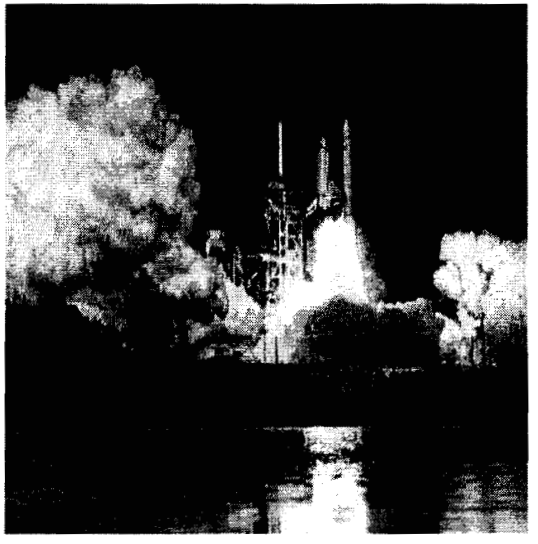
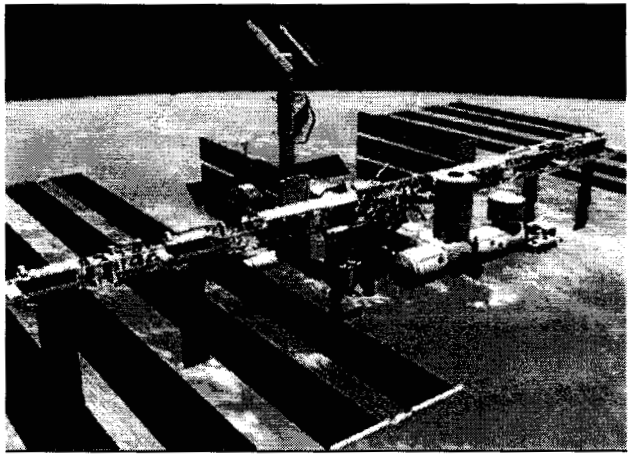
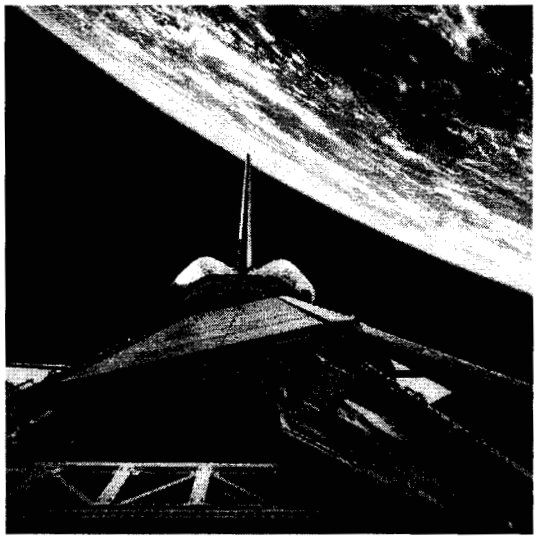
JPL

NASA NEPP / NEPAG

COTS Actives Initiative for Space Applications







Space Parts Working Group
April 16-17, 2002

M. Sandor/S.Agarwal/D. Peters

NEPP-NASA Electronic Parts and Packaging

Charter: The NEPP Program characterizes emerging technologies for future NASA projects.

http://nepp.nasa.gov/index.cfm

NEPAG - NASA EEE Parts Assurance Group

Charter: To exchange EEE Parts information of mutual interest on the subjects of quality, reliability, availability, and technology used in Space flight.

http://eee.larc.nasa.gov/forum

NASA's use of COTS electronic components in future Space applications has raised concerns about their inherent reliability and quality.

Can COTS components be used as procured in some benign environments and for short duration applications?

What must be done to insure COTS components can be used in extreme and severe environment applications and for very long durations?

To answer these questions, NASA is undertaking a *comprehensive* investigation and performing *extensive* evaluations of various COTS components from select manufactures.

