Teledyne e2v

Radiation Tolerant COTS+ Space Microprocessors

De-risking the introduction of ARM based solutions

Mikaël BALL
Project Leader – Space Processors
Data Processing Solutions
+33 7 77 36 01 75
mikael.ball@teledyne-e2v.com

Thomas GUILLEMAIN
Marketing & Business Development
Data Processing Solutions
+33 6 84 21 15 20
thomas.guillemain@teledyne-e2v.com
T-e2v Space Processors
Semiconductor Division

**High Performance, High Reliability** Semiconductor solutions

Addressing **Critical functions** of the complete signal chain in

**Demanding Applications**

**Specific Qualified versions** of many standard products

**Strategic Partnerships** (NXP, ...)

---

**Te2v Microprocessors Key Figures**
- 30+ years experience in up screening processors
- ~45 products launched during the last 20 years
- 10s to 100s of kunits shipped per year in Aerospace & Defense
- 100s of units shipped per year in Space Markets
Agenda

• Teledyne e2v current COTS+ Radiation Tolerant Microprocessors

• Teledyne e2v Space Qualification Flows & Radiation Testing

• Next steps: de-risking the introduction of ARM based solutions for Space
Teledyne e2v
COTS+ Microprocessors Space Offering

February 2019
“Commercial Space dilemma”

- Perform always more complex and powerful data processing into space
- Ensuring a decent level of radiation tolerance
- Reduced payload SWaP (Size, Weight & Power)
- Use devices with significant space heritage
- Faster TTM
- At an aggressive price if possible

Rationale (non exhaustive)

- **Direct** on board data processing
- **Increased** on board data processing requirements
- **Higher level** of data selection
- **Higher accuracy level** of data to be transmitted
- Increased **Quality Of Service**
- Increased **autonomy**
- Increased **observation** capabilities
- ....
COTS (Commercial off the shelf) components

Parts designed for commercial applications where the manufacturer or vendor establishes and controls the specifications for performance, configuration & reliability with no additional, external requirements.

COTS / COTS+ in Space applications

COTS can be used in Space, but the key points will be to ensure they are reliable for Space.

This is what Teledyne e2v brings & warrants in Space Microprocessors. This is what our customers are requesting.
Teledyne e2v Space Microprocessors
COTS+ Radiation Tolerant – Current Portfolio

**ORGANIC package solutions**
Ruggedized radiation tolerant technology
Standard plastic package
Device selection and lot validation

- PowerArchitecture®
- Dual Core Microprocessors
- 1.2-1.5 GHz
- 45nm SOI
- ECSS / NASA Grades Qualification

- PowerArchitecture®
- Single Core Microprocessors
- 1.2 GHz
- 90nm SOI
- QML-Y Qualification

**CERAMIC Non-Hermetic FlipChip**
Ruggedized radiation tolerant technology
Advanced packaging on ceramic
Standardized quality grade

- PowerArchitecture®
- Dual Core Microprocessors
- 1.2-1.5 GHz
- 45nm SOI
- ECSS / NASA Grades Qualification

- PowerArchitecture®
- Single Core Microprocessors
- 1.2 GHz
- 90nm SOI
- QML-Y Qualification
Teledyne e2v Space Processors
Where to find us?

Non exhaustive List

- **GEO** (Geostationary Orbit) 36,000 kms
- **MEO** (Medium Earth Orbit) 8,000-12,000 kms
- **HEO** (Highly Elliptical Orbit)
- **LEO** (Low Earth Orbit) 300-1,100 kms

Manned Space

- P5020
- PC7448
- P2020
- PC8548

Non exhaustive List
Teledyne e2v
Space Qualification Flow

February 2019
Remove infant failures

Minimize risks of corner lots & corner parts

Assess the quality of the process
ECSS / NASA Qualification Flow

What Teledyne e2v puts in place

Remove infant failures

Minimize risks of corner lots & corner parts

Assess the quality of the process

Burn In

Single Lot Date Code

100% Inspection

DPA

Destructive Physical Analysis
ECSS / NASA Qualification Flow

What we have observed

We have observed rejected parts after 120 hours of Burn In!

