The NASA Electronic Parts and Packaging (NEPP) Program – FY12 Overview

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Unclassified

Outline

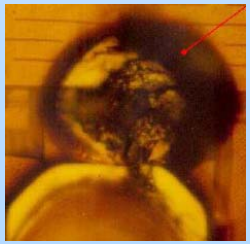
- Introduction to NEPP
- NEPP Technologies and Space Systems
- Knowledgeshare
- Collaborations
- Consortia/Universities
- FY12 Planning
- Summary
- Backup Slides

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



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, 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**

NEPP Works Two Sides of the Equation

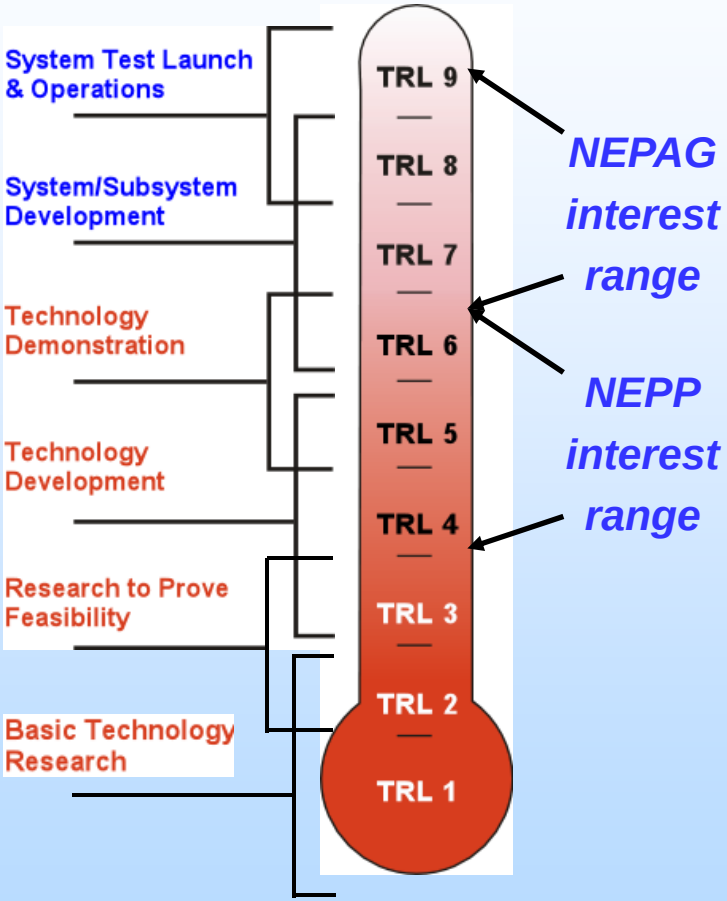
- **Assurance**
  - ***Issues applicable to space systems being designed and built (i.e., currently available technologies)***
  - **Examples**
    - **Cracked capacitors**
    - **Power converter reliability**
  - **Communication infrastructure**
    - **NASA Electronic Parts Assurance Group (NEPAG)**
  - **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**
  - **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 2015 launch, technology freeze dates are likely 2012 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)

