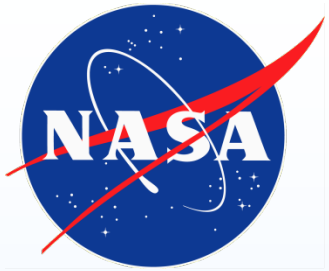

# The NASA Electronic Parts and Packaging (NEPP) Program: Roadmap for FY15 and Beyond


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# Acronyms

| Acronym | Definition |
|---|---|
| AMOLED | Active Matrix Organic Light Emitting Diode |
| CBRAM | Conductive Bridging Random Access Memory |
| CGA | Column Grid Array |
| CIGS | Copper Indium Gallium Selenide |
| CMOS | Complementary Metal Oxide Semiconductor |
| COTS | Commercial Off The Shelf |
| DDR4 | Double Data Rate Four |
| DNA | Deoxyribonucleic Acid |
| DoD | Department of Defense |
| DRAM | Dynamic Random Access Memory |
| EEE | Electrical, Electronic, and Electromechanical |
| EPC | Efficient Power Conversion |
| ESL | Electronic System Level |
| FeRAM | Ferroelectric RAM |
| FPGA | Field Programmable Gate Array |
| FY | Fiscal Year |
| GaN | Gallium Nitride |
| Gen | Generation |
| GSFC | Goddard Space Flight Center |
| HALT | Highly Accelerated Life Test |
| HAST | Highly Accelerated Stress Testing |
| HEMTs | High-electron-mobility transistors |
| HP Labs | Hewlett-Packard Laboratories |
| HW | Hardware |
| IC | Integrated Circuit |

| Acronym | Definition |
|---|---|
| IP | Intellectual Property |
| IR | Infrared |
| IR/Infineon | International Rectifier/Infineon Technologies |
| LCoS | Liquid-Crystal-on-Silicon |
| MEMS | Micro Electrical-Mechanical System |
| MOSFETS | Metal Oxide Semiconductor Field Effect Transistors |
| MRAM | Magnetoresistive Random Access Memory |
| NASA | National Aeronautics and Space Administration |
| NAVY Crane | Naval Surface Warfare Center, Crane, Indiana |
| NEPP | NASA Electronic Parts and Packaging |
| Occam | Open Conditional Content Access Management |
| OLED | Organic Light Emitting Diode |
| PBGA | Plastic Ball Grid Array |
| R&D | Research and Development |
| RERAM | Resistive Random Access Memory |
| RF | Radio Frequency |
| SEE | Single Event Effect |
| SERDES | Serializer/Deserializer |
| SiC | Silicon Carbide |
| SOC | Systems on a Chip |
| TI | Texas Instruments |
| TRL | Technology Readiness Level |
| VNAND | Vertical NAND |
| WBG | Wide Band Gap |

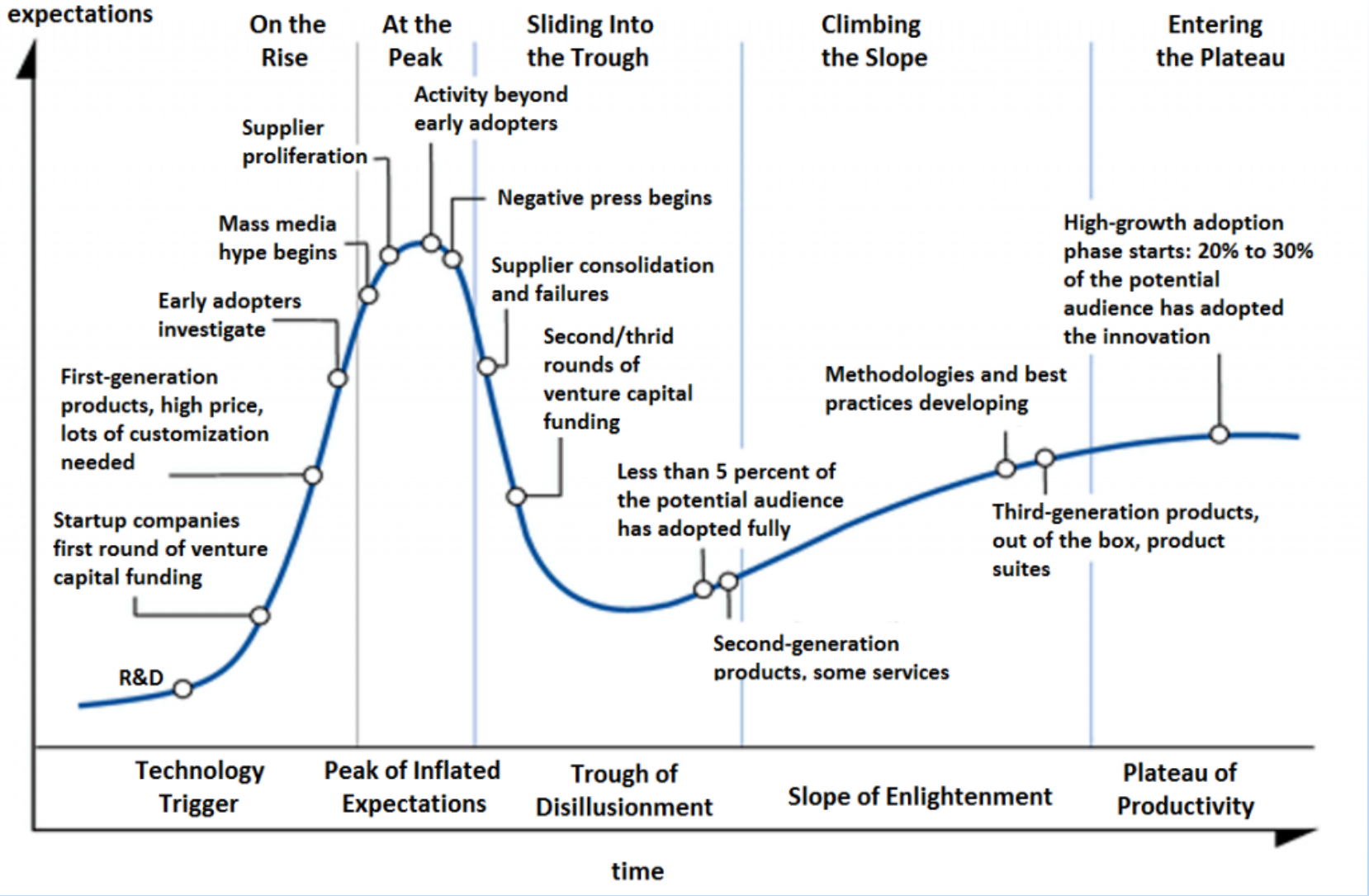
# Technology Selection Criteria for NEPP Investigation

- **The technologies should satisfy all or most of the following criteria:**
  - **Wide applicability,**
  - **Product level or in productization, and,**
  - **No distinction: COTS to hi-reliability aerospace.**
- **Partnering arrangements with other organizations preferred.**
- **In general, we avoid:**
  - **Laboratory technologies, e.g., <TRL3,**
  - **Limited application devices with certain exceptions (critical application or NASA center specialization).**

