorer
MIL	Military
MIPS	Millions of Instruction per Second
MP3	Moving Picture Experts Group-I or II Audio Layer III
MRO	Mars Reconnaissance Orbiter
Msps	Megasamples per second
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts and Packaging
NID	NASA Interim Directive
nm	nanometer
NMOS	N-type Metal Oxide Semiconductor
NPR	NASA Procedural Requirements
NPSL	NASA Parts Selection List
NRE	Non-Recurring Engineering
PCB	Printed Circuit Board
POF	Physics of Failure
RF	Radio Frequency
SAA	South Atlantic Anomaly
SCD	Source Control Drawing
SDRAM	Synchronous Dynamic Random Access Memory
SEE	Single Event Effect
SERDED	Serializer Deserializer
SEU	Single Event Upset
Si	Silicon
SMA	Safety and Mission Assurance
SMEX	Small Explorer
SOC	Systems on a Chip
SOI	Silicon on Insulator
SWaP	Size, Weight, and Power
TID	Total Ionizing Dose
TMR	Triple Modular Redundancy
um	micron

NEPP Overview

***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

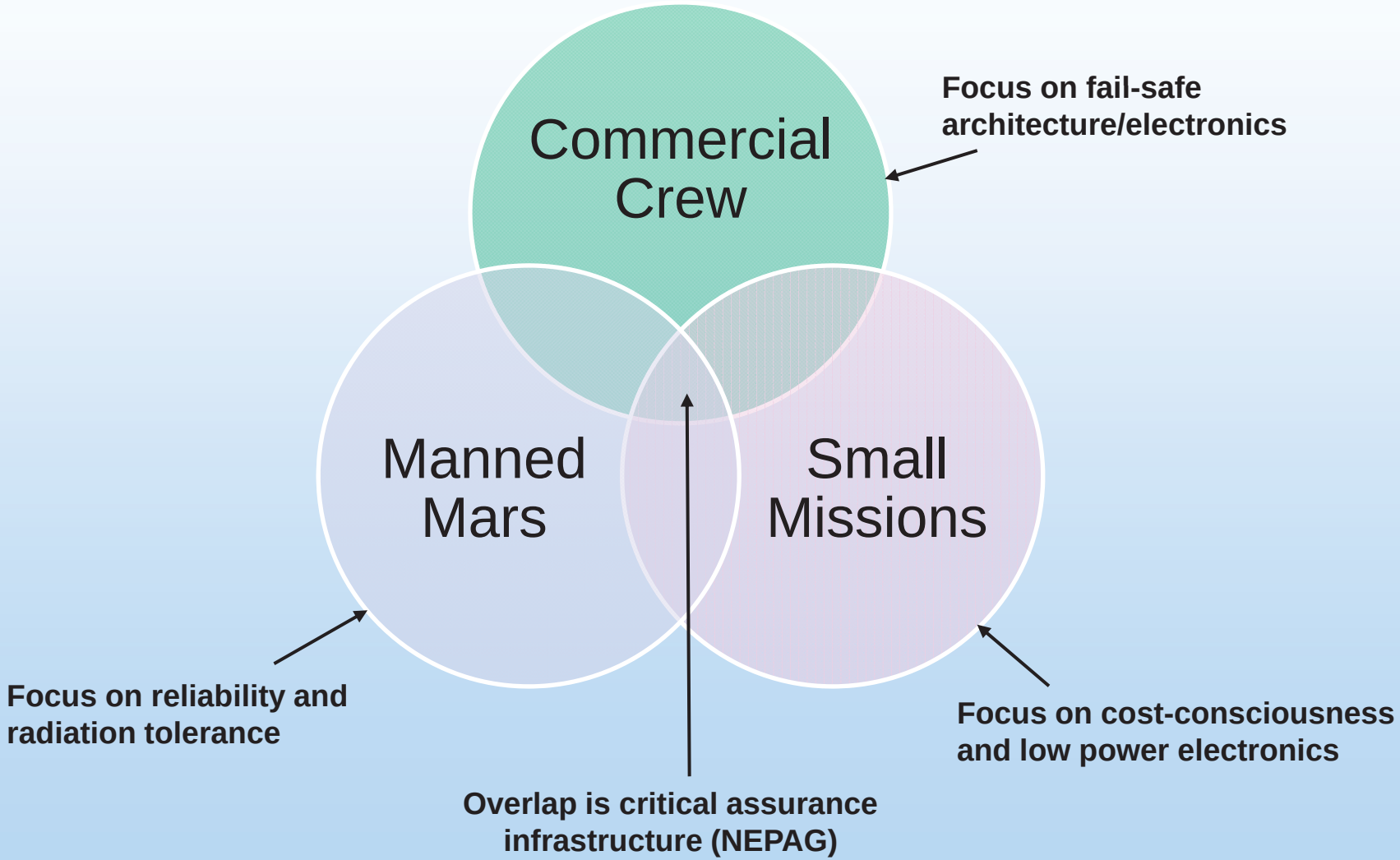
Test/Qualification Methods
Evaluate improved or more cost-effective concepts

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.