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

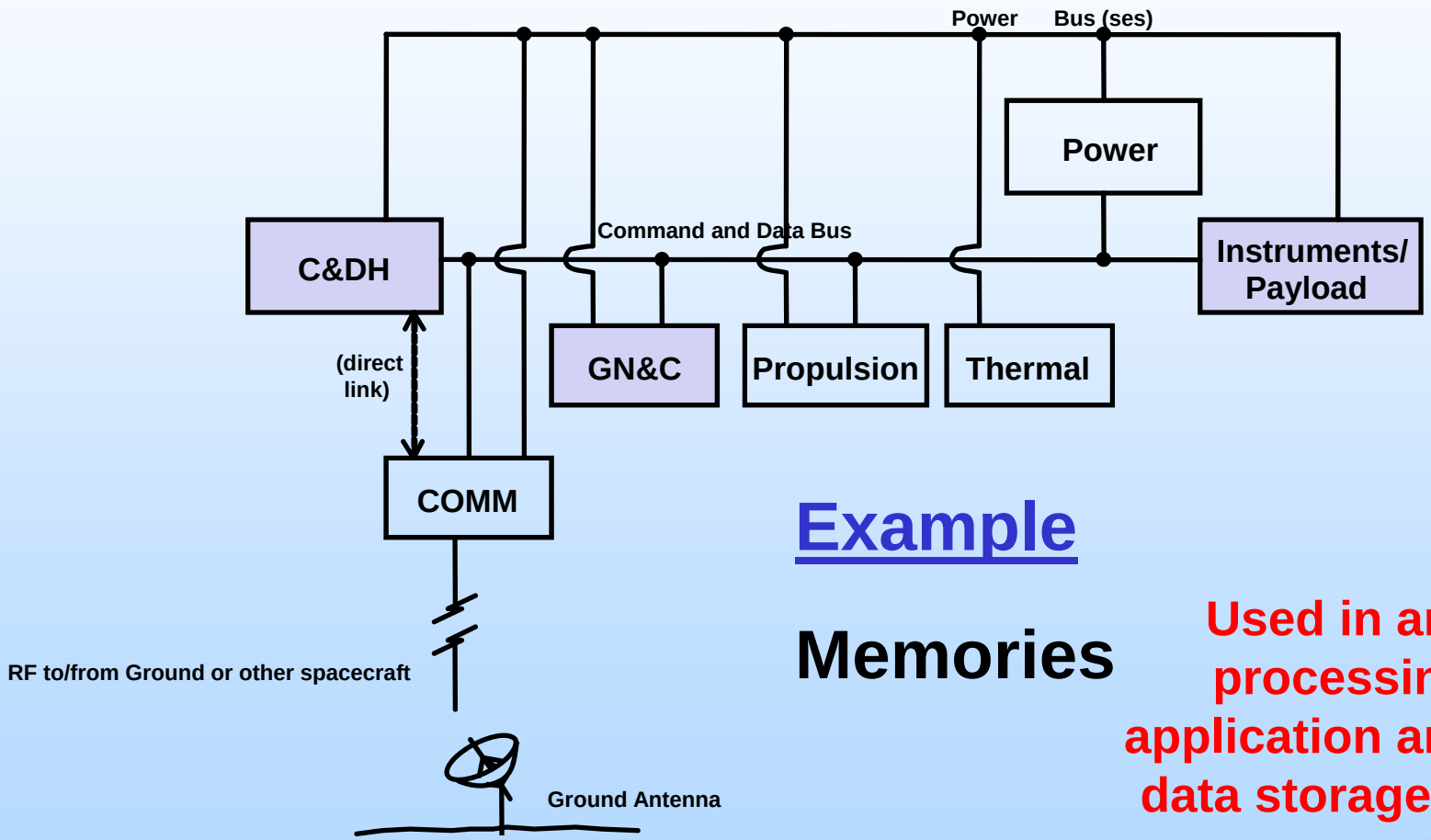
Presented by Kenneth LaBel at the Radiation Hardened Electronics Technology (RHET) Meeting, October 25-27, 2011, Minneapolis, MN, and published on nepp.nasa.gov.

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:**
  - **Direct funding from DoD**
    - **DTRA and NRO as well as in-kind efforts with AFRL, NRL, SNL, NAVSEA, etc…**
  - **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***

Metric: 90% of NEPP Tasks should have NASA-wide Utility

Typical Spacecraft Electrical Architecture



Example

Memories

Used in any processing application and for data storage on a spacecraft.