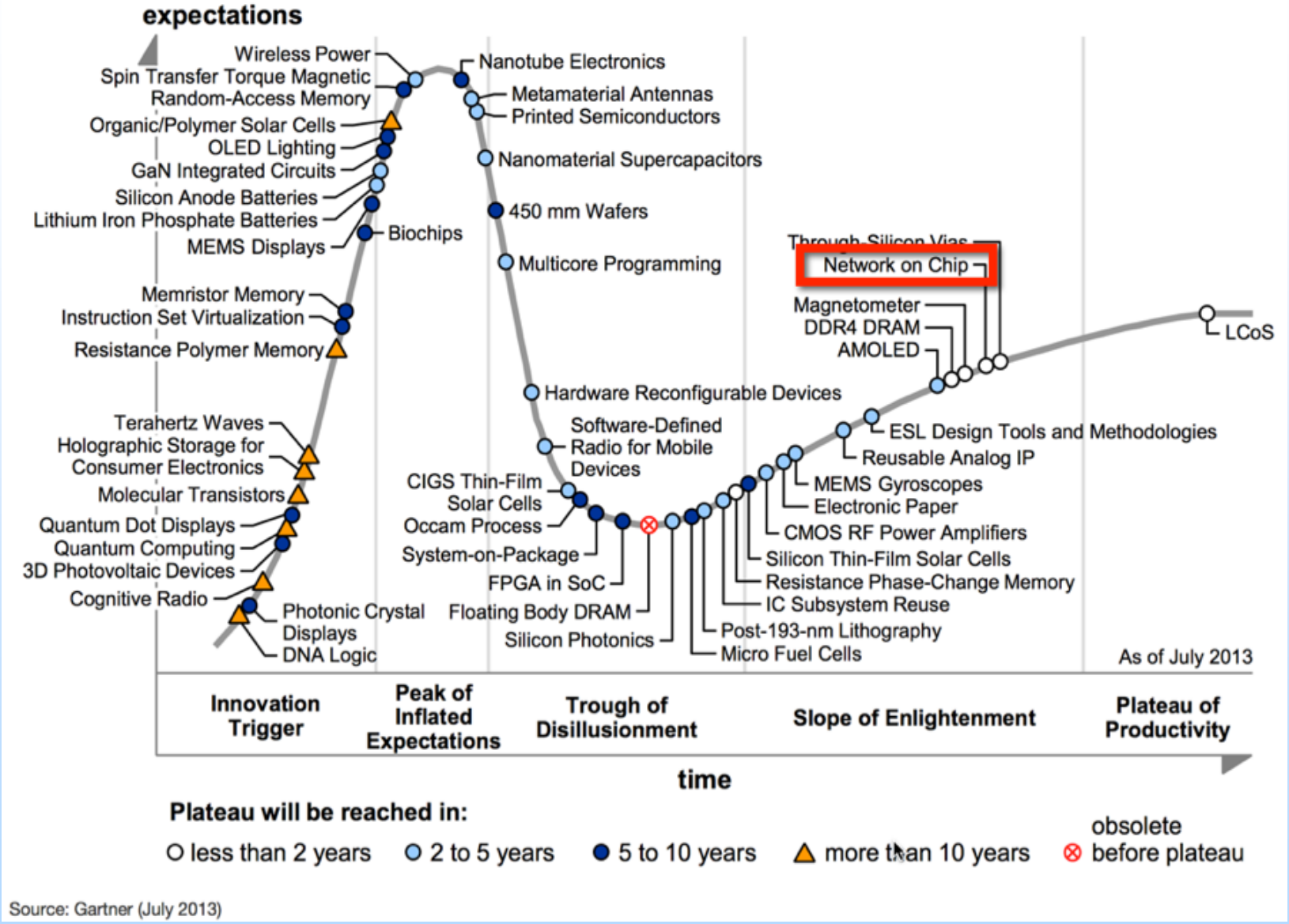
# Technology Investigation Roadmap Discussion

- **Technology assurance efforts are not explicitly included except on "Small Missions" chart.**
  - ***Guidelines are a product of many technology evaluation tasks.***
- **Only major product categories shown.**
- **Technology areas not on Roadmap but under consideration include:**
  - **Electro-optics (fiber optics),**
  - **Advanced analog and mixed-signal devices,**
  - **Imaging sensors,**
  - **Modeling and simulation,**
  - **High-speed communication (SERDES, fast data switches), and,**
  - **Adjunct processors (eg., graphics, signal processing)**
- **Note 1: Advanced CMOS technologies not explicitly included:**
  - **NEPP leverages samples from ongoing DoD and/or commercial sources.**
  - **14nm is current target.**
- **Note 2: "Reliability testing" may include product and/or package testing.**

