ThalesAlenia
a Thales / Leonardo company **Space**

ESCCON 2021

FEEDBACK ON COTS USE...
PART1 MICROSATELLITES

... OR HOW SMALL SATELLITES EXPERIENCE ON COTS CAN BE AN EXAMPLE FOR FUTURE CONSTELLATIONS ?

THALES ALENIA SPACE, CNES, STEEL ELECTRONIQUE

01/02/2021
0005-0013088076 N.JAUSSEIN

QUALITY
IS WHAT WE DO

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FIRST TIME COTS

1998: French CCT* first COTS* definition :

2001: MYRIADE

☞ Abréviations courantes :
- ✓ COTS = Commercial Off The Shelf (equipements à l'origine)
- ✓ PEM = Plastic Encapsulated Microcircuits
- ✓ PED = Plastic Encapsulated Devices
- ✓ CEP = Composant Encapsulé Plastique
- ✓ Composants Industriels

Commercial EEE parts:
without any reference to MIL/
ESA/SCC system
not necessary submitted to
screening or reliability tests

Commercial parts → **MICROSAT** ← High reliability

High reliability parts:
Covered by spatial or military
standard
(ESA/SCC, MIL, CECC).
Temperature range (-55°C, +125°C)
and hermetic package.

2013: ECSS-Q-ST-60-13 class 1 2 and 3 for COTS use (active EEE)

2017: NASA-STD-8739.10 grade 1, 2, 3, 4 for COTS (active&passive EEE)

2018: Thales Alenia Space Internal Standard for the use of COTS (active&passive EEE)

*COTS: EEE COTS commercial Off the Shelf. *CCT (CNES French "Technical Competences Community", COMET now Experts Community)

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MYRIADE/MYREV QUALIFICATION HERITAGE FOR SCIENTIFIC MISSIONS

2015-2020

2005

2001

SMALL SATELLITE (0 to 500kg)

50kg   300kg   500kg

Microsatellite   Minisatellite

Not at scale

2nd GENERATION MINISATELLITE

CLASS 2 mission

from MYRIADE blocks

(class3 updated to reach class2)

5 Y mission (completed)

RNC CNES (similar to ECSS-Q-ST-60-13 Class 2)

3rd GENERATION BIGGER SATELLITE

CLASS 2 mission

from MYREV blocks

(class3 updated to reach class2)

3Y mission (on going) (successfully qualified)

ECSS-Q-ST-60-13 Class 2

1ST GENERATION MICROSATELLITE

CLASS 3 missions

MYRIADE platform

2Y / 3Y missions (completed)

CNES µST-AQ-S-0-348-CNS

Use of COTS and HiRel EEE validated by industrials as Thales Alenia Space with CNES agency and various Equipment Suppliers

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MIRIADE/MYREV APPROACH

/// 1ST MYRIADE (2001), class3 platform

/ COTS component pre-qualification performed by CNES
- All COTS used in the platform validated by Industrials and CNES via Justification Documents (~60)
- If data collection, no systematic tests as screening at component level
- Tests at equipment level, (life test + TID) on EQMs, screening on FMs
- First use of active but also passive COTS
- SUCCESSFUL EVALUATION APPROACH with first use of COTS

/// 2ND MYRIADE (2005) and MYREV (2015) originally class3 platform updated to reach class2

/ All COTS used in the platform validated by Industrials and CNES via a Justification document
- Screening at component level
- Delta Set of additional Justification Documents approved (2nd MYRIADE + MYREV => ~55)
- LAT (Life test, VRT)
- Destructive Process Analysis
- Use of active but also passive COTS
- SUCESSFUL INDUSTRIAL APPROACH with systematic screening at component level

ADVANTAGES : High knowledge on COTS

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NEW TECHNOLOGIES / VERSUS HIREL