Knowledgeshare

- 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
  - NEPP Annual Electronics Technology Workshop (ETW) in June (~200 attendees)
    - 3rd Annual ETW: Week of June 4th 2012
    - May hold additional HiREV (National High Reliability Electronics Virtual Center) Review Meeting in conjunction
  - Standards working groups
  - Telecons
  - Documents such as Guidelines, Lessons Learned, Bodies of Knowledge (BOKs)

Consortia/Working Groups and Universities

- NEPP partially funds (via membership fees) two university-led electronics reliability research consortia
- NEPP utilizes working groups for information exchange and product development
  - External examples:
    - Joint Electron Device Engineering Council (JEDEC) commercial electronics and GEIA G12 Government Users
  - Internal (NASA) examples:
    - DC-DC converters and connectors
- NEPP fosters university research in electronic parts
  - Examples
    - Radiation effects modeling at Vanderbilt University
    - Ultra-high speed electronics at Georgia Tech

The NEPP Program in a Nutshell

Management

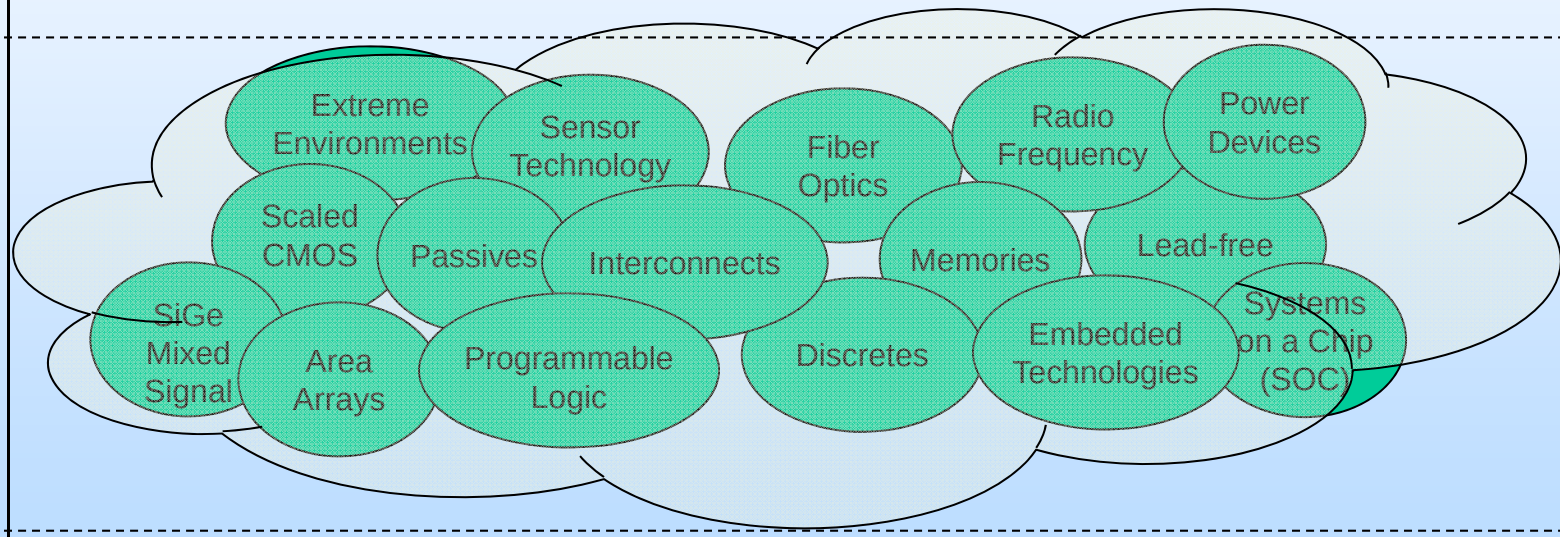
Ken LaBel - 561
Radiation Effects
Advanced Actives
NEPP Events

Mike Sampson - 300
NEPAG
Passives
Packaging

Core Elements

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

Focus Technologies



Products/ Deliverables

- Guidelines
- Specifications and Standards
- Test Methods
- Website Content
- NASA Parts Selection List
- Tools
- Data
- Technical Reports
- Bodies of Knowledge
- Conference Papers