# Gartner Hype Cycle Concept

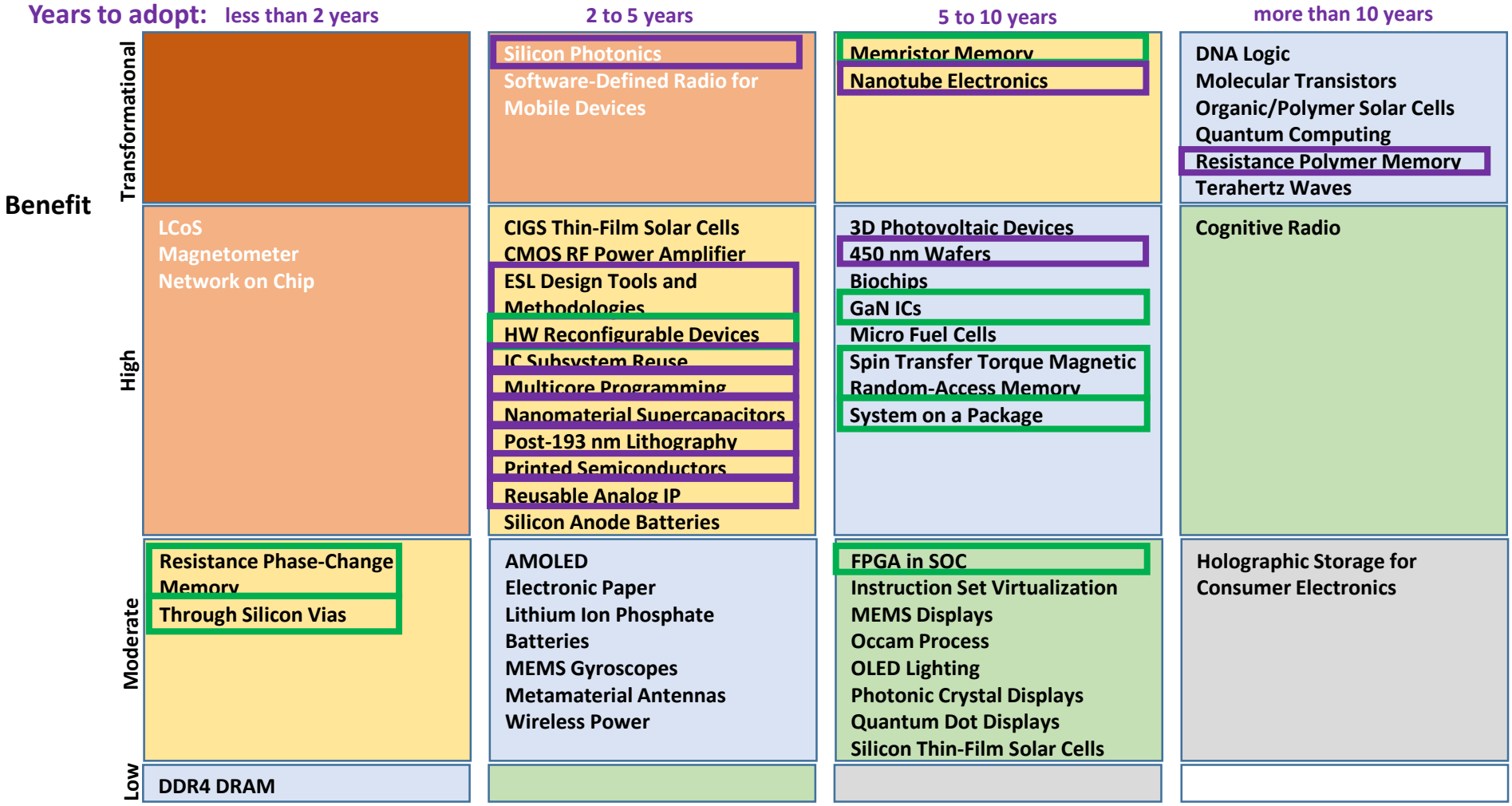


# Gartner Hype Cycle for Electronics 2013




Source: Gartner (July 2013)

# NEPP and Gartner Electronics Hype Cycle 2013



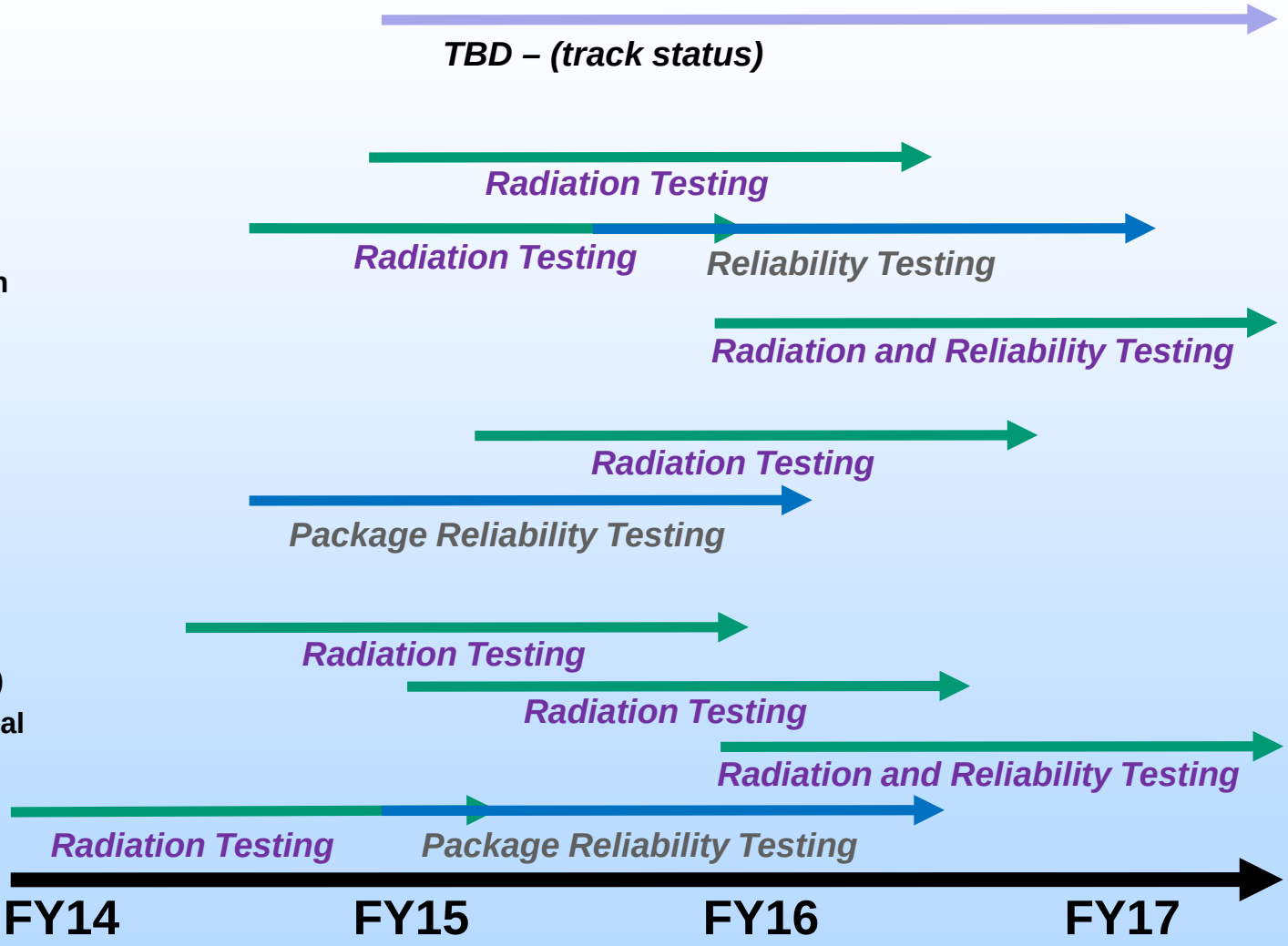
# Field Programmable Gate Arrays (FPGAs)

