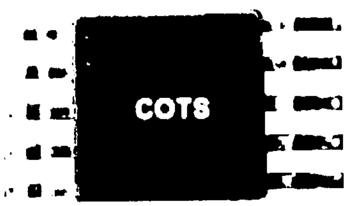
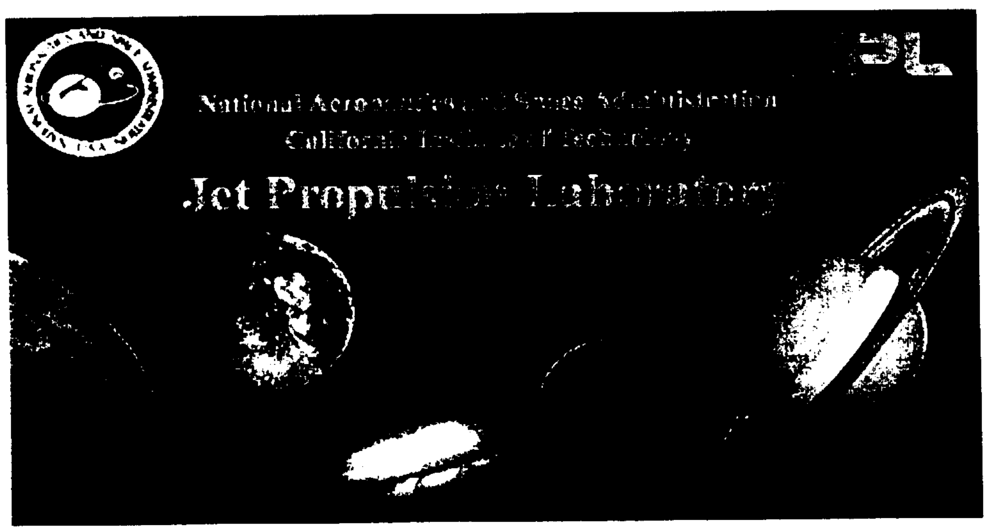
Electronic Packaging for Space Applications Workshop

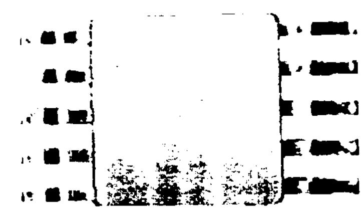
1999

Commercial Off-The-Shelf (COTS) Prog

Methodology and Results of Upscreening Electronic Parts in Plastic Packages







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Electronic Parts Engineering Office

AGENDA:

ADVOCACY FOR COTS

MARS01 PROGRAM/REQUIREMENTS

MARS01 COTS SCREENING FLOW

TEST RESULTS - ELECTRICAL, C-SAM, BURN-IN

VALUE ADDED ANALYSIS (Risk Reduction)

VALUE ADDED ANALYSIS (Cost)

IMPACT of COTS^{++} SCREENING

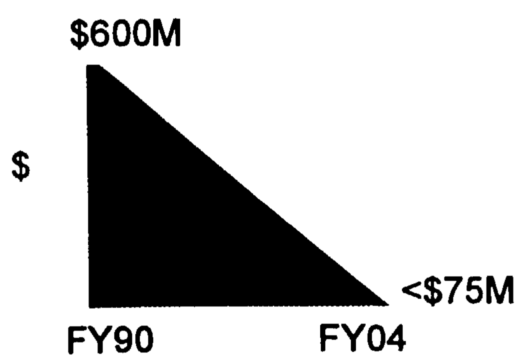
SUMMARY

We Have Moved From Risk Avoidance to Risk Management:

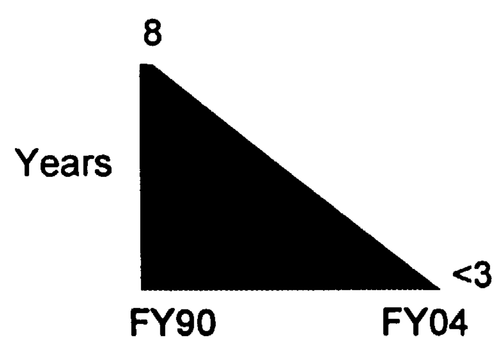
JPL/NASA Project Drivers:

- Must infuse the latest technology (COTS is risky for High-Rel Space Application)
- Must significantly reduce development costs (COTS cost is conditional with risk)
- Must significantly reduce development time (COTS life cycle is short)

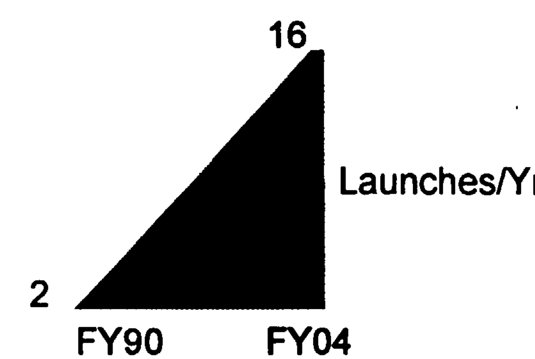
Average Development Costs



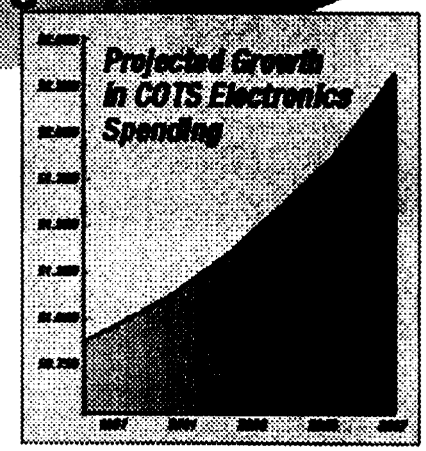
Average Development Time



Average Flight Rate



Advocacy for Using COTS(plastic packages)



Military & Aerospace Publication

1. State of-the-art parts are mostly available as COTS

2. COTS plastic parts performance capabilities continue to increase (e.g. processing power & high density memories)

3. COTS plastic parts enable reduction of hardware weight and volume

4. COTS plastic parts initial acquisition cost is less than ceramic

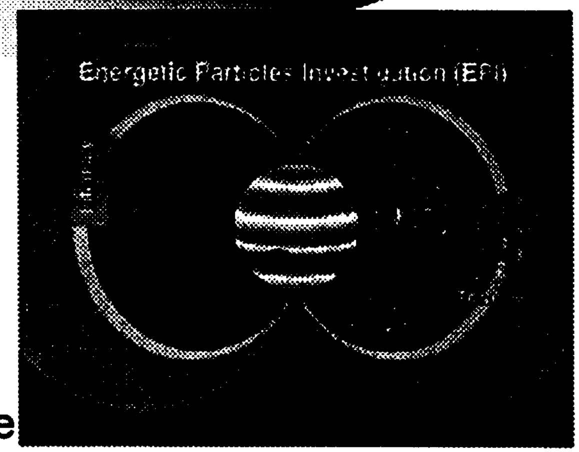
5.COTS plastic parts have been reported to demonstrate good to excellent reliability in commercial and aerospace applications

6. Often they are the only option when Grade 1 is not offered or available

COTS PEM Risk Mitigation Addresses the Following Concerns:

- Narrow Temperature Range for Commercial Grade
- Plastic Assembly Quality
- Lot Non-Uniformity & Traceability
- Adequacy of Vendors Testing
- Infant Mortality
- Die Construction and Quality

Radiation Requirements Complicates COTS for Space Applications:



Rad Hard Assurance often unknown

Radiation requirement is unique-

Can't leverage off other high rel users like automotive

TID response depends on process-

"Positive" process changes can reduce radiation tolerance

SEE depends on circuit design and dimensions-

Commercial vendor can change these without notice

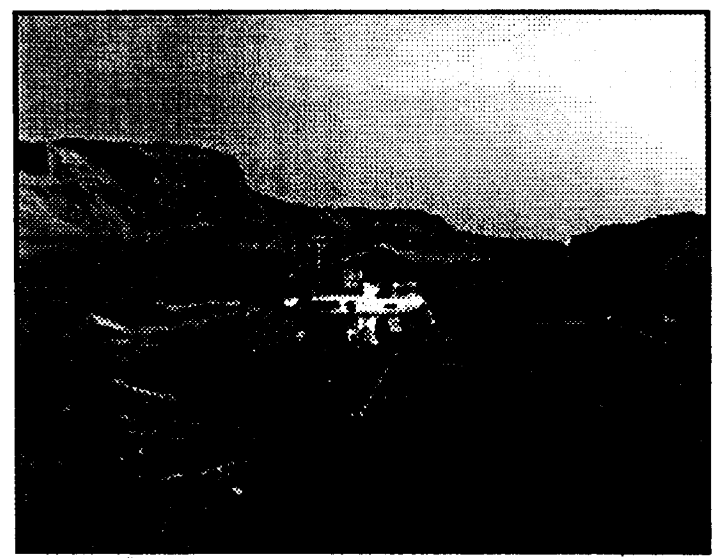
No good way of predicting radiation response without testing-

Exception is a controlled Rad Hard process line

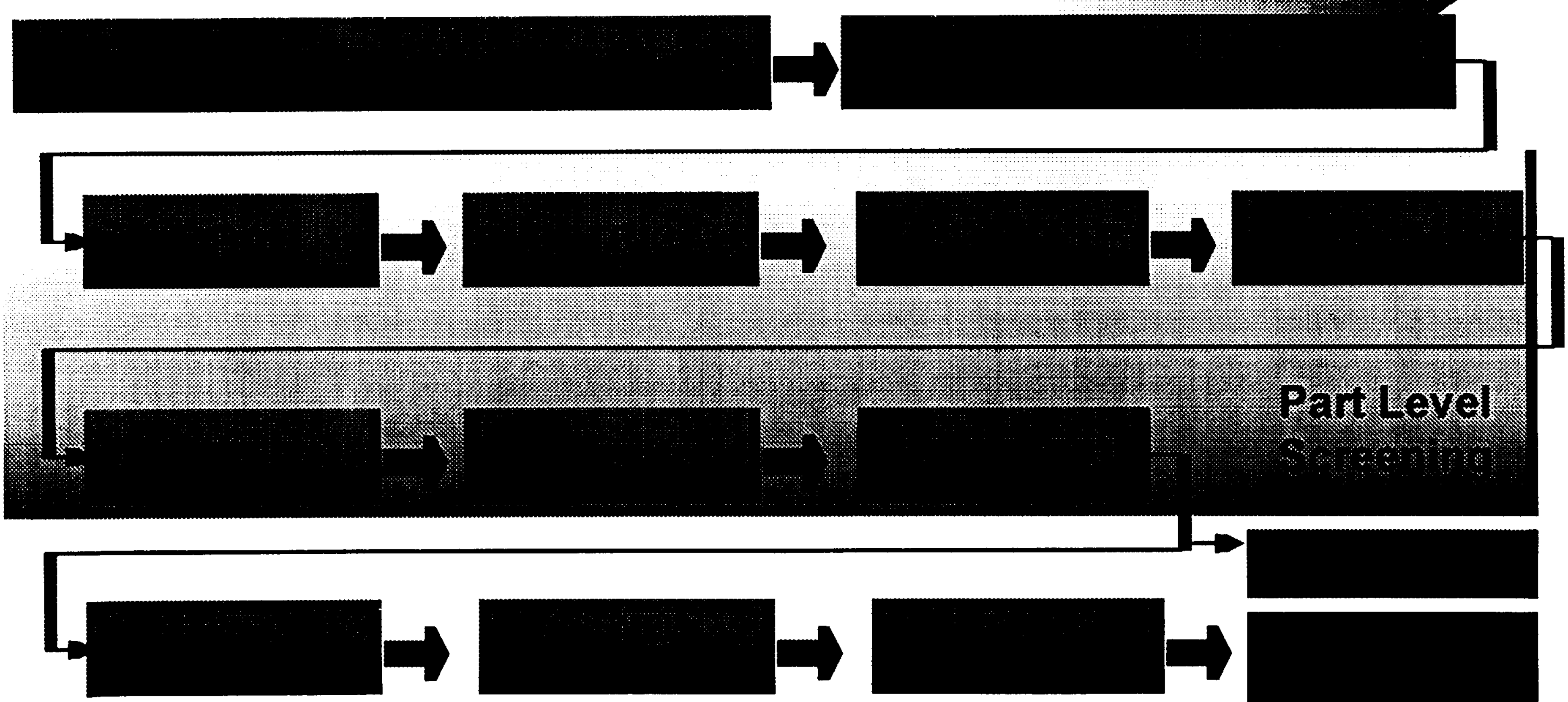
Radiation risk mitigation techniques are often required- $$$