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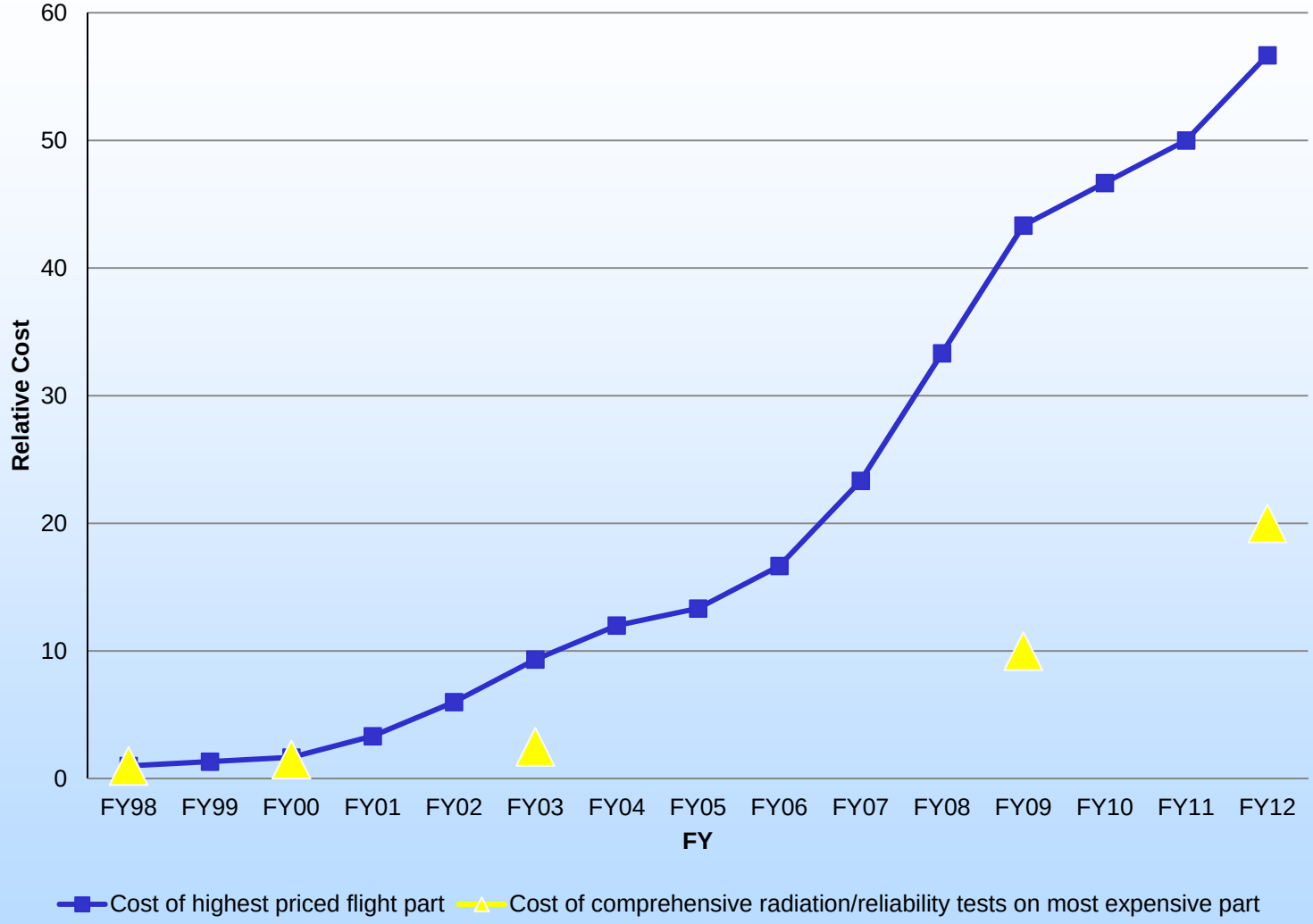
FY12 Sample Major Tasks/Challenges