Contributing Organizations

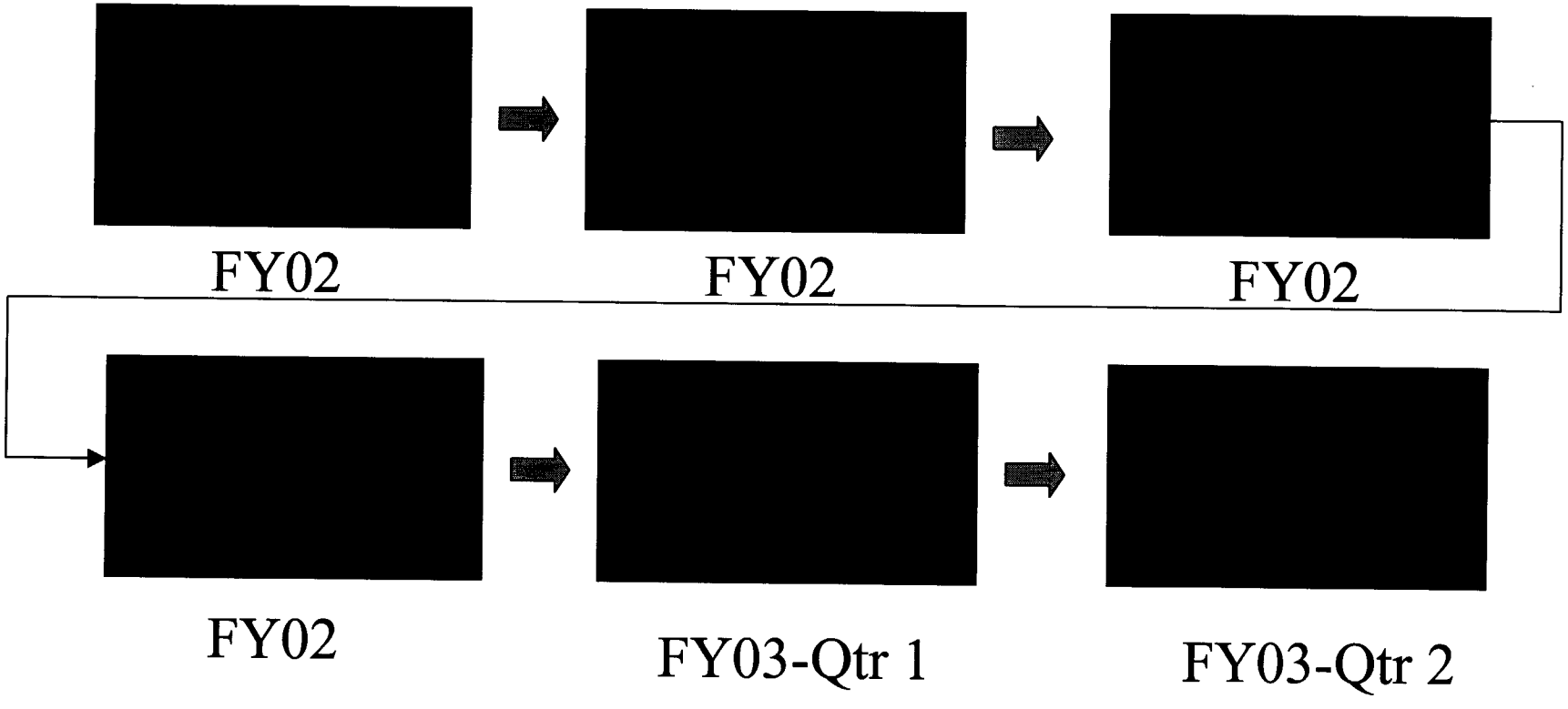
(Weekly telecon is held with these organizations)

- NASA/ARC
- NASA/GRC
- NASA/GSFC
- NASA/JPL
- NASA/JSC
- NASA/KSC
- NASA/LaRC
- NASA/MSFC
- AMCOM
- NAVSEA
- USAF/Aerospace Corporation
- USAF/TRW ICBM
- ESA
- JHU/APL
- NASDA

