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

OBDP - On Board Data Processing
25-27 February 2019, ESA, Netherlands

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
Everywhereyoulook™

- 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

OBDP - On Board Data Processing
25-27 February 2019, ESA, Netherlands

Commercial Space Dilemna

What our customers are saying

"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+ components

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

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

CERAMIC Non-Hermetic FlipChip

Ruggedized **radiation tolerant technology**
Advanced **packaging on ceramic**
Standardized quality grade

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

Teledyne e2v Space Processors
Where to find us ?

Non exhaustive List

36,000 kms

8-12,000 kms

GEO MEO HEO LEO

300-1,100 kms

Manned Space

P5020

GEO
(Geostationary Orbit)
36,000 kms

PC7448

MEO
(Medium Earth Orbit)
8,000-12,000 kms

HEO
(Highly Elliptical Orbit))

P2020

LEO
(Low Earth Orbit)
300-1,100 kms

P2020

PC8548

Teledyne e2v
Space Qualification Flow

February 2019

Organic Package Solutions

ECSS / NASA Qualification Flow Purpose

Remove
infant failures

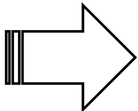
Minimize risks of corner
lots & corner parts

Assess the quality
of the process

ECSS / NASA Qualification Flow

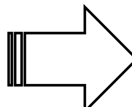
What Teledyne e2v puts in place

Remove infant failures



Burn In

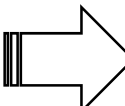
Minimize risks of corner lots & corner parts