- **Continued/new efforts in**
  - **State-of-the-art commercial device/technology evaluation**
    - **FPGAs (Virtex-5QV among others), Flash Memories, DDR2/3 Memories**
  - **Power conversion devices**
    - **Point-of-loads (POLs) – new market entries**
    - **Advanced/new power MOSFETs**
      - **SiC, GaN, new Si entries**
  - **Sub 65nm CMOS**
  - **Test guidelines: FPGAs, ADCs, Flash, DDR Memories**
  - **Technology modeling, and so on**
- **Problem child**
  - **What to do with large area array package devices/packages?**
    - **Ex., Xilinx 1700+ pin CCGA or PBGA**
    - **Class Y dilemma**

Estimated Test/Parts Costs Normalized to FY98



Bottom line:

Costs have risen significantly, unfortunately NEPP budget hasn't!

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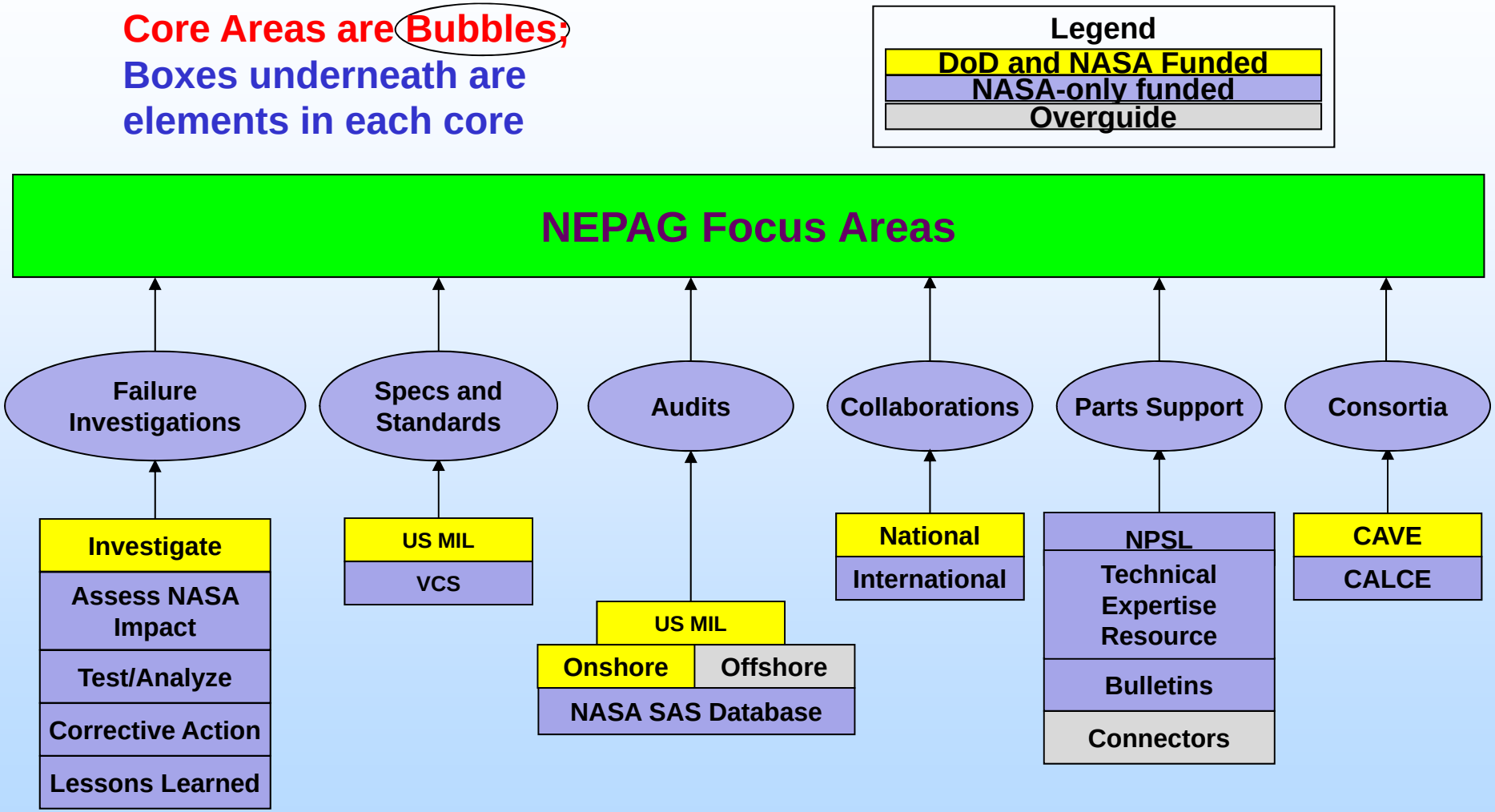
Summary