Goals of This Initiative

- Validate COTS (PEMs) meet data sheet performance as specified
- Determine COTS (PEMs) reliability as claimed by vendor
- Determine COTS (PEMs) robustness beyond vendor specification
- Identify which screening and qualification methodologies are high value
- Identify which vendors are more superior in product quality and reliability
- Establish a COTS data base for future part selection and applications
- Establish a COTS risk posture upon which a NASA guideline can be proposed for typical NASA applications, missions, and environments

Baseline Flow/Timeline Chart



Tasks Planned

- COTS Parts Candidate Selection
- Test House Selection
- COTS Parts Procurements
- Establish Evaluation Requirements
  - DPA
  - FIT Subgroup evaluation
  - Upscreening evaluation
  - Die reliability evaluation
  - Package reliability evaluation
- Data Evaluation/Analysis
- Disseminate Report

Part Candidates Selected

Out of original 100 parts proposed by members of the NEPAG team, the following 5 part types were selected:

- Analog Digital Converter
- Analog Mux
- High Speed Operational Amplifier
- High Precision Reference
- High Common Mode Voltage Difference Amplifier

Part Candidates Selection Criteria

- There is a present or future requirement by a NASA Center
- Evaluated parts must be available for NASA projects upon final acceptance
- Part complexity is medium, necessary for easy testability and analysis
- Procurements - immediate part availability(off-the-shelf)

Test House Selection Process

- RFQs sent to 4 preselected test houses
- RFQs were reviewed for cost, schedule, and capability
- Three RFQs received (on time)
- Test houses were visited
- Technical requirements were augmented

Part Procurements

- 600 of each line item were procured
- 3 date codes from each vendor were solicited
- Average cost for COTS PEMs ~ $4
- 100 parts per line item are planned to hold in reserve
- Two evaluations were planned:
  - 250 Part plan (selected)
  - 500 Part plan (not selected)

Actives COTS Initiative Review Board (ACIRB)

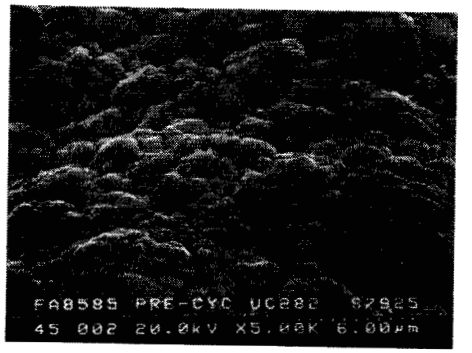
A review board has been formed with members from GRC, GSFC, JPL, JSC, LaRC, and MSFC.

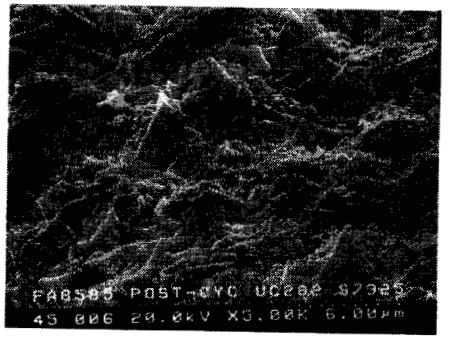
Their Role:

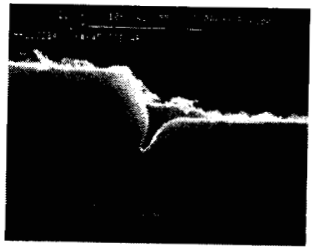
- Monitor Work Weekly
- Examine Data
- Technical Issues Resolution
- Perform Progress Reviews

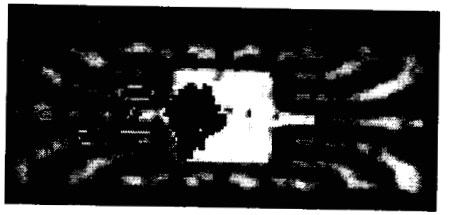
Some Reliability Concerns (PEMs)