We have observed large variants from lot to lot!
**Worst case (FM lot)**
Defect area: ~20%
Distributed small defects

**Best case (FM lot)**
Defect area: ~3%
Few small defect near die center

**Standard case (prototype lot)**
Defect area: ~6.9%
Few larger defects on die edges

---

**C-SAM**: Confocal Scanning Acoustic Microscopy
# ECSS / NASA Qualification Flow

## High Level

### Space Up Screening

1. External visual & serialization
2. Temperature cycling
3. X-Ray
4. C-SAM inspection
5. Initial electrical meas. (pre-burn-in)
6. Engineering review
7. Static burn-in test @ 125°C (or max. temperature)
8. Post static burn in electrical meas. @ 25°C
9. Dynamic burn-in test @ 125°C (or max. temperature)
10. Post Dynamic burn in electrical meas. @ 25°C
11. Defective percentage calculation
12. Extreme temperature range electrical tests
13. Physical dimension controls
14. External visual
15. Packing & CoC

### Lot by Lot Qualification

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Baseline C-SAM</td>
</tr>
<tr>
<td>2.</td>
<td>Preconditioning</td>
</tr>
<tr>
<td>3.</td>
<td>Electrical measurements</td>
</tr>
<tr>
<td>4.</td>
<td>Life testing Subgroup 1</td>
</tr>
<tr>
<td>5.</td>
<td>Temperature cycling Subgroup 1</td>
</tr>
<tr>
<td>6.</td>
<td>Highly accelerated stress test (HAST) - Subgroup 2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DPA (Destructive Physical Analysis)

**Targets**
- Integrity of the package (cracks)
- Quality of assembly (Void issues)
- Defects in the silicon die (cracks)
Ceramic Non-Hermetic FlipChip

Purposes of QML-Y Qualification

- Remove infant failures
- Minimize risks of corner lots & corner parts
- Assess the manufactured die quality

Additional Quality & Robustness level for Space
**Teledyne e2v QML-Y Space Flow**

*High Level*

### Screening

1. Wafer lot Acceptance
2. Wafer sawing
3. Die Visual selection
4. Cust. or Teledyne e2v intern. inspection
5. Die attach
6. Die shear
7. Underfill dispense & cure
8. SMD attach
9. SMD visual inspection
10. Substrate serialization
11. Underfill CSAM
12. Solder ball attach
13. Precap
14. Heat sink attach
15. Temperature cycling
16. PIND Test
17. Marking & serialization
18. SMD X-Ray
19. Heat sink CSAM
20. Visual inspection
21. Initial (pre-burn-in) electrical meas.
22. Engineering review
23. Dynamic Burn-In test
24. Post dynamic BI electrical meas. @ 25°C
25. Static burn-in test
26. Post Static BI electrical meas. @ 25°C
27. Calculate percent defective
28. Extreme temperature range electrical test
29. Column attach (if applicable)
30. Physical dimension control
31. External visual
32. Post column attach elec. test (if applicable)
33. Customer or Teledyne e2v final inspection
34. Packing & CoC

### QCI

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group D9</td>
</tr>
</tbody>
</table>

### Initial Qualification

<table>
<thead>
<tr>
<th>Group C</th>
<th>Solderability</th>
<th>Die shear</th>
<th>Resistance to solvents</th>
<th>SMD shear test</th>
<th>Ball shear</th>
<th>Column pull test</th>
<th>MSL3 + temperature cycling + CSAM</th>
<th>MSL3 + THB + CSAM</th>
<th>MSL3 + Mech. Shocks &amp; vibrations + CSAM</th>
</tr>
</thead>
</table>
Qualification Flow Poster


Poster detailing the qualification flow and QCI implemented by Teledyne e2v following the below standards and guidelines:

Order a free printed poster from the link below or contact your local sales.
https://www.e2v.com/products/semiconductors/space-semiconductors/
Teledyne e2v Space Microprocessors are all tested in Radiation

Radiation Testing & Mitigation are mandatory
## T-e2v Space Processors
### Radiation Information

