Past, Present and Future Trends for NASA’s EEE Parts Program

MAXIMIZING SPACE PARTS
ASSURANCE RESOURCES

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NASA’s Vision
To improve life here,
To extend life to there,
To find life beyond.
Overview

- Today’s Major Challenge for EEE Parts Assurance - Commercial-Off-The-Shelf (COTS)
- Standardization - Uses and Benefits
- NASA’s History with EEE Parts Standardization
- “New” Options for EEE Part Standardization
  - AQEC
  - By Manufacturer
  - By Higher Level Assembly
- Conclusions
Commercial-Off-The Shelf

The Reality

To an **Accelerating Degree NASA Needs to Use COTS for Performance and Increasingly for Availability**

Also The Reality

NASA Could Not Afford to Build Shuttle, Hubble, or Chandra With **All COTS EEE Parts AND** Assure Their Reliability Using Part-Specific, Traditional Assurance Practices

Today’s Drivers for Change

1) **Cost-Constrained Missions**
2) **Tight Schedules**
3) **Aggressive Science and Technology Goals**
   - COTS Frequently Seen as a Solution to All Three
   - COTS Can be the **ONLY** Solution Where Essential Technology Capability is the Driver

But, the Hidden Costs and Complications of a COTS-Based Solution Can Surprise the Unwary
Cost of Ownership – Microcircuits

NASA Cost Estimate Model Assumes Typical Mix of Part Types for Spacecraft/Instrument

NEPAG Risk Matrix (Inherent Risk)

<table>
<thead>
<tr>
<th>Part Groups</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>NPSL Level 1 975 Grade 1</td>
<td>NPSL Level 2 975 Grade 2</td>
<td>NPSL Level 3 Vendor Flow</td>
<td>COTS</td>
</tr>
<tr>
<td>Actives</td>
<td>MIL Class S,V,K ESA Level B NASDA Class I</td>
<td>MIL Class B,Q,H ESA Level C NASDA Class II</td>
<td>MIL 883B QML M,N,T,D,E</td>
<td>COTS</td>
</tr>
<tr>
<td>Passives</td>
<td>MIL S/R Fail Rate ESA Level B NASDA Class I</td>
<td>MIL P Fail Rate ESA Level C NASDA Class II</td>
<td>MIL M/L Fail Rate DSCC Drawing</td>
<td>COTS</td>
</tr>
</tbody>
</table>
COTS Risk Factors

- Frequent Process and Design Changes
- Lot-to-Lot Variation
- “Lots” Can Consist of Unknown Mixes of Sub-lots
- Integrity of Plastic Encapsulated Microcircuit (PEM) Packages Difficult to Assess
- Manufacturer Reliability Data May Contain Unidentified Biases and Have Limited Relevance to Procured Parts
- Design Margins Minimized, << Conservative Than MIL
- Limited Operating Temperature Range (0°C to 70°C)
- Minimal Screening Determined by Primary Market Needs
- Rapid Obsolescence
- Unpredictable, Lot-Variable Radiation Characteristics

Traceability?

Made in one or MORE of the following countries: China, Hong Kong, India, Japan, Taiwan, South Korea, Malaysia, Singapore...The exact country of origin is unknown
Two Principal EEE Parts Options

**Military/Hi Rel**
- Known performance (reliability)
- Specification driven
- MIL Temp. Range (-55C +125C)
- Controlled/monitored sources
- Consistent requirements
- Known traceability
- Change notification
- Interchangeability
- Use-as-is or minor upgrading
- Older technologies
- Long lead times
- High procurement costs

**Commercial-Off-The-Shelf (COTS)**
- Unknown performance (and reliability)
- Commercial market driven
- Limited Temp Range (0 to +70C)
- Unmonitored sources
- Variable market driven requests
- Variable traceability (none?)
- Limited change notification
- Vendor specific variations
- Upgrading for assurance
- Newest technologies
- Short lead times
- Low procurement costs