Single Lot Date Code

100% Inspection

Assess the quality of the process



DPA
Destructive Physical Analysis

ECSS / NASA Qualification Flow
What we have observed

ECSS / NASA Qualification Flow
What Teledyne e2v puts in place

TELEDYNE e2V
Everywhereyoulook™

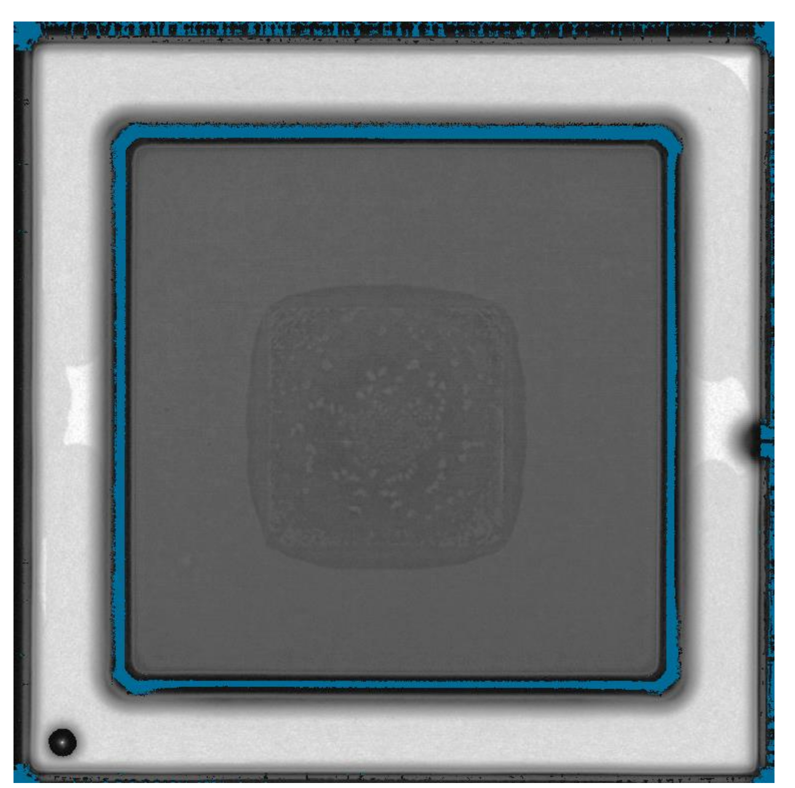
Page 13

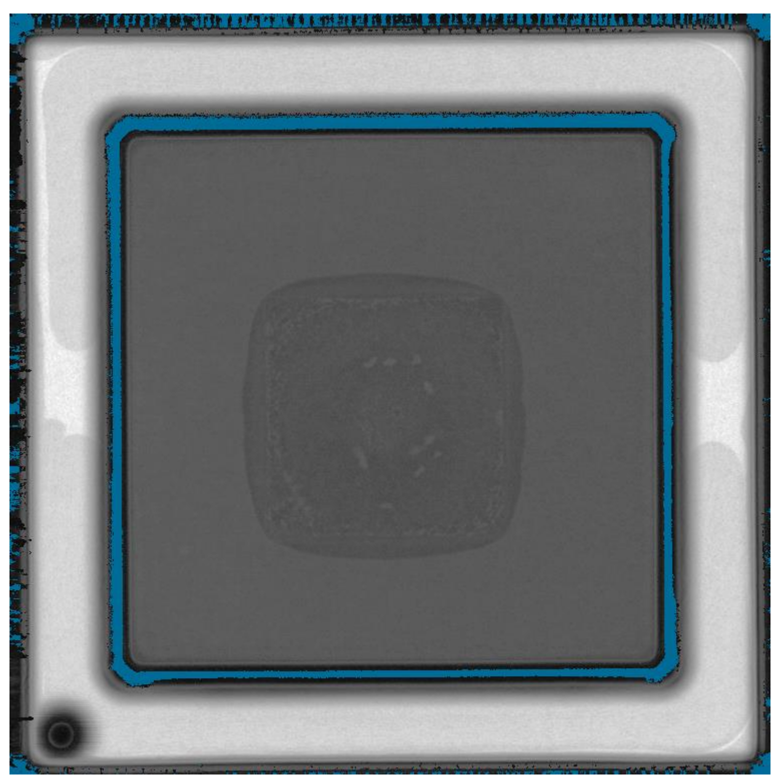
Goal		Measure
Remove infant failures	⇨	Burn In
Minimize risks of corner lots & corner parts	⇨	Single Lot Date Code / 100% Inspection
Assess the quality of the process	⇨	DPA Destructive Physical Analysis

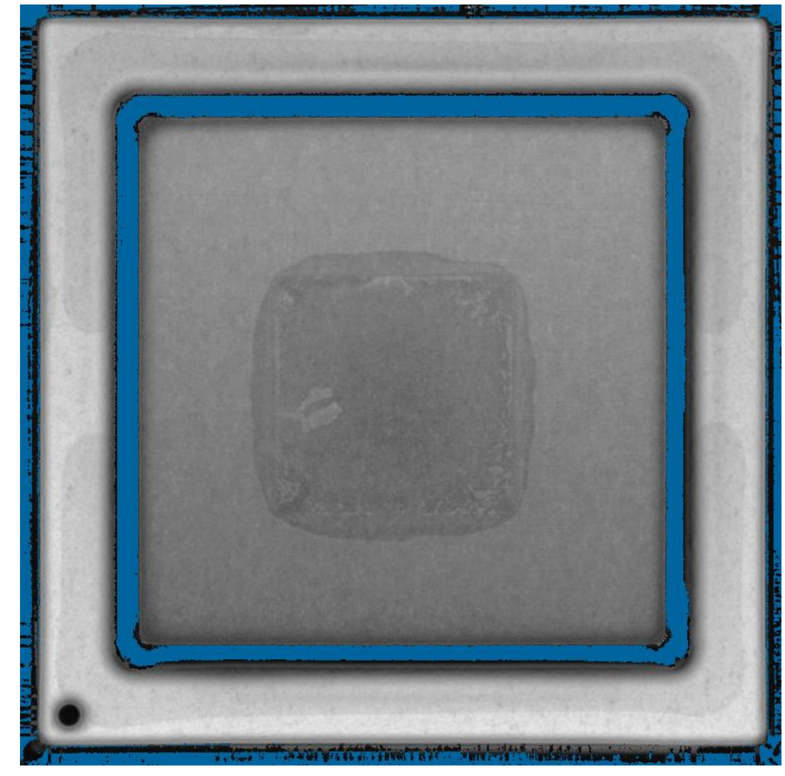
We have observed rejected parts after 120 hours of Burn In !