24nm NAND Flash memory

Die Size
In mm^2

Intel/Micron 256Gb 64L TLC 3D NAND	59.0
Samsung 128Gbit 32L TLC V-NAND	69.0
Samsung 16nm 64Gbit MLC NAND	86.0
Samsung 86Gbit 32L MLC V-NAND	87.0
Toshiba/SanDisk A19nm 64Gbit MLC NAND	94.0
Samsung 256Gb 48L TLC V-NAND	100.0
Toshiba/SanDisk 15nm 128Gbit MLC NAND	100.0
Samsung 21nm 64Gbit MLC NAND	103.0
Toshiba/SanDisk 19nm 64Gbit MLC NAND	113.0
Intel/Micron 256Gbit 32L MLC 3D NAND	168.0
Intel/Micron 384Gbit 32L TLC 3D NAND	168.0
Micron 16nm 128Gbit MLC NAND	173.0
Intel/Micron 20nm 64Gbit MLC NAND	202.0
Intel/Micron 128Gb 3D XPoint	206.5

0 20 60 100 140 180 220

2017 NAND Technology & Die Size / Manufacturer
(AnandTech)

Complex technology reverse bonding technology

Cu wires

New Packages QFN, BGA, D2PACK, SOT23

Recent NAND Components on the market Tech Insights

Flash Memory Summit

Category	Parent Devices	NAND Component	Manufacturer	#Die/PKG	Description
Mobile Phone	Samsung Galaxy S10+	THGAF8T0T43BAIR	Toshiba	4	128 GB 3D TLC (64L)
	Xiaomi Mi 9 SE	H9HQ53AECMMDAR-KEM	SK Hynix	11	BGA: 16 GB 3D TLC
	Huawei Honor V20	KLUDG4U1EA-B0C1	Samsung	4	128 GB 3D TLC (64L)
	LG Stylo 4+	MT29TZZZ7D7DKLAH	Micron	3	eMMC: 32 GB TLC (2D)
Tablets /Notebook	Dell XPS 13	H27Q1T8P0A2R (SSD)	SK Hynix	4	32 GB 3D TLC (72L)
	Apple iPad Pro 11	TSB324S	Toshiba	8	256 GB 3D TLC (64L)
	Google Pixelbook C0A	KLMDG4UERM-B041	Samsung	4	32 GB 3D TLC (48L)
	Microsoft Surface Go	H26M74002HMR	SK Hynix	4	64 GB TLC (2D)
IoT	Amazon Echo Dot	KMFJ20005A-B213	Samsung	1	eMMC: 4 GB (2D)
SSD	Samsung Z-SSD 983 ZET	K9QHGB8J0M-CCB0	Samsung	8	64 GB Z-NAND (48L, SLC)
	Samsung SSD PM983	K9DUGB8H1A-DCK0	Samsung	16	512 GB 3D TLC (64L)
	Intel SSD 660p	29F04T2ANCQHI	Intel	4	512 GB 3D QLC (64L)
	Intel SSD DC P4511	29F04T2ANCTHI	Intel	8	512 GB 3D TLC (64L)

Flash Memory Summit
Santa Clara, CA   9

2019 NAND FLASH market
(Tech Insights)

Advantage: In line with market trend, for mass storage & optimum footprint on PCB

*DSM: Deep Sub Micron (<0,90nm, ECSS-Q-ST-60-13 definition)

https://www.anandtech.com/show/11454/techinsights-publishes-preliminary-analysis-of-3d-xpoint-memory

https://www.flashmemorysummit.com/Proceedings2019/08-07-Wednesday/20190807_FTEC-202-1_Choe.pdf

Advantage:
- use of the latest front-end & back-end technologies
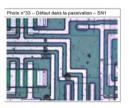- better performances reached

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New approach for DPA, new methods and criteria (JEDEC standards /MIL ones)
New knowledge needed by laboratories analysis with EEE manufacturers support

\# QUALITY IS WHAT WE DO
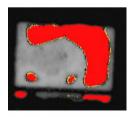
FINDING AND CORRECTIVE ACTIONS

///Lack in passivation

Photo n°33 – Défaut dans la passivation – SN1

-> new procurement with successful Lot acceptance tests

///Delamination in plastic package location,

-> depending on delamination

- new procurement
- or same lot but successful Lot Acceptance Test after preconditioning
- Adapted specification from to spec MIL -> JEDEC

///CNES ALERTS/ INFORMATION

- **Voids in passivation**
- **Counterfeit risk**
- **Information sheet on risk of cracks on some hybrids (recommendation to follow MIL-PRF-38535 Class S/ Xray, DPA, ...)**