Traditional Solution - Standardization

- **What We Do When Things Get TOO Varied**
- **Standardization Can Be Used To:**
  - *Ensure interchangeability of parts from different sources*
  - *Enhance reliability by promoting use of parts, whose satisfactory performance has been established*
  - *Reduce number of items to be stocked*
  - *Maximize efficiency and effectiveness of limited resources*
  - *Achieve economies of scale for procurements*
  - *Provide a single measurement system so everyone gets the same result*
  - *Incorporation of lessons learned*

* Challenges for COTS EEE parts
Optimum Use of Scarce Resources

The project parts engineer can get ~50% of parts from the standard parts list. Project resources can be focused on the rest. The “wizards” are available as a technical resource.

The standardization “wizards” identify, research and evaluate parts as standards. Compile Standard Parts List.

NASA’s History of Standardization

• Began As Project-Specific Attempts to Reduce Part Count and Improve Reliability
• At That Time (1960’s) There Was/Were:
  – No established system to provide “space qualified” parts
  – Newly emerging solid state technologies
  – Limited knowledge and resources
  – Unknown reliability, part-to-part, lot-to-lot, vendor-to-vendor
• NASA Centers With Multiple Projects Realized Center-Level Standardization Could Increase Efficiency
• Standard Parts Used for Critical and Basic Functions, Non-Standards Used Where Their Function is Essential

Better to know a lot about a few parts rather than know little about many
NASA’s History of Standardization

- 1962/3, First Space Level Specifications (transistors) MSFC, GSFC
- 1962, MSFC Publishes PPL-100
- 1964, GSFC Publishes PPL-1
- 1969, MIL-M-38510 Class A&B Microcircuits
- 1970?, JPL Publishes PPL
- 1973, Class S Microcircuit Spec MIL-M-0038510
- 1995, First Release of GSFC “Instruction”, now EEE-INST-002
- 1996, Last GSFC PPL, PPL-21 Notice 1
- 1997, NPSL On-line Begun
- 1998, MIL-STD-975 Canceled (Revision M, Notice 3)

Current NASA EEE Parts Standardization

- No Formal Agency-Wide Standardization
- Instead, Center-Specific Parts Guides:
  - MSFC-STD-3012
  - GSFC EEE-INST-002
  - JPL-D-20348
  - SSP 30312 (Space Station)
- Guides Still Define Part Grades or Levels:
  - 1: MIL Class S, V, K, JAN, S and R Failure Rates
  - 2: MIL Class B, Q, H, JANTXV, P Failure Rates
  - 3: MIL Class M, N, D, E, 883B, JANTX, JAN, M Failure Rates
  - 4: COTS, etc.
- Rules:
  - “Use-As-Is” for Required Grade or a Level Higher
  - All Others Require Disposition by Non Standard Parts Approval Request (NSPAR) or by a Parts Control Board
Current NASA EEE Parts Standardization

- Not “One NASA”, but Rather Center-Specific Approaches
- Standardization Today Is Encouraged by Cost
  - Cost of ownership usually less for “use -as-is” MIL part than for “upgraded” COTS
- Standard Parts Are Mostly US MIL
  - They Are Generally Reliable
  - Becoming Increasingly Outdated
  - How Much Longer Will They Be Available?
- There Are NO COTS Standard Parts - Yet?
- How Can COTS Be Standardized?
  - With the Frequent Changes, Limited Testing, Restricted Temp Range, Unknown Reliability, Unpredictable Radiation Hardness

There are At Least Three Possible Answers

Possible Answer #1 - Aerospace Qualified Electronic Component

- AQEC - Concept of Government/ Industry Aviation Group
  - Could Address Some of NASA Concerns About PEMs
- AQEC Would be Manufactured As Part of Normal Production
- It is a “Definition” Not a Spec or Standard
  - Will define “Aerospace Temp. Range” (ATR)
    - -40 °C to +125 °C
- Each Manufacturer Would Generate Own Specification
- Does Not Require Specific Testing
- Qualification Requires:
  - Assessment of part’s ability to operate over ATR
  - Device specific data sheet and part number
  - Expected lifetime within ATR documented on data sheet
  - Stable part configuration for a period TBD