MARS01 Pancam Plastic Parts Reliability Requirements:

- Mission Life $\leq$ 1 years (1500 hours operating)
- Operating Temperature (day only) = -50°C to +10°C
- Number of T/C $\approx$ 365
- No Assembly Board Burn-In Planned
- Outgassing is a concern
- Environmental Moisture is not critical



Lander & Rover



COTS^{++} Plastic Infusion Baseline Flow
(Tailored for MARS01 application/mission requirements)

DPA Results (No. of Rejects):

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
External Visual: Pass	External Visual: Pass	External Visual: Pass
Radiographic: Pass	Radiographic: Pass	Radiographic: Pass
Internal Visual: Pass	Internal Visual: Pass	Internal Visual: Pass
SEM: Pass (0/4)	SEM: Pass [1] (1/8)	SEM: Pass (0/4)

(1) Voids found in the sidewall metalization at contact windows and was observed to be thin for one part. Although all parts were of the same date code, the dice were clearly from different processing lots.

Note: Reject criteria was defined by JPL to be a potential risk to mission success.

Initial Electrical Test Results (Pre T/C & C-SAM - No. of R...

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
At +25°C: 0/78	At +25°C: Not tested	At +25°C: 0/78
At -55°C: 0/78	At -55°C: Not tested	At -55°C: 1/78[(1)]

(1) Failed parametric

Note: T/C condition = -60C to +25C (10 cycles)

Reported Failure Mechanisms from PEM Delamination:

- Stress-induced passivation damage over the die surface
- Wire bond degradation due to shear displacement
- Accelerated metal corrosion
- Die attach adhesion
- Intermittent electricals at high temperature
- Popcorn cracking
- Die cracking

C-SAM Results (No. of Rejects):

Amplifier - Vendor A

Top Side: 0/78 (1)

Back Side: 3/78

ADC - Vendor B

Top Side: 30/78

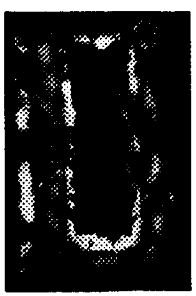
Back Side: 8/78

DC-DC Converter - Vendor C

Top Side: 0/78

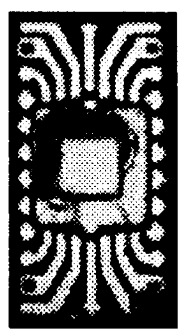
Thru Scan: 16/78

Typical Rejects:

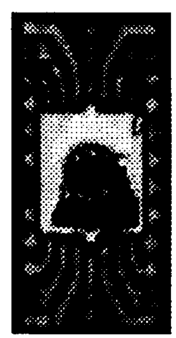


Pass (1)

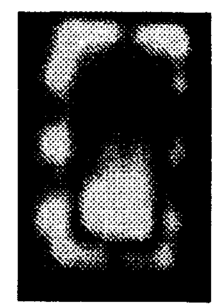
Fail



Fail



Fail



Fail

Note: Units with delamination are defective and were defined by JPL to be a potential risk to mission success. (1) All units showed 100% delamination caused by a special die top coating.These parts were not rejected. F.A .confirmed a die top coating. This was validated by the supplier as a gel coat and is used to relieve stress of the die and improve performance.

