SUMMARY
IMPACT OF COTS SCREENING
VALUE ADDED ANALYSIS (Cost)
VALUE ADDED ANALYSIS (Risk Reduction)
TEST RESULTS - ELECTRICAL, C-SAM, BURN-IN
MARS01 COTS SCREENING FLOW
MARS01 PROGRAM REQUIREMENTS
ADVOCACY FOR COTS

AGENDA:

Electronic Parts Engineering Office
Jet Propulsion Laboratory
Average Flight Rate
Launches/yr

Average Development Time
Years

Average Development Costs
FY04 $

Must significantly reduce development time (COTS life cycle is short)
Must significantly reduce development costs (COTS cost is conditional with risk)
Must interface the latest technology (COTS is risky for high-reliability space application)

JPL/NASA Project Drivers:
We have moved from risk avoidance to risk management:

Electronic Parts Engineering Office
JET PROPULSION LABORATORY
Advocacy for Using COTS (Plastic Packages)

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

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

3. COTS plastic parts enable reduction of hardware weight and volume (e.g., processing power & high density memories).

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

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

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

Electronic Parts Engineering Office
Jet Propulsion Laboratory
Die Construction and Quality

Inherent Mortality

Adherence of Vendors Testing

Lot Non-Uniformity & Traceability

Plastic Assembly Quality

Narrow Temperature Range for Commercial Grade

Following Concerns:

COTS PEM Risk Mitigation Addresses the

Electronic Parts Engineering Office

Jet Propulsion Laboratory
Radiation risk mitigation techniques are often required.

Exception is a controlled Red Hard process line.

No good way of predicting radiation response without testing.

Commercial vendor can change these without notice.

SEE depends on circuit design and dimensions.

"Positive" process changes can reduce radiation tolerance.

TID response depends on process.

Can't leverage off other high Rel users like automotive.

Radiation requirement is unique.

Rad Hard assurance often unknown.

Radiation Requirements Complicates COTS for Space Applications.

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

MARS01 Pancam Plastic Parts Reliability Requirements:
Note: Reject criteria was defined by JPL to be a potential risk to mission success.

Although all parts were of the same date code, the dice were clearly from different processing lots.

SEM: Pass (0/4)
Internal Visual: Pass
Radiographic: Pass
External Visual: Pass

SEM: Pass (1/8)
Internal Visual: Pass
Radiographic: Pass
External Visual: Pass

SEM: Pass (0/4)
Internal Visual: Pass
Radiographic: Pass
External Visual: Pass

Amplifier - Vendor A
DC-DC Converter - Vendor C
ADC - Vendor B

DPA Results (No. of Rejects):

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

(1) Failed Parametric

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT -55°C: 0/78</td>
<td>AT -55°C: Not tested</td>
<td>AT -55°C: Not tested</td>
<td>AT +25°C: 0/78</td>
</tr>
<tr>
<td>AT +25°C: 0/78</td>
<td>AT +25°C: Not tested</td>
<td>AT +25°C: Not tested</td>
<td>AT -55°C: Not tested</td>
</tr>
</tbody>
</table>
• Die cracking
• Popcorn cracking
• Intermittent electricals at high temperature
• Die attach adhesion
• Accelerated metal corrosion
• Wire bond degradation due to shear displacement

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

DC-DC Converter - Vendor C

Thru Scan: 16/78
Top Side: 0/78

Back Side: 8/78

ADC - Vendor B

Amplifier - Vendor A

C-SAM Results (No. of Rejects):


electronic parts engineering office
jet propulsion laboratory
(1) Failures included parametric and functional

<table>
<thead>
<tr>
<th>Vendor</th>
<th>DC-DC Converter</th>
<th>ADC - Vendor A</th>
<th>ADC - Vendor B</th>
<th>Amplifier - Vendor C</th>
<th>Pre-Burn-in - No. of Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>AT + 55°C: 1(1)</td>
<td>AT + 55°C: 0</td>
<td>AT + 25°C: 10(1)</td>
<td>AT + 25°C: 0</td>
<td>10</td>
</tr>
</tbody>
</table>
# Electrical Test Results (Post Burn-In - No. of Rambus)

<table>
<thead>
<tr>
<th>Amplifier - Vendor A</th>
<th>ADC - Vendor B</th>
<th>DC-DC Converter - Vendor C</th>
</tr>
</thead>
<tbody>
<tr>
<td>At +25°C: 0</td>
<td>At +25°C: 0</td>
<td>At +25°C: 0</td>
</tr>
<tr>
<td>At -55°C: 0</td>
<td>At -55°C: 3^{(1)}</td>
<td>At -55°C: 0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Vendor C</th>
<th>Vendor B</th>
<th>Vendor A</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-DC Converter</td>
<td>ADC</td>
<td>Amplifier</td>
</tr>
</tbody>
</table>

Electrical Test Results (ACI - No. of Rejects)
Note: Vendors B product is potentially more at risk because of high number of pre and post B.