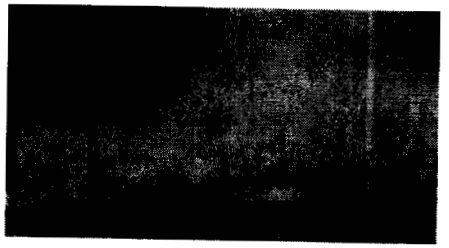
- Lack of lot traceability and part uniformity
- Purple Plague ($AuAl_2$)/ Kirkendall Voiding
- Cold Start-Up Performance
- Maximum Tj allowable with low (<125°C) and high Tg (>170°C) of molding compounds
- Performance beyond commercial/industrial temperature range
- Use of Pb free plating of leads (pure tin)
- Plastic Package Delamination
- Barrier/Aluminum/Copper Metallization Coverage











EVALUATION

Steps for NASA COTS Guidelines Development
Project: NEPP/NEPAG COTS

				250 Plan**	500 Plan**	
Step	**Screen**	**Required**	**Reject Criteria**			**Special Instructions**
1	DPA	1. SEM / Cross section of steps,via, contacts 2. Xray Fien Focus 3. Glass transition temperature for plastic package(2 ea/date code). Ref: Mil-Std-1580B	Any abnormal processing especially with metalization. Thinning, voids, notches, or apparent abberations will be recorded.	**22 pcs (see note3)**	**45 pcs**	**Junction temperature during burn-in must be at least 25C below the measured glass transition temperature(Tg).**
2	Serialization	Laser Serialization or other means for traceability	N/A	All Devices	All Devices	
3	1st Electricals	Test to data sheet @ +25C, 70C, 0C, (with functional sub groups)	Data to be read & recorded	All Devices	All Devices	**Calculate/Compare Vendors AOQL from rejects.**
	Subgroup 3A - FIT Verification					
3A	FITS Verification Sample Static Burn-In	BI @ 125C with interim readout 168 hrs, 500hrs and 1000hrs.	Data to be recorded @ +25C, 70C, 0C (with functional sub groups)	**22 pcs**	**45 pcs**	**1. Calculate /Compare Vendors FIT rate . 2. Junction temp ≤25C below Tg 3. Parts to be bagged and tagged**

EVALUATION

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4	Temp Cycle	Ta = -65C to +150C	10 cycles ; Mil-Std-883 method 1010 Cond C	All Devices	All Devices	
5	X-Ray	Mil-Std-883 method 2012, Inspect for wire sweep (top view)		All Devices	All Devices	
6	C-SAM	Inspect for delamination and or cracks between LF & MC, die surface to MC, die attach to die pad, die pad to MC.	Delamination, voids, or cracks: >10% of area. Rejects will be identified and recorded. Photographs will be reviewed by the Specialist	All Devices	All Devices	
7	Electricals	Test to data sheet @+85C, +125C, -40C,-55C, (with functionality)	Any part failing to meet data sheet parametrics at the temperatures specified. Data to be recorded/reviewed for outliers.	All Devices	All Devices	**Bag and tag/ remove hard failures**
8	Dynamic Burn-In	Circuit used is per application (168hrs at +125C);Vcc= max rating	N/A	All Devices	All Devices	**Junction temperature during burn-in must be at least 25C below the measured glass transition temperature.**
9	Electricals	Test to data sheet @ +25C, +70C,+85C, 0C, +125C, -40C,-55C, (with functionality)	Any part failing to meet data sheet parametrics at the temperatures specified. Data to be recorded/reviewed for outliers/drifters	All Devices	All Devices	

EVALUATION

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	Group C - Die Evaluation Sampling Tests					
11	Dynamic Burn-in Life Test	Circuit used is per application (at +125C)	N/A	**45 pcs for 1000hrs life test**	**22 pcs for 2000hrs life test**	**Junction temperature during burn-in must be at least 25C below the measured glass transition temperature.**
12	End Point Electricals	Test to data sheet @ +25C, +70C,+85C, 0C, +125C, -40C,-55C, (with functionality)	Any part failing to meet data sheet parametrics at the temperatures specified. Data to be recorded/reviewed for outliers/drifters	45 pcs	22 pcs	**Do interim R/R at 250 & 500 hrs for 1000 hr life.Do interim R/R at 500, 1000 and 1500 hr for 2000 hr life test.**
13	DPA	Die visual inspection/Bonding inspection at die pad and leadframe		22pcs	10 pcs	Photo documentation required