Notional NEPP View of EEE Parts Needs Diversity



FY15 NEPP Core –
Automotive/Commercial Electronics (Small Missions)

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

Legend
- NEPP Ongoing Task
- FY15 New Start
- Overguide/Pending Availability

NEPP Research Category – Automotive/Commercial Electronics

Automotive Electronics
- BOK on specs, standards, and vendor approaches (NEPAG)
- Extended Temperature Evaluation of Automotive Capacitors
- Reliability evaluation of ceramic capacitors, discrete transistors, and microcircuits

Alternate Test Approaches
- Effectiveness of Board Level Testing for Piecepart Qualification (will utilize boards with automotive microcontrollers)

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

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

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

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

Work performed by NASA and Navy Crane

Does not yet include automotive "safety critical"

FY15 NEPP Core - Complex Devices

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

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NEPP Research Category – Complex Devices

FPGAs – Radiation
- Xilinx Virtex 5QV
- Xilinx 28nm Virtex-7, Kintex-7
- Xilinx Zynq
- Microsemi RT4G and Igloo2
- Embedded Coldfire™
- Altera Stratix-V
- Xilinx 20nm Altera 14nm

FPGAs – Reliability
- Xilinx Virtex 5QV Daisy Chain Package Evaluation
- Xilinx 28nm
- Microsemi RT4G Daisy Chain Package Evaluation
- Altera Stratix-V

Advanced Packaging
- Class Y, N Support
- HALT for PBGA + others
- Thermal Interface Materials
- Area Array Column Guideline
- Commercial Stacked (SSDs)
- Class Y and IPC

Memory Devices (COTS)
- Resistive Memory (RERAM, CBRAM) Radiation, Reliability
- 3D Structure FLASH Memory Samsung VNAND Radiation, Reliability
- DDR3 Memory Radiation, Reliability
- Micron 16nm planar FLASH Radiation, Reliability

Advanced CMOS
- IBM trusted foundry 14-32 nm Radiation
- Robustchip/ Cisco 28nm and below Radiation
- Intel 14 nm Radiation
- Other technologies (MRAM, CNT)

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

FY14 NEPP Core - Power Devices

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

Legend
- NEPP Ongoing Task
- FY15 New Start
- Overguide/Pending Availability

NEPP Research Category – Power Devices

- **Power Converters**
  - Hybrids/DC-DC Converter Working Group
  - POL Reliability + SEU Susceptibility
  - DC-DC Converter Selection Guideline
- **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

FY15 NEPP Core - Assurance

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

Legend
- NEPP Ongoing Task
- FY15 New Start
- Overguide/Pending Availability

NEPP Research Category – Assurance

Radiation
- Ultra-ELDRS
- RHA Review Support
- Board level proton testing Guideline (was BOK)
- 3D Inspection X-ray Dose Study
- JEDEC JESD57 Update

Parts
- BME Capacitors – teaming w Aerospace Corp
- MLCC Reliability Guideline
- Tantalum Capacitors Reliability (includes DLA drawing #103032)
- Super/Ultra Capacitors BOK
- Ultra Small Passives BOK
- Integrated Inductor/Resistor BOK

Packaging
- NEPP Roadmap Update
- Leadless Package Trends
- Hermeticity Test Method Guideline/ Mil-STD Update

Connectors/ Wire
- NASA Connector Working Group
- NASA Connector Usage BOK
- TBD Connector tests
- Aluminum Wire Evaluation

Assurance
- Low Proton Energy Test Guideline
- NASA Parts Policy Update
- Radiation Assurance Policy/Guidance
- Project Parts Database Mining
- SME Support – Trusted FPGAs/ Integrity

Does not yet include CRÈME website or proton facility efforts

FY15 NEPAG Core

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

Legend

- NEPP Ongoing Task
- FY15 New Start
- Overguide/Pending Availability

NEPAG Focus Areas

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

Lead Centers: GSFC – passives , JPL – actives, LaRC – hybrids, JPL - actives

Cosmic Ray Effects on Micro-Electronics (CREME) Website

- https://creme.isde.vanderbilt.edu/
  - Hosts the industry-standard toolset for predicting single event upset (SEU) rates for space.
- CREME, in its near 20-year history of development, has been a product of NRL, NASA, DTRA, and internal Vanderbilt funding.
  - On June 1 of this year, Vanderbilt announced the impending closure of this highly used research and qualification tool.
- NEPP and NASA Space Weather have provided stopgap funds to keep website open until early next FY
- Long-term solution is being worked to transfer to a government website
  - Likely site is NASA's Community Coordinated Modeling Center (CCMC - http://ccmc.gsfc.nasa.gov/)
  - Plan development and evaluation of this option is underway by a multi-Agency team (ad hoc)
- Preliminary costing received