Potential Risk of failure has been reduced by \( \approx 62\% \)

\[
\text{W.C.F. Failure Rate Expected After JPL Screen (COTS+)} = 100\% (1 - \left[ 0.990^{-1} \times 0.985^{-1} \times 0.950^{-1} \times 0.900^{-1} \right]) = 100\% (1 - \left[ 0.7578^{-1} \times 0.7878^{-1} \times 0.7178^{-1} \times 0.6178^{-1} \right]) \approx 70\%
\]

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

Unit Yield: 61/78
Unit Yield: 31/78
Unit Yield: 75/78

DC-DC Converter - Vendor C
ADC - Vendor A
Amplifier - Vendor B

Circuit Card Assembly (CCA) Risk Reduction

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**Value Added Analysis (Cost):**

<table>
<thead>
<tr>
<th>Component</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-DC Converter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amplifier</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Part Acquisition Cost:**

- $300K
- $333.4K
- $9 x 0.08 t.f. = $4.56K (400% potential savings)

**Risk of Failure Cost:**

- $300K (all material & labor) x 9 x 0.70 t.f. = $189K

**Value Added for Screening/CCA:**

- $8.8K
- $16.3K
- $33K

**O/H Cost:**

- $2.0K
- $2.5K
- $6.3K

**Engineering Cost:**

- $1.8K
- $1.8K
- $6.8K

**Part Acquisition Cost:**

- $350K
- $200K
- $100K
Risk mitigation weighting factors used: Minimum = 1, Moderate = 3, Significant = 9

<table>
<thead>
<tr>
<th>High</th>
<th>High</th>
<th>Low</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>38</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Total Score

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

COTS+ PEM Upscreen Impact on Risk Mitigation

Electronic Parts Engineering Office
Jet Propulsion Laboratory
Total = 24.8% (5 types)
Total = 31.60% (3 types)

ACI = 0.00%
Burn-in = 1.28%
Temp Cycle = 5.55%
C-SAM = 24.35%
Incoming = 0.42%

COTS++ Upstream Results
Summary/Conclusions:

Jet Propulsion Laboratory
Electronic Parts Engineering Office
<table>
<thead>
<tr>
<th>Part Numbers</th>
<th>20/78</th>
<th>4/80</th>
<th>20/78</th>
<th>5/78</th>
<th>Total: 3/78</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
</tr>
<tr>
<td>0/80</td>
<td>0/80</td>
<td>0/74</td>
<td>3/68</td>
<td>7/78</td>
<td>0/78</td>
</tr>
<tr>
<td>3/72</td>
<td>0/80</td>
<td>3/77</td>
<td>1/78</td>
<td>7/78</td>
<td>7/78</td>
</tr>
<tr>
<td>0/80</td>
<td>4/80</td>
<td>1/78</td>
<td>0/78</td>
<td>0/78</td>
<td>0/78</td>
</tr>
<tr>
<td>8/80</td>
<td>0/80</td>
<td>n/a</td>
<td>0/4</td>
<td>1/8</td>
<td>0/4</td>
</tr>
</tbody>
</table>

Temp Cycle: 0/78

C-SAM: 3/78

In progress: 0/78

DPA: 0/4

Amplifier-Vend. A

S-Regulator-Vend. B

Voltage C-Vend. A

DC-DC Conv-Vend. C

COTS++ Upstreaming Releas by Part X Vendor

Electronics Parts Engineering Office

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unknown risks/concerns are understood and mitigated.

• Using COTS PEMs without any value added

launch).

screened parts has been reduced by a much as 400% (before

The cost of failure for future CAS manufactured with the

60%

potential risk of failure for the MAR501 CCA by approximately

The tailored screening flow used has significantly reduced the

used.

been validated from the results of the tailored screening flow

• The concerns/risks anticipated with using COTS PEM have

Summary/Conclusions:

Electronic Parts Engineering Office
Jet Propulsion Laboratory