<table>
<thead>
<tr>
<th>ORGANIC package solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruggedized radiation tolerant technology</td>
</tr>
<tr>
<td>Standard plastic package</td>
</tr>
<tr>
<td>Device selection and lot validation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CERAMIC Non-Hermetic FlipChip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruggedized radiation tolerant technology</td>
</tr>
<tr>
<td>Advanced packaging on ceramic</td>
</tr>
<tr>
<td>Standardized quality grade</td>
</tr>
</tbody>
</table>

### Commercial Space Grade by Te2v

<table>
<thead>
<tr>
<th><strong>P2020</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• SEU*: 53 LET</td>
</tr>
<tr>
<td>• SEL: No LU at 63 LET</td>
</tr>
<tr>
<td>• TID: 100 krad (Si)</td>
</tr>
</tbody>
</table>

*Source: NASA JPL, Space Micro*

<table>
<thead>
<tr>
<th><strong>P5020</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• SEU*: 14 LET</td>
</tr>
<tr>
<td>• SEL: No LU expected (Tested until 14 LET)</td>
</tr>
<tr>
<td>• TID: On Customer request</td>
</tr>
</tbody>
</table>

*Source: NASA JPL*

<table>
<thead>
<tr>
<th><strong>PC7448</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• SEU*: 62 LET</td>
</tr>
<tr>
<td>• SEL: No LU till 62 LET</td>
</tr>
<tr>
<td>• TID: 100 krad (Si)</td>
</tr>
</tbody>
</table>

*Source: EADS Nucletudes*

<table>
<thead>
<tr>
<th><strong>PC8548</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• SEU*: 86 LET</td>
</tr>
<tr>
<td>• SEL: No LU till 86 LET</td>
</tr>
<tr>
<td>• TID: 100 krad (Si)</td>
</tr>
</tbody>
</table>

*Source: Teledyne e2v*

---

**SEU*: Data available up to xx LET
Teledyne e2v
New Space COTS Products Introduction

February 2019
What’s next @ Teledyne e2v
New Product Introductions

What challenges for New Space Microprocessors?

- Perform more complex and powerful data processing in space
- Reduced payload SWaP (Size, Weight & Power)
- Good Level of radiation tolerance
- Significant space heritage

Teledyne e2v Space Compute Intensive solutions will follow our Space Qualification Flow

- Heavy Space Qualification
- Radiation Testing & Mitigation
What’s next @ Teledyne e2v
New Product Introductions

LS1046-Space

Performances, Ecosystem & Optimized Power
Quad 64-bit Arm® Cortex®-A72 cores

Qormino®
QLS1046-Space

Performances, Ecosystem
Optimized Power, Modularity, Faster TTM
Quad 64-bit Arm® Cortex®-A72 cores
4GB DDR4 memory (72 bits, incl. 8 bits ECC)
Obsolescence Program
What’s next @ Teledyne e2v
New Product Introductions

LS1046-Space

Qormino®
QLS1046-Space

Preliminary Radiation Results
- LS1046: Q3 2019

Preliminary Radiation Results
- 4GB DDR4 Memory: Q3 2019
- Qormino Solution: H1 2019
Teledyne e2v Space Microprocessors
COTS+ Radiation Tolerant Portfolio

ORGANIC package solutions
Ruggedized radiation tolerant technology
Standard plastic package
Device selection and lot validation

CERAMIC Non-Hermetic FlipChip
Ruggedized radiation tolerant technology
Advanced packaging on ceramic
Standardized quality grade

Commercial Space Grade by Te2v
(Based on ECSS-Q-ST-60-13C & NASA EEEINST-002 - Section M4 – PEMs)

Microprocessors based on QML-Y Standard

Radiation Testing Results Available
Radiation Testing On Going / Planned
Space Multi Flight Heritage
Conclusions

- **Supplier of Advanced & Powerful Space Microprocessors**
  - **GHz+ class** processors for **Compute intensive** applications
  - Complementing Worldwide Space Offering

- **Space Microprocessor Portfolio with Flight Heritage**
  - *Existing, mature, proven COTS H/W platforms & Strongest S/W ecosystem* in Avionics & Space

- **Mastering Radiation Tolerant Space Qualification Flows**

- **De-Risking the Introducing of ARM Cortex A72 based Solutions**