**Trusted FPGA**
- DoD Development

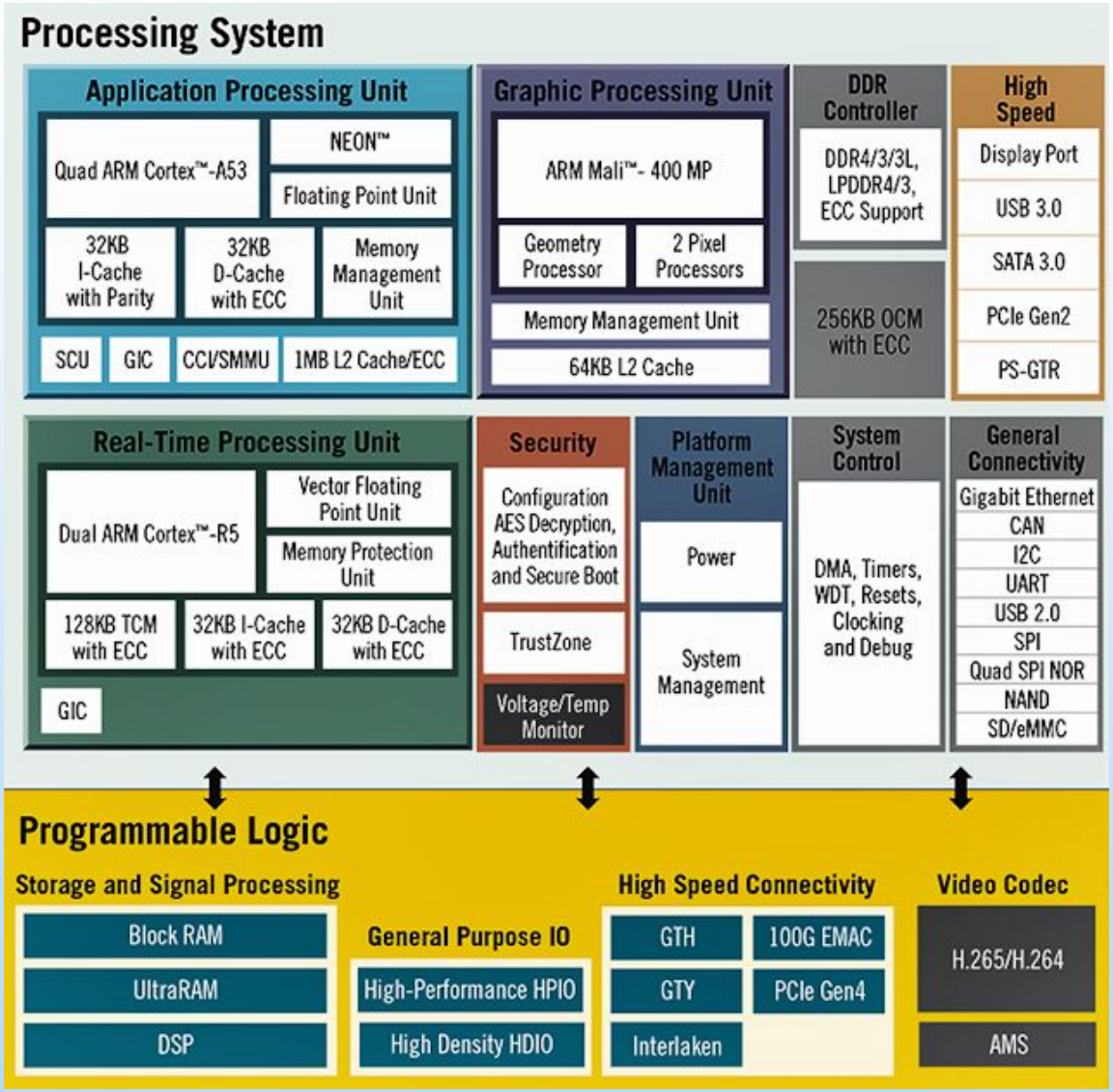
**Altera**
- Stratix 5 (28nm TSMC process commercial)
- Max 10 (55nm NOR based commercial – small mission candidate)
- Stratix 10 (14nm Intel process commercial)

**Microsemi**
- RTG4 (65nm RH)

**Xilinx**
- 7 series (28nm commercial)
- Ultrascale (20nm commercial – planar)
- Ultrascale+ (16nm commercial - vertical)
- Virtex 5QV (65nm RH)



# Xilinx Zynq UltraScale+ Multi-Processor System on a Chip (MPSoC) family




*From Xilinx.com*

# Advanced Processors

**Next Generation Space Processor (NGSP)**

- Joint NASA-AFRL Program for RH multi-core processor
- TBD architecture/process

**RH Processor**

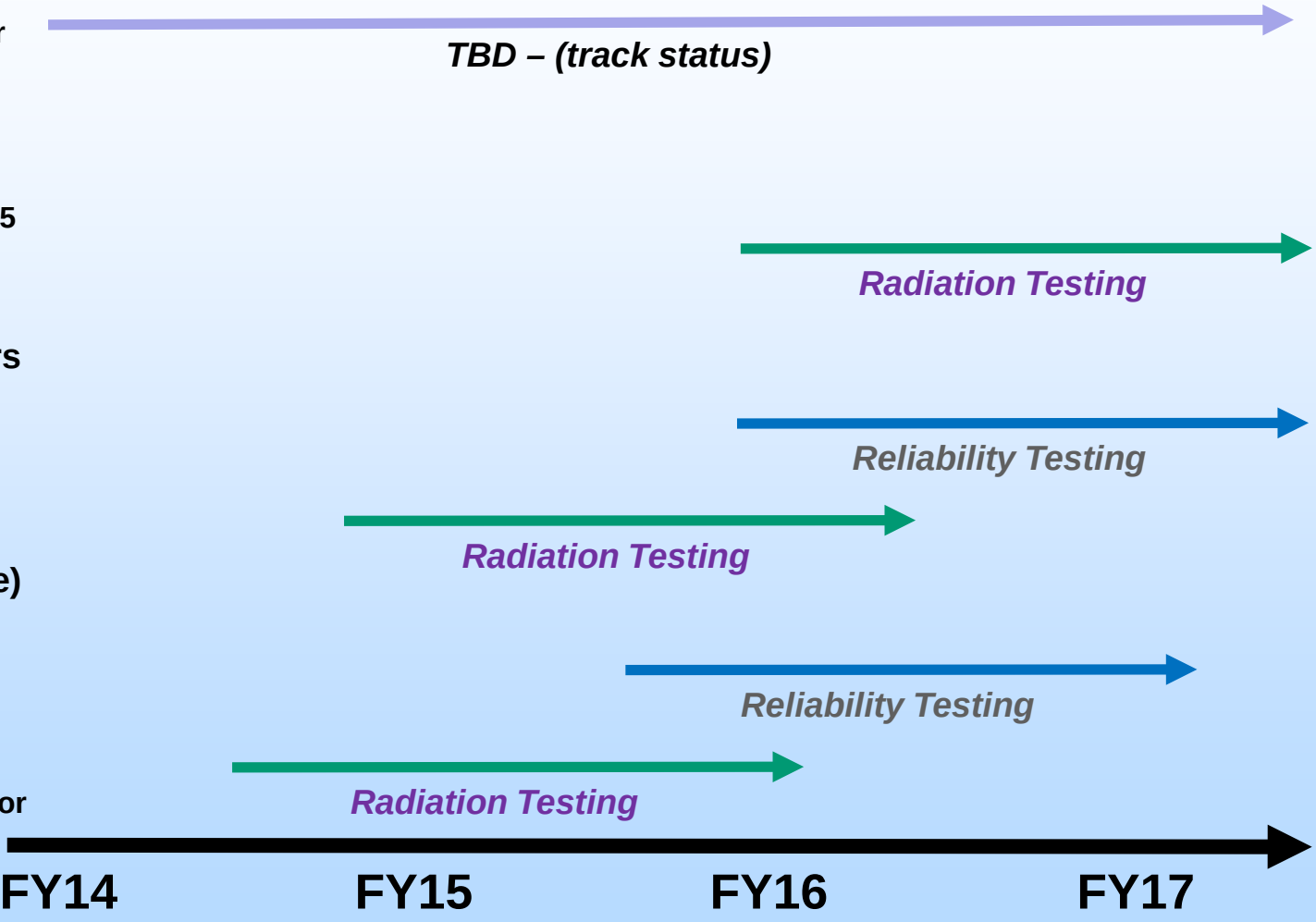
- BAE Systems RAD5510/5545
- Replacement for RAD750

**Intel Broadwell Processors**

- 14nm FinFET commercial
- 1st high-performance sans heatsink (lower power for performance)