We have observed large variants from lot to lot !

C-SAM Inspections
Example







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

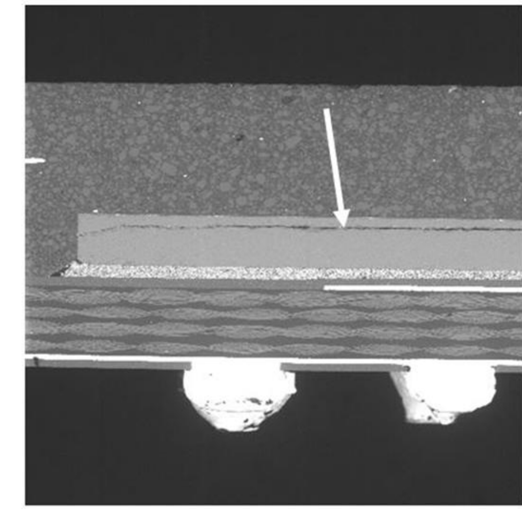
1. Baseline C-SAM	*Parts in Subgroup 1 only*
2. Preconditioning	Moisture soak
	SMT devices Reflow simulation
	Through hole devices, Resistance to soldering temperature
3. Electrical measurements	Per device specification
4. Life testing Subgroup 1	HTOL, 125°C
	Electrical measurement
5. Temperature cycling Subgroup 1	Temperature cycling
	Electrical measurement
	C-SAM
6. Highly accelerated stress test (HAST) - Subgroup 2	Biased HAST
	Unbiased HAST

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

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

QCI

QCI
Group A
Group B
Group C
Group D1
Group D2
Group D3
Group D4
Group D5
Group D8
Group D9