Indiana University Cyclotron Facility (IUCF) Closure

- IUCF has been the most used higher energy proton test facility for most of the U.S. space industry (electronics).
  - It is primarily a medical facility that NASA and others have supported to develop a parallel capability for proton testing of electronics.
  - IUCF has recently announced the impending closure of this site (http://news.iu.edu/releases/iu/2014/08/proton-therapy-center.shtml).
- This has not gone unnoticed by NEPP nor our DOE/DoD brethren: we are actively discussing options that include:
  - Use of Tri-University Meson Facility (TRIUMF) – Vancouver, Canada,
  - Massachusetts General Hospital (MGH) Francis H. Burr Proton Therapy Center, and,
  - Multiple other proton therapy centers (see: http://proton-therapy.org for example listing)
    - Detailed discussions have begun on access to these facilities as well as exploration of "simplified" procurement approaches

Facilities Contacted

Facility	Location	Status	Next
CDH Proton Facility - ProCure	Chicago, Ill	IBA cyclotron at 230 MeV, but uses a "scanning gun" - beam sort of rasters through an area. Can "scatter" to do IC sizes, but not board level. Not a first general option, but backup facility.	Site visit.
Hampton University Proton Therapy Institute (HUPTI)	Hampton, VA	Telecon held - basically meets specs. Has a tbd room which can be used. Possible interleaving. VERY PROMISING. Right beam structure and possibly much more than 300 hours/year.	Site visit.
James M. Slater Proton Treatment and Research Center at Loma Linda University Medical Center (LLUMC)	Loma Linda, CA	Synchrotron - challenging for SEE tests. JPL following up.	
M.D. Anderson Cancer Center	Houston, TX	Synchrotron - challenging for SEE tests.	None planned.
Mass General Francis H. Burr Proton Therapy	Boston, MA	Already in use 2 of 3 weekends. Little additional time available.	
ProCure Proton Therapy Center	Oklahoma City, OK	IBA cycolotron at 230 MeV, but uses a "scanning gun" - beam sort of rasters (wobbles) through a 1 cm diameter area 3x in 1 second. Can do fixed "microbeam". Not a first general option, but fixed microbeam can be of use. Maybe 300 hours a year on nights/weekends.	Possible site visit.
ProCure Proton Therapy Center	Somerset, NJ	No response as of yet, but pencil beam w scanning.	TBD
Provision Center for Proton Therapy	Knoxville, TN	Very interested in opportunity: building a second cyclotron. One for R&D, one for treatments.	Telecon held - site visit needed.
Roberts Proton Therapy Center at University of Pennsylvania Health System	Philadelphia, PA	Have made initial contact - Ray Ladbury is following on based on "specs"	TBD
Scripps Proton Therapy	LaJolla, CA	Request has been forwarded. Awaiting further response.	
Seattle Cancer Care Alliance Proton Therapy - ProCure	Seattle, WA	Part of ProCure network, but have an additional 50 MeV source for neutron therapy. Very interested. Can basically meet specs, but would like to use a small room they have as a new beam line for SEE testing. Investment needed to do so, but could use patient room on weekend type schedule in the mean time.	Site visit
Tri-University Meson Facility (TRIUMF)	Vancouver, CAN	We run BL2C-105 MeV about 1 week per month from April to December and BL1B-350/480 MeV for a week or so about 4 times per year. We use these beam lines for neutron users as well and they use more than half of the time. That said we can accommodate new users and we can discuss expanding our beam time with TRIUMF management if there is more demand. However we don't run protons for testing as much as IUCF does. We normally run on a first come - first served basis and use a purchase order to reserve beam time.	Looking at international agreement option and ITAR/export issues.
University of Florida Proton Therapy Institute	Jacksonville, Fl	Telecon held and basically meets specs. Sundays and maybe evenings for ~300 hours a year.	Site visit.
University of Maryland Proton Treatment Center	Baltimore, MD	Under construction with expectation to run beam in late 2015. Say the specs are fine.	Site visit to discuss sometime in fall

Working to get Chuck Foster under consulting contract to help

Electrical, Electronic, and Electromechanical (EEE) Parts for Small Missions Workshop on September 10-11, 2014

- **Held at GSFC and on-line via WebEx**
- **Two full days of talks and panels.**
  - **Over 300 registrants were provided with a range of topics including**
    - **Invited talks from ESA and NASA on CubeSat and Small Missions overviews, as well as,**
    - **A keynote from Prof. Michael Swartwout/St. Louis University on the first 272 CubeSats providing statistics on success rates.**
    - **Technical areas included CubeSat processors and power systems, tailored approaches to parts assurance, automotive electronics, and tutorial information on the unique space environment.**
- **Presentations cleared for release are posted on the NEPP website (http://nepp.nasa.gov).**

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).**
- **NEPP Workshop planned for June 23-26 2015. Will be a mix of traditional June meeting plus CubeSat focus.**