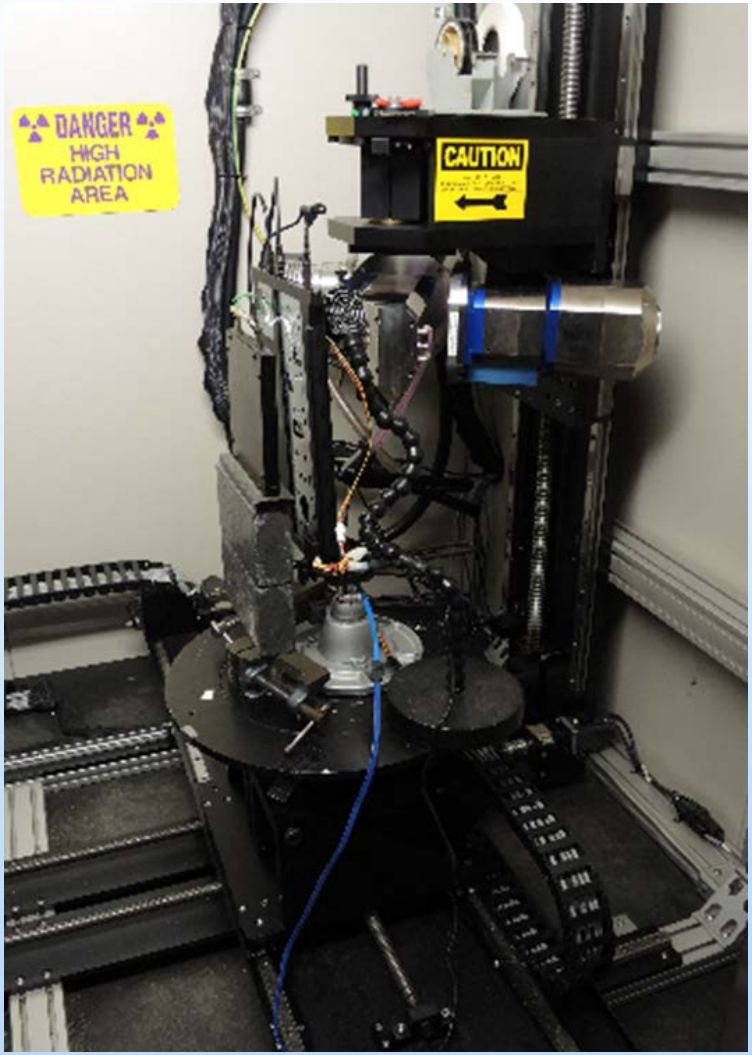
**Freescale P5020/5040**

- Commercial 45nm network processor
- Preparation for RH processor




***Note: Future considerations under discussion include automotive "self-driving" processor options.***

# Preliminary Radiation testing of 14nm Intel with Navy Crane



# Microcontrollers and Mobile Processors (Small Missions)

**TBD – other**

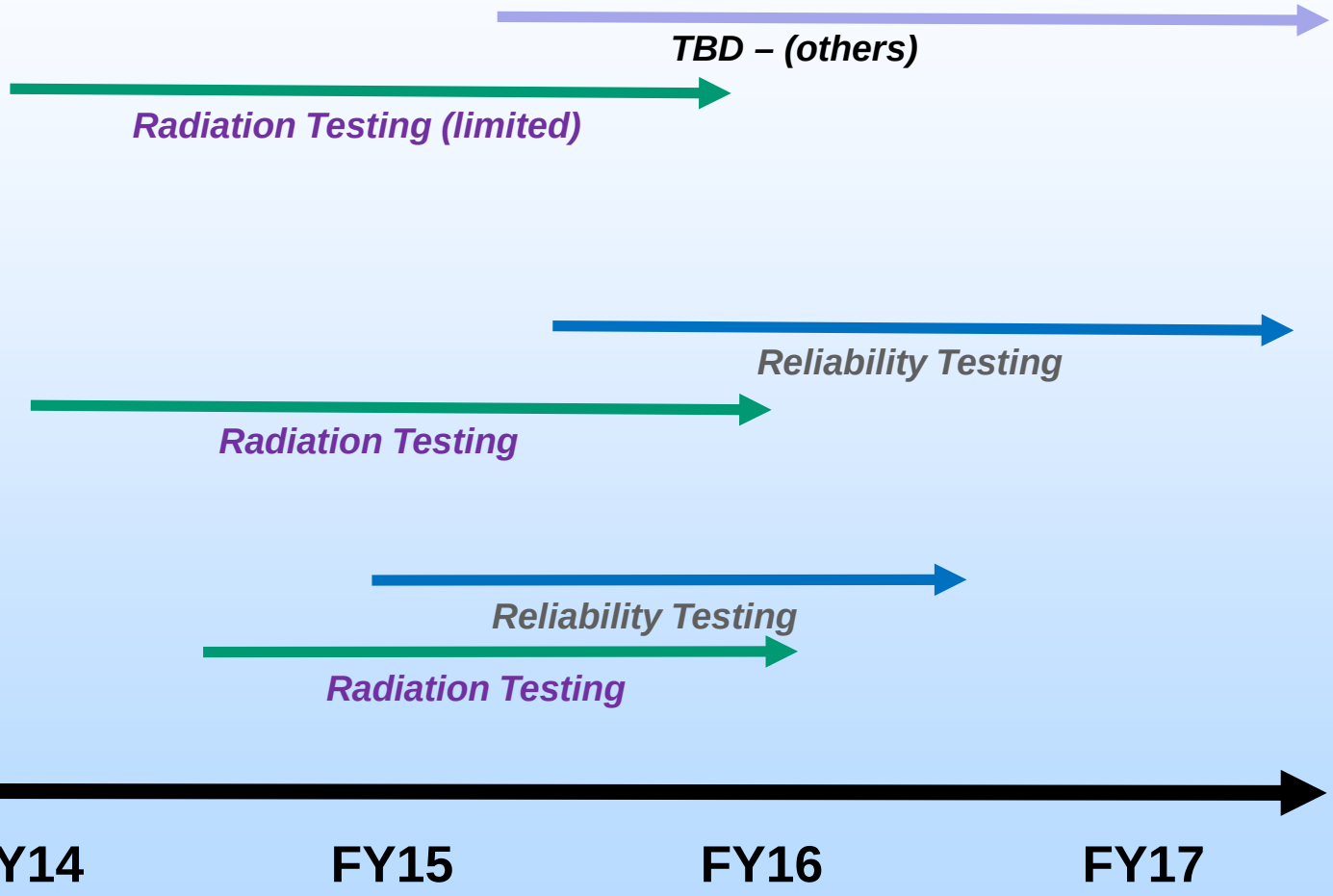
- Atmel AT91SAM9G20, and TI Sitara AM3703,
- ARM (Snapdragon), Intel Atom mobile

**TI MSP430**

- Popular CubeSat microcontroller
- Several varieties

**Freescale MPC56XX**

- 90nm on-shore fab
- Automotive Grade
- Being used for both part and board level testing