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CONCLUSION

/ Both MYRIADE 1ˢᵗ Gen. (screening FMs & LAT EQM @ boards level) or MYRIADE 2ⁿᵈ Gen. & MYREV approach (screening@ EEE level) have shown successful results

/ Component lot validation model used with:
- A Justification document
- A DPA as a minimum
- A Screening at component level (for MYRIADE 2ⁿᵈ Gen & MYREV)

/ High electrical performance reached with market "high runner" products

/ Use of new technologies with caution and appropriate qualification

/ Also, Equipment Suppliers experience shared with customers for selection and use of COTS EEE

> Positive Feedback than can but re-used for future satellites class2 /class3 even class1 if additional tests performed
>
> Possible Models for NEWSPACE and NANOSAT

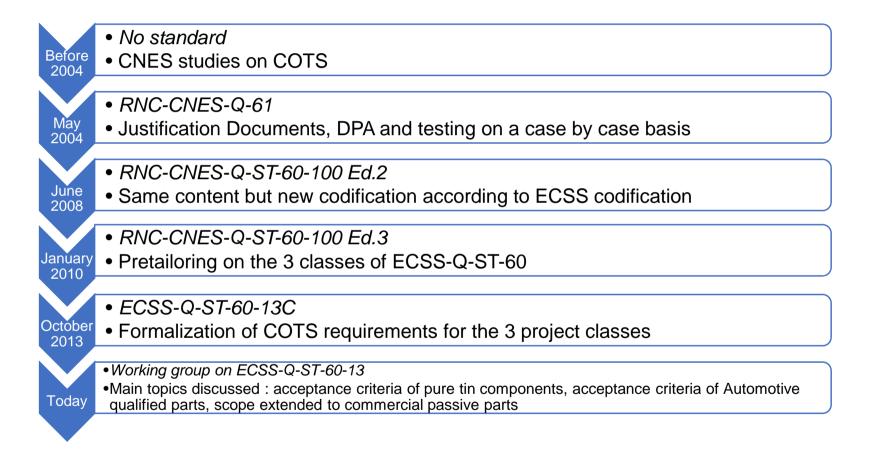THALES ALENIA SPACE INTERNAL

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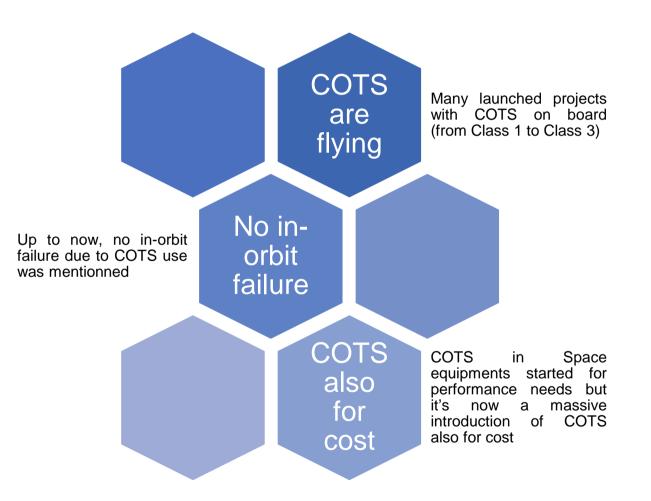
Charlène Doucet

cnes
CENTRE NATIONAL
D'ÉTUDES SPATIALES

Main steps of COTS standards

Before 2004	• *No standard* • CNES studies on COTS
May 2004	• *RNC-CNES-Q-61* • Justification Documents, DPA and testing on a case by case basis
June 2008	• *RNC-CNES-Q-ST-60-100 Ed.2* • Same content but new codification according to ECSS codification
January 2010	• *RNC-CNES-Q-ST-60-100 Ed.3* • Pretailoring on the 3 classes of ECSS-Q-ST-60
October 2013	• *ECSS-Q-ST-60-13C* • Formalization of COTS requirements for the 3 project classes
Today	• *Working group on ECSS-Q-ST-60-13* • Main topics discussed : acceptance criteria of pure tin components, acceptance criteria of Automotive qualified parts, scope extended to commercial passive parts

Heritage