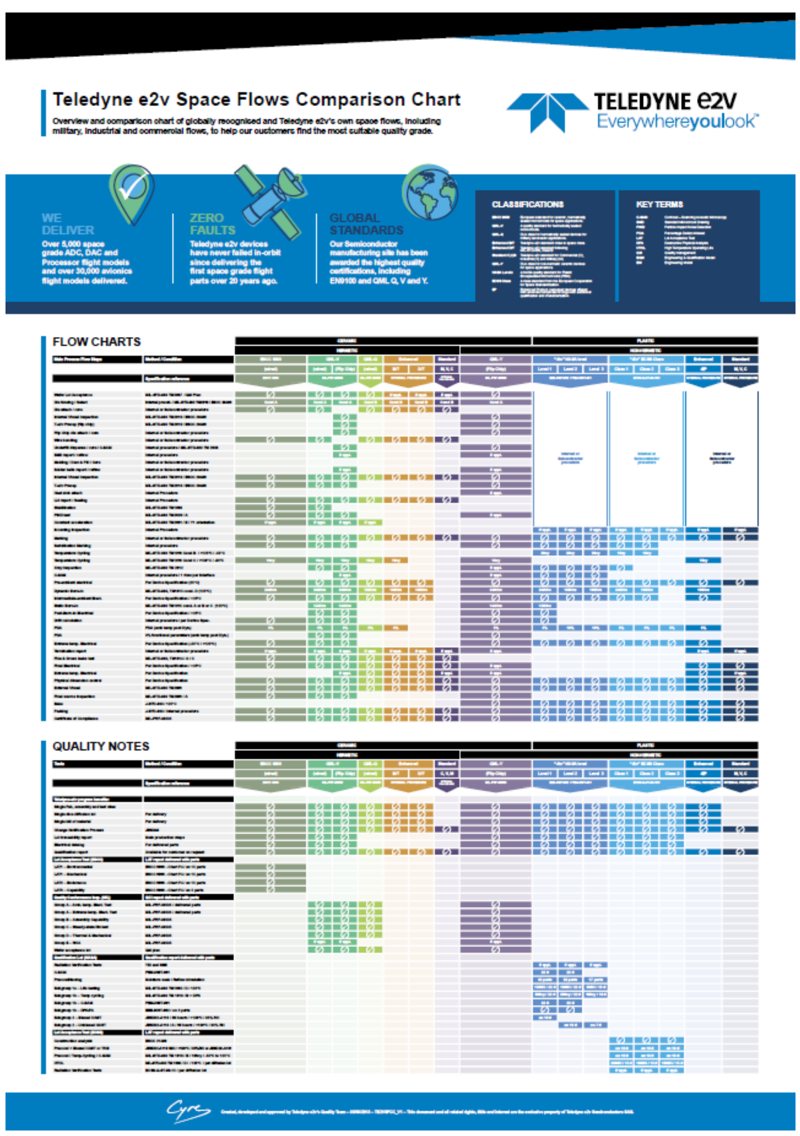
Initial Qualification

Initial Qualification
Group C
Solderability
Die shear
Resistance to solvents
SMD shear test
Ball shear
Column pull test
MSL3 + temperature cycling + CSAM
MSL3 + THB + CSAM
MSL3 + Mech. Shocks & vibrations + CSAM

Qualification Flow Poster

https://www.e2v.com/content/uploads/2018/07/Space_Flows_Comparison_Chart_TE2VSFCC_V1.pdf

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/

Radiation Testing
Key Highlights

Teledyne e2v Space Microprocessors are all tested in Radiation

Radiation Testing & Mitigation are mandatory

T-e2v Space Processors
Radiation Information

ORGANIC package solutions

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

Commercial Space Grade by Te2v

P2020

- **SEU*** 53 LET
- **SEL** No LU at 63 LET
- **TID** 100 krad (Si)

Source : NASA JPL, Space Micro

P5020

- **SEU*** 14 LET
- **SEL** No LU expected *(Tested until 14 LET)*
- **TID** On Customer request

Source : NASA JPL

CERAMIC Non-Hermetic FlipChip

Ruggedized radiation tolerant technology
Advanced packaging on ceramic
Standardized quality grade

QML-Y Microprocessors

PC7448

- **SEU*** 62 LET
- **SEL** No LU till 62 LET
- **TID** 100 krad (Si)

Source : EADS Nucletudes

PC8548

- **SEU*** 86 LET
- **SEL** No LU till 86 LET
- **TID** 100krad (Si)

Source : Teledyne e2v

SEU : Data available up to xx LET*

Teledyne e2v
New Space COTS Products Introduction

February 2019

OBDP - On Board Data Processing
25-27 February 2019, ESA, Netherlands

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)
Obsolecence Program

What's next @ Teledyne e2v

New Product Introductions

LS1046-Space

Preliminary Radiation Results

- LS1046 : Q3 2019

Qormino®
QLS1046-Space

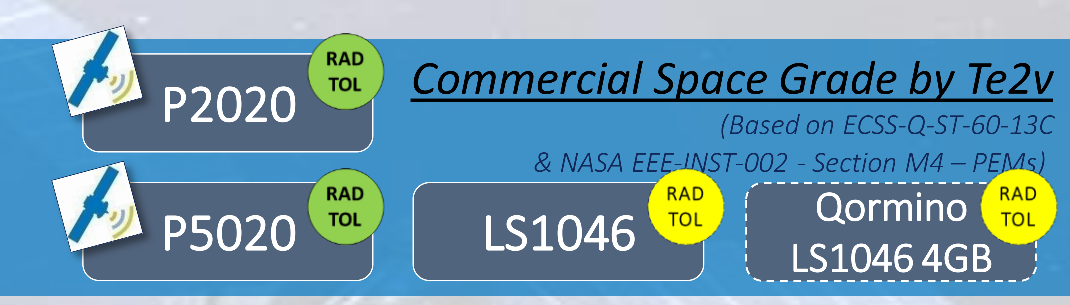
Preliminary Radiation Results

- 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

Teledyne e2v Space Processors

Conclusions

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

- **Space Microprocessor Portolio 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**