EVALUATION

Steps for NASA COTS Guidelines Development
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	Group D - Package Evaluation Sampling Tests					
14	Lead Solder Precondition	See Attachment A for Details		**50 pcs**	**100 pcs**	
14A	Post electricals	Test to data sheet @ 25C				
15	Temp Cycle Qual	Ta = -65C to +150C	700 cycles; Mil-Std-883 method 1010, Cond C	**22 pcs**	**45pcs**	**Perform 100% CSAM and do DPA on 4 pcs upon completion**
16	Post Temp Cycle Electricals	Test to data sheet @ +25C, +85C,+70C, 0C, +125C, -40C,-55C, (with functionality)	Any part failing to meet data sheet parametrics at the temperatures specified. Data to be recorded and statistically compiled	22 pcs	45pcs	**Do interim R/R at 200 & 500 cycles**
17	HAST Qual	130C/85% RH, JESD22-A110-B	96 hrs	**22 pcs**	**45pcs**	**Perform 100% CSAM and do DPA on 4 pcs upon completion**
18	Post HAST Electricals	Test to data sheet @ +25C, +85C, +70C, 0C, +125C, -40C, -55C, (with functionality)	Any part failing to meet data sheet parametrics at the temperatures specified. Data to be recorded and statistically compiled	22 pcs	45pcs	
19	Vibration	Mil-Std-883 method 2007 Cond A		**22 pcs**	**45pcs**	
19A	Post electricals	Test to data sheet @ 25C		22	45	
20	Cold Startup	8 hour soak at -55C unbiased		**22 pcs**	**45pcs**	**1. Test at nominal Vcc supply for functionality (in situ at -55C) 2. Test at 25C to data sheet with R&R**

EVALUATION

Steps for NASA COTS Guidelines Development
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Baseline Step							
Step 14		Attachment A	**Lead Solder Preconditioning**			ss= 50; 6 are controls	
			250 Plan				
	Surface Mount Preconditon		22 pcs		**Resistance to Soldering Heat**		22 pcs
	Ref JESD22-A113-B				Ref JESD22-B106-B		
	Applicable Steps:				Notes: para 4.2;Solder bath will be 315C+or-10C		
	Para 3.1.2				Hermeticity tests are not applicable to PEMs		
	Para 3.1.4						
	Para 3.1.6 VPR only						
Step 14A	**Post Electricals**			Step 14A	**Post Electricals**		
Step 15	**Temp Cycle**			Step 15	**Temp Cycle**		
Step 16	**Post Electricals**			Step 16	**Post Electricals**		
Step 16A	**100% CSAM plus DPA on 4 pcs**			Step 16A	**100% CSAM plus DPA on 4 pcs**		
Step 17	**HAST Qual**			Step 17	**HAST Qual**		
Step 18	**Post Electricals**			Step 18	**Post Electricals**		
Step 18A	**100% CSAM plus DPA on 4 pcs**			Step 18A	**100% CSAM plus DPA on 4 pcs**		
	Complete				**Complete**		

EVALUATION

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Destructive Physical Analysis Requirements

Qty Available: 24 each part type

1. SEM/Cross sections of steps, via, and contacts (Photo with dimensions) + worst case ball bond (1ea)
2. Metal(s) material and composition
3. X-Ray (top view)
4. Glass Transition Temperature (sample of 1 per date code)
5. Outgassing (sample of 1 ea per date code)
6. Optical inspection (die photo)
7. Lead and lead plating composition (presence of tin)
8. Passivation(s) type and thickness (if a top coating is used ID composition and thickness)
9. External visual (photo of package markings)
10. DPA Final Report (hard copy and pdf format)

Concluding Remarks

- This is a cooperative effort undertaken by seven NASA to evaluate COTS for Space.
- Using a Space level component (hermetic) is still the recommended choice over the equivalent non-hermetic.
- "COTS" should be approached with caution and used only with proper evaluation, testing, and or qualification (including for radiation).
- The published reliability data of vendors is relative to the commercial environment and not relative to the high reliability Space environment.
- The total overall objective of this multi agency task is to facilitate insertion of COTS into NASA and other governmental agency Space systems at minimal risk.