Electrical Test Results (Pre Burn-In - No. of Re[illegible])

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
At +25°C: 0	At +25°C: 10 (1)	At +25°C: 2(1)
At +55°C: 0	At +55°C: 0	At +55°C: 1(1)

(1) Failures included parametric and functional

Electrical Test Results (Post Burn-In - No. of Re[illegible]).

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
At +25°C: 0	At +25°C: 0	At +25°C: 0
At -55°C: 0	At -55°C: 3(1)	At -55°C: 0

(1) Failures were parametric and functional

Note: Burn-In Conditions = Dynamic at 72 hrs, @+55C, @max rated Vdd. This condition was calculated to simulate 1500 hrs at -10C using a T acceleration factor of 21 & Ea=.33ev. The 3 burn-in circuits simulated the actual operation of the parts.

Electrical Test Results (QCI - No. of Rejects)

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
At +25°C: 0	At +25°C: 0	At +25°C: 0
At -55°C: 0	At -55°C: 0	At -55°C: 0

Note: All parts passed (ss = 10 good parts/part type)

Note: Burn-In Conditions = Extended dynamic at 72 hrs, @+55C, @max rated Vdd. This condition was calculated to simulate additional 1500 hrs at -10C using a T acceleration factor of 21 & Ea=.33ev. The 3 burn-in circuits simulated the actual operation of the parts.

Circuit Card Assembly (CCA) Risk Reduction

Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
Unit yield: 75/78	Unit yield: 31/78	Unit yield: 61/78

W.C.Failure Rate Expected Before Screen (COTS):

$= 100\%(1 - [75/78^{1} \times 31/78^{1} \times 61/78^{1} \times 100/100^{1} \times \ldots\ldots])$ or $\leq 70\%$

W.C.Failure Rate Expected After JPL Screen (COTS^{++}):

$= 100\%(1 - [.990^{1} \times .985^{1} \times .950^{1} \times 100/100^{1} \ldots\ldots])$ or $\leq 8\%$

Potential Risk of failure has been reduced by ≈ 62%

Note: Vendor B product is potentially more at risk because of high number of pre and post BI rejects as well as the number of package related defects. Rejects and defects were rated as equal risk.

VALUE ADDED ANALYSIS (Cost):

	Amplifier - Vendor A	ADC - Vendor B	DC-DC Converter - Vendor C
Part Acquisition Cost:	$.260k	$1.8k	$.350k
Part Screening Cost:	$6.8k	$13.8k	$6.3k
Engineering O/H Cost:	$2.0k	$2.5k	$2.0k
Value added for screening/CCA:	$8.8k/9 + $16.3k/9 +$8.3k/9 = $3.7k		

Risk of Failure Cost Before Screen: $30k(all material & labor) x 9 x .70 f.r. = $189K

Risk of Failure Cost with Screen: ($30k + $33.4k) x 9 x .08 f.r. = $45.6k (>400% Potential Savings)

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COTS^{++} PEM Upscreen Impact on Risk Mitigation

	Amplifier	ADC	DC-DC Converter
• Narrow Temperature Range for Commercial Grade	1	1	3
• Plastic Assembly Quality	3	9	9
• Lot Non- Uniformity & Traceability	1	9	3
• Adequacy of Vendors Testing	1	9	3
• Infant Mortality	1	9	1
• Die Construction and Quality	1	1	1
Total Score	8	38	20
COTS^{++} Impact on Lowering Risk	Low	High	High

Risk mitigation weighting factors used: Minimum = 1, Moderate = 3, Significant = 9