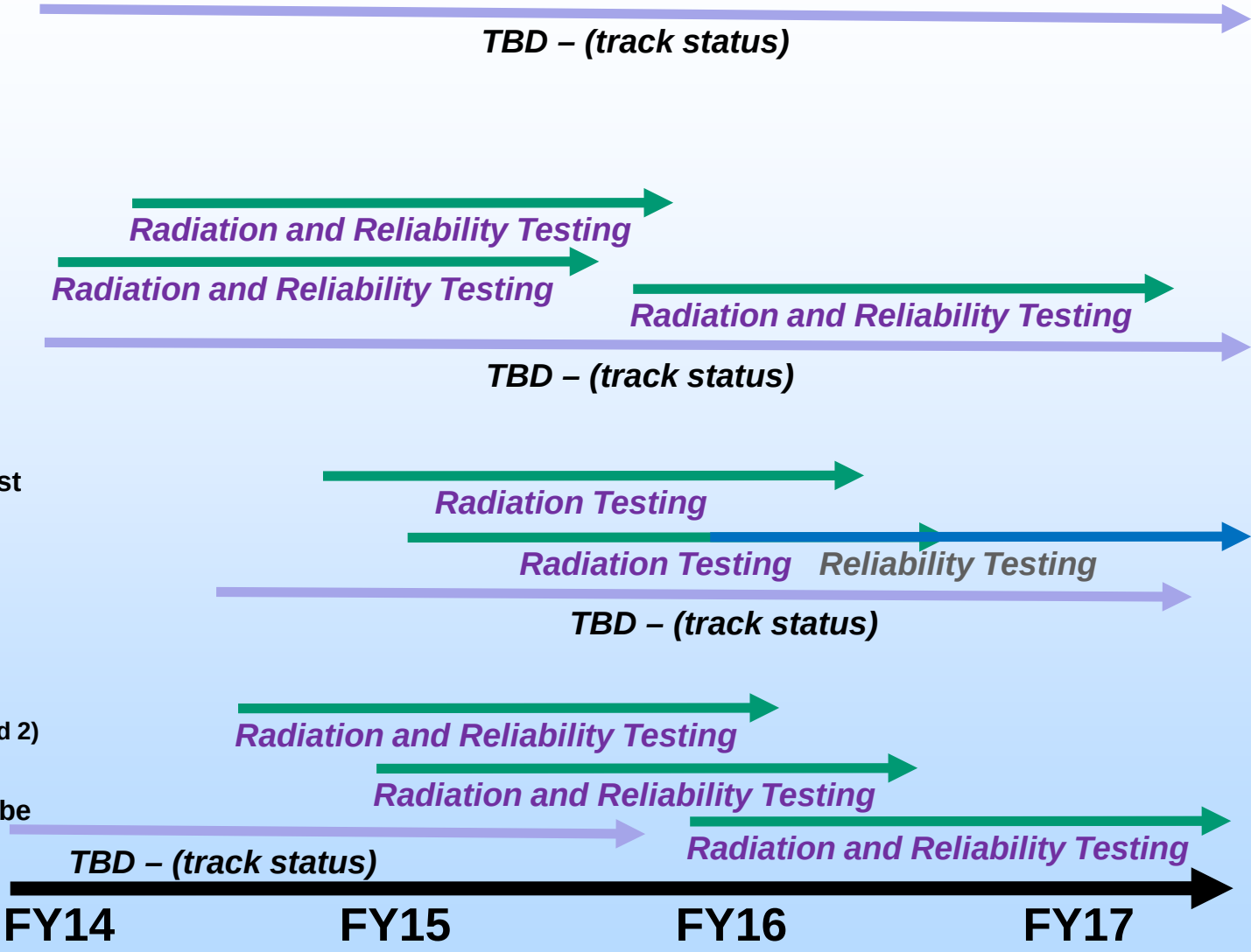
# Commercial Memory Technology

**Other**
- MRAM
- FeRAM

**Resistive**
- CBRAM (Adesto)
- ReRAM (Panasonic)
- ReRAM (Tezzaron)
- TBD (HP Labs, others)

**DDR 3/4**
- Intelligent Memory (robust cell twinning)
- Micron 16nm DDR3
- TBD – other commercial

**FLASH**
- Samsung VNAND (gen 1 and 2)
- Micron 16nm planar
- Micron Hybrid memory Cube
- TBD - other commercial



# Small Missions

**EEE Parts Guidelines**

- Small missions (Class D, CubeSat – 2 documents)
- System on a chip (SOC) single event effects (SEE) guideline

*Guideline development*

*Guideline development*

**Commodities evaluation**

- See commodities roadmaps for processors, power
- CubeSat Star Tracker

*Radiation Testing*

*Reliability Testing*

**Automotive grade electronics**

- Multiple classes of electronics (passives, actives, ICs)
- Testing by NASA and Navy Crane

*Reliability Testing*

**Alternate test – board level**

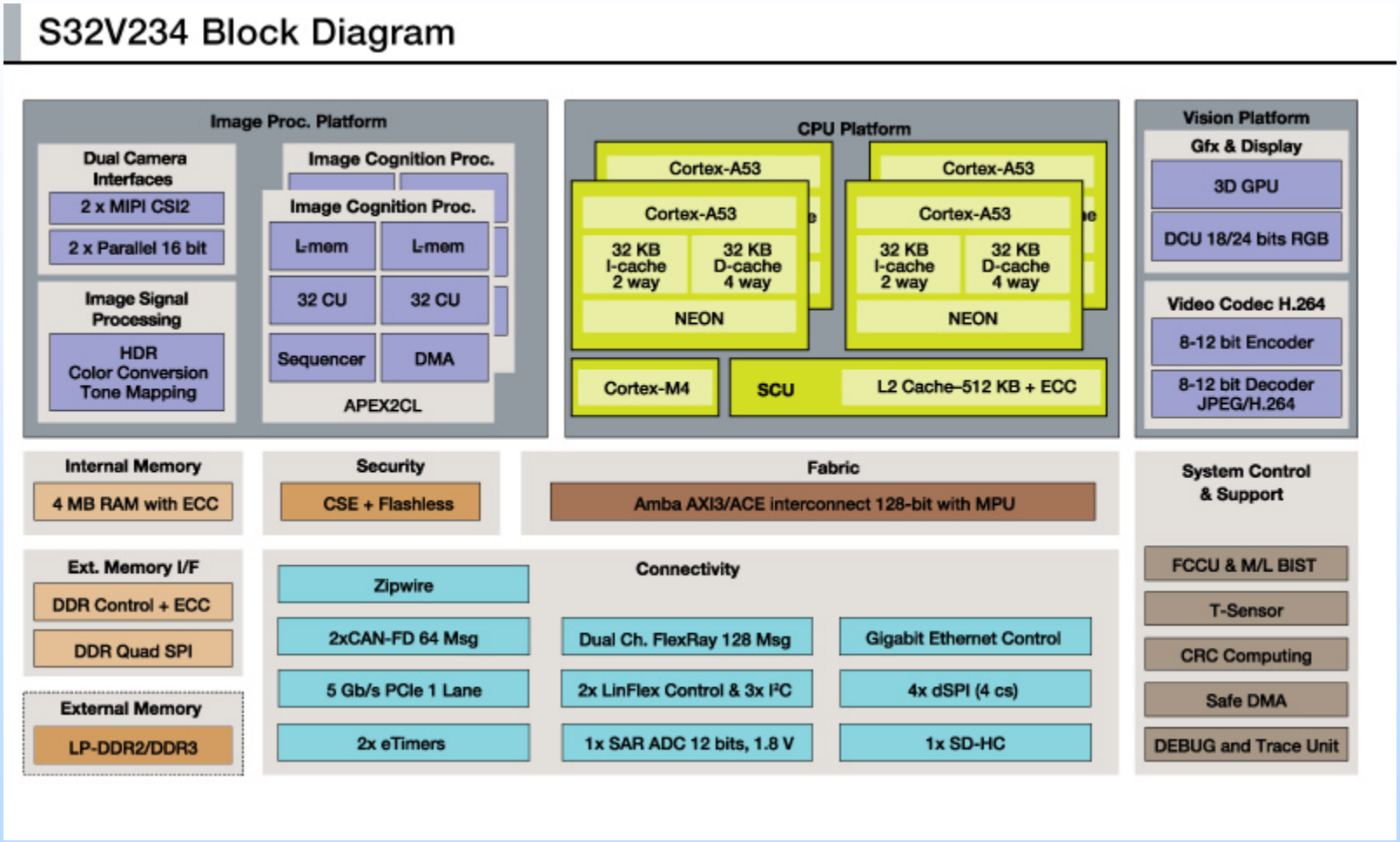
- Freescale MPC56XX
- Automotive Grade
- Both part and board level reliability testing