Still Very Much a Work in Progress
Possible Answer #1 - AQEC

• What’s in It for the Manufacturer?
  – Extra business – from an untapped market segment
  – Prestige – by being able to advertise the parts are used in space
  – Knowledge – from the detailed experiences of hi-rel users
  – Minimal additional costs for one-time characterization of part over extended temperature range provision of reliability models
  – Two major US manufacturers are offering their own “enhanced plastic” lines of PEMs, that offer many AQEC-like features

• What’s in It for the User?
  – Insight into manufacturer reliability numbers
  – A manufacturer specification showing part performance over an extended temperature range
  – Some restriction on rapidity of changes
  – Notification of changes

Possible Answer #2 - Standardization by Manufacturer

• Use Approved Supplier List to Define Standard Parts
• Some Manufacturers’ Products Better Meet Our Needs
• Large Supplier Product Characteristics Tend to Be Fairly Stable Over Time and Across Product Lines
• Mergers and Acquisitions Can Have Unpredictable Impacts
• Assurance Still Requires Diligence
• Procurement From the Standard List Would Likely Still Require Lot Assurance Testing and/or Focused Screening
• Use Integrated Product Teams

Federal Acquisition Regulations (Law) Makes This Very Difficult for NASA, Not for Our Contractors
Possible Answer #3 - Standardization by Higher Level Assembly (HLA)

• Many Spacecraft and Instrument Systems Are Available as COTS Assemblies
  – Power supplies
  – Attitude control
  – Star trackers
  – Communication systems
  – Processors
  – Ground systems
• Example: BAE Systems’ RAD750 Processor Board
  – Projects want it configured differently
    • Mission environment
    • Technology readiness
    • Functionality
  – Could We Standardize?
  – What Are the Benefits?

Possible Answer #3 - Standardization by Higher Level Assembly (HLA)

• What Are the Particular Benefits of Standardization at the Next Higher Assembly For the Assembly Manufacturer?
  – Increased demand for fewer variations
  – Lower set-up costs
  – Higher yields
  – Reduced delivery schedules
  – Fewer items to stock
  – Higher profits
Possible Answer #3 - HLA

- What Are the Particular Benefits of Standardization at the Higher Level Assembly For the Aerospace User?
  - The assembly manufacturer has the prime responsibility to keep up with part and vendor changes
  - Optimizes Scarce Technical Resources
    - Multi-discipline assurance teams can develop an intimate understanding of the assembly design, materials, workmanship and performance of the standard assemblies
    - Standardized test and assessment protocols can be developed as part of a performance specification
    - Opportunity for competition once standard assemblies are defined

Barriers to HLA Standardization

- Identifying Suitable Candidates
- Getting Acceptance of One or a Few Variants to Satisfy Most Applications
- Persuading the Assembly Manufacturers to Cooperate in Developing Standards
- Achieving Culture Change at NASA
  - Concept of HLA standardization is new and different
  - Intra-organizational participation
  - Establishment of Product Teams
- Concerns About Consistent Reliability as Parts, Materials and Designs Change
Conclusions

- Standardization Continues As a Key Strategy in NASA’s Approach to EEE Parts Assurance
- Increasing Use of COTS Parts Makes Traditional, Parts-focused Standardization Much More Difficult
- Three Strategies for Standardization Approaches That Could Accommodate COTS Have Been Suggested
- COTS Compatible Standardization Is Likely to Require a NASA Culture Change to Achieve Success Through Any of the Three Suggested Options
- It Seems Unlikely That Any of the Three Options Will Achieve the Assurance of Reliability Enjoyed With MIL Parts