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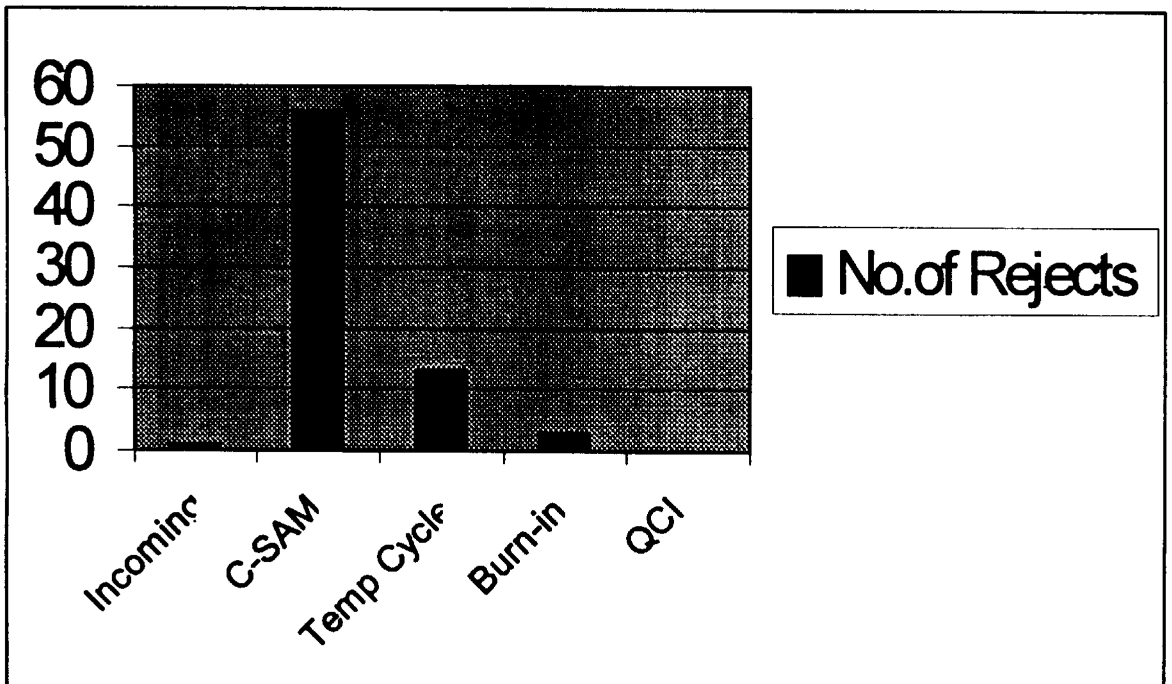
Summary/Conclusions:

COTS^{++} Upscreening Results



Incoming = 0.42%

C-SAM = 24.35%

Temp Cycle = 5.55%

Burn-in = 1.28%

QCI = 0.00%

Total = 31.60% (3 types)

Total = 24.8% (5 types)

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COTS^{++} Upscreening Rejects by Part & Vendor

	Amplifier-Vend. A	ADC-Vend. B	DC-DC Con.-Vend.C	Voltage C-Vend.A*	S.Regulator-Vend.B*
DPA:	0/4	1/8	0/4	In progress	In Progress
Incoming:	0/78	n/a	1/78	0/80	8/80
C-SAM:	3/78	38/78	16/77	4/80	0/80
Temp Cycle:	0/78	10/78	3/77	0/80	3/72
Burn-In:	0/78	3/68	0/74	0/80	9/69
QCI:	0/10	0/10	0/10	0/10	0/10
Total:	3/78	51/78	20/78	4/80	20/80

* New data with different part numbers

Summary/Conclusions:

- The concerns/risks anticipated with using COTS PEMS have been validated from the results of the tailored screening flow used.
- The tailored screening flow used has significantly reduced the potential risk of failure for the MARs01 CCA by approximately 60%.
- The cost of failure for future CCAs manufactured with the screened parts has been reduced by a much as 400% (before launch).
- Using COTS PEMs without any value added screening/characterization will jeopardize any Project until the unknown risks/concerns are understood and mitigated.