*Reliability Testing*

*Radiation Testing*

FY14 FY15 FY16 FY17

# Automotive Processors and Systems for Self-Driving Cars?




***From Freescale.com***

# Wide Band Gap (WBG) Technology

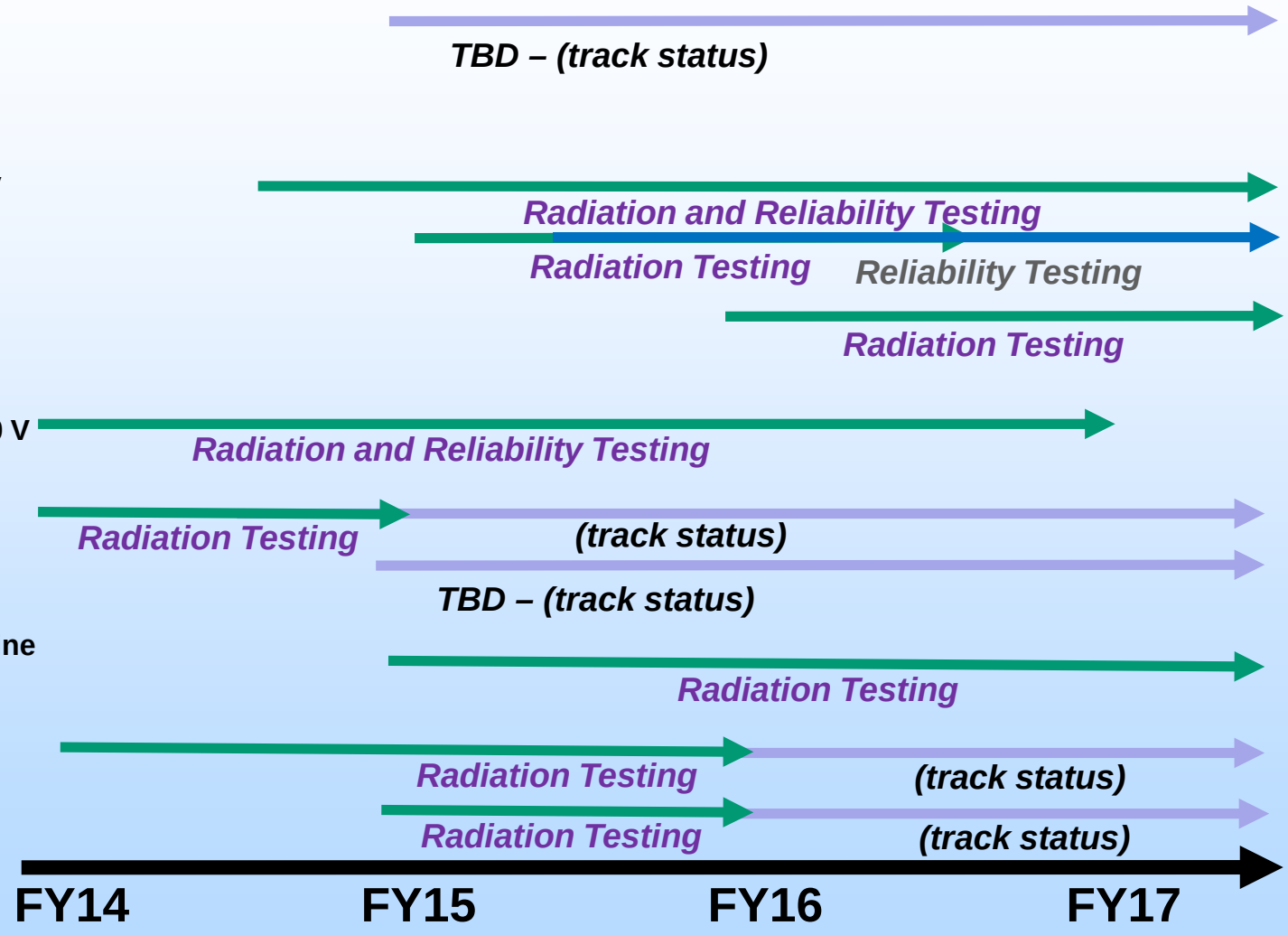
**GaN Class V development**
- Microsemi with EPC

**GaN Enhancement Mode HEMTs**
- EPC Gen 2-3, 200 V - 600 V
- GaN Systems 100 V, 650 V
- Panasonic 600 V (target)
- IR/Infineon 600 V (target)