- **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 and invite you to visit our website (http://nepp.nasa.gov) and join us at our annual meeting in June at NASA/GSFC.**
- **Questions?**

Backups

NASA Electronic Parts Assurance Group (NEPAG)

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



Sample FY12 Radiation Plans for NEPP Core (1)

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

Legend
- DoD and NASA funded
- NASA-only funded
- Overguide

NEPP Research Categories – Active Electronics

SiGe. Mixed Signal
- IBM 9hp
- SiGe Physics Modeling
- Advanced Data Conversion, Amplifiers, Drivers
- Architectural comparison

Develops students at Georgia Tech

Scaled CMOS
- Commercial Devices
- Memories – Non-volatile, volatile
- FPGAs
- Processors, SOCs
- Structured ASICS
- Test Structures
- Silicon on Insulator (SOI)
- Ultra-low power
- Below 45nm
- CNTs
- RHBD Support

Partners include: DoD, IBM, TI, Intel, Boeing, Actel, Atmel, Xilinx, Altera, Cypress

Sensor Technologies
- IR
- Visible
- Cryo SEL
- Others

Partners at: AFRL, Cypress, Ball

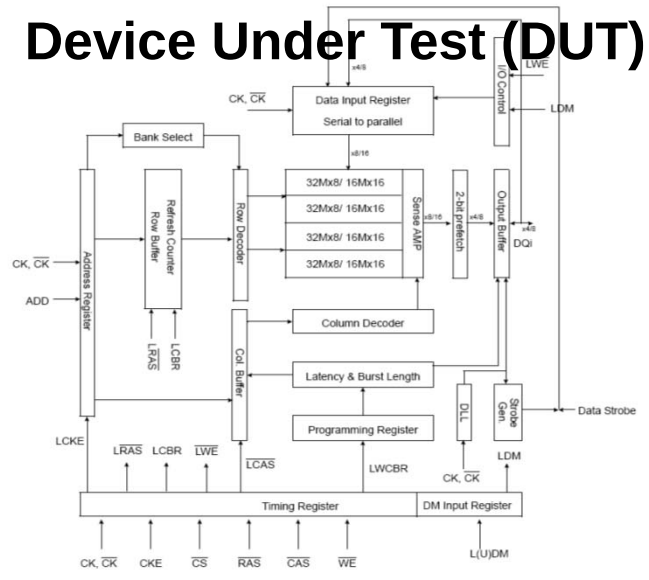
Photonics
- Fiber Amplifiers
- Exotic-doped Fiber components
- Wavelength Division Multiplexing
- Free space Optical interconnects
- Fiber Data Links
- Optocouplers and PM Optocouplers

Performance Tools
- 32 and 45 nm CMOS
- SiGe
- Low proton energy
- Compact model based rate prediction

Develops students at Vanderbilt

Disclaimer:
Statistics and "Qualification"

Device Under Test (DUT)



Commercial 1 Gb SDRAM

-68 operating modes

-can operate to >500 MHz

-Vdd 2.5V external, 1.25V internal

Single Event Effect Test Matrix

full generic testing

Amount	*Item*
3	Number of Samples
68	Modes of Operation
4	Test Patterns
3	Frequencies of Operation
3	Power Supply Voltages
3	Ions
3	Hours per Ion per Test Matrix Point

66096 Hours

2754 Days

7.54 Years

Doesn't include temperature variations!!!

The more complex a device, the more application-specific the test results

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