**SiC MOSFETs**
- Cree Gen 1-2 1200 V - 1700 V
  Gen 3- narrower neck
- STMicro baseline SEE test
- Rohm Trench design

**SiC Diodes**
- Manufacturer X SEE baseline and hardening efforts

**SiC ICs**
- Ozark IC
- Manufacturer X



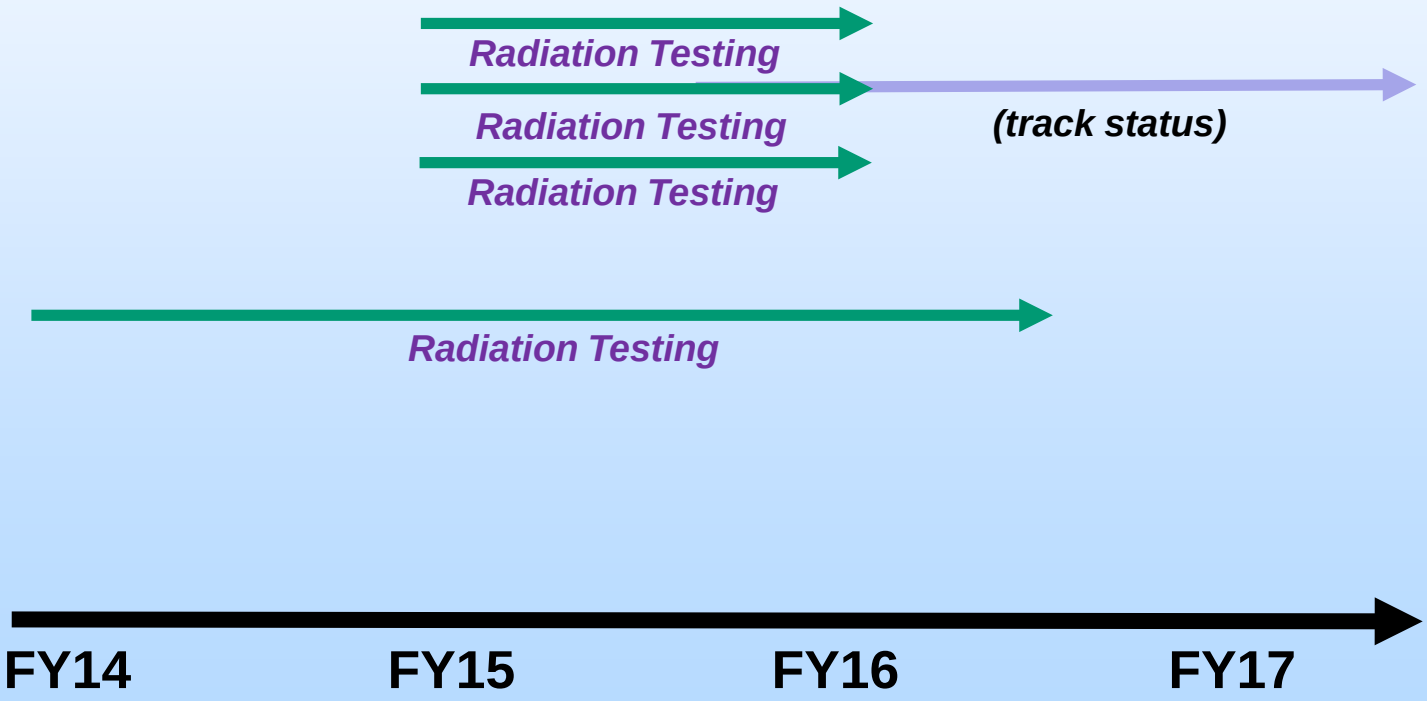
# Silicon Power Devices

**MOSFETs – Rad Hardened**

- Microsemi i2MOS
- Infineon superjunction 100 V, 600 V (target)
- IR/Infineon R8 trench 20 V

**Schottky Diodes**

- Multiple vendors, reverse voltage ratings, and forward current ratings



# Packaging Technologies (1 of 2)

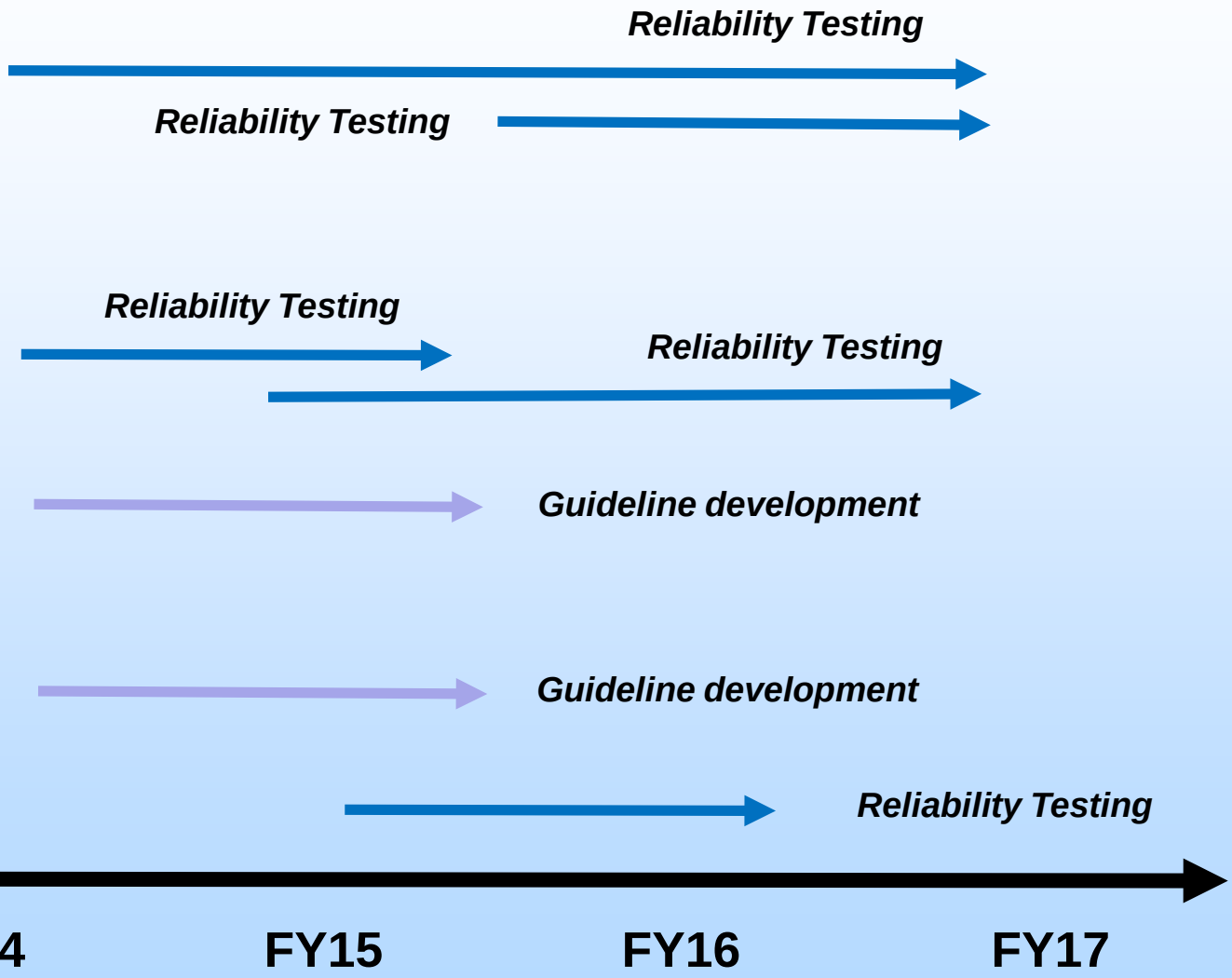
**High Density, Non-hermetic Column Grid Array (CGA)**
- Xilinx CN/Kyocera Daisy Chain
- Microsemi Daisy Chain
- *Materials analysis, long term stress, root cause failure*

**HALT Methodology/Qualification**
- HALT/HAST comparison
- Plastic BGA matrix

**Area Array Column**
- Selection guide

**Thermal Interface Materials**
- Selection guide

**PBGA Thermal Cycle Evaluation**



# Packaging Technologies (2 of 2)

**Bump Reliability**
- Technology review
- Test vehicle options

*Guideline research*

**3D Packaging Technologies**
- Technology review
- Test vehicle options

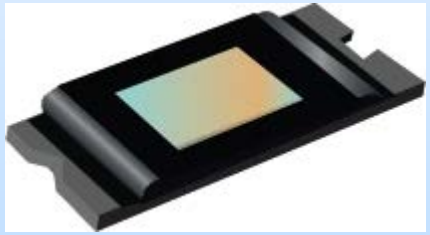
*Guideline research*

**QFN package reliability**
- Reliability/Qualification metrics

*Reliability Testing*

# And Just When You Think Your Roadmap is Set, New Parts are Released

- **Examples**
  - **More complex processors**
    - **TI Multicore DSP+ARM KeyStone II System-on-Chip (SoC)**
  - **Integrated “instruments”**
    - **TI DLP2010NIR – near IR sensing and controller**



# Summary and Comments

- **NEPP Roadmaps are constantly evolving as technology and products become available.**
  - **Like all technology roadmaps, NEPP's is limited to funding and resource availability.**
  - **Not shown are TBD passives and connector roadmaps under development.**
  - **NEPP is working to develop preliminary plans on interfacing to the NASA Reliability and Maintainability Program and its work on Model Based System Engineering (MBSE) approaches.**
- **We look forward to further opportunities to partner.**

***https://nepp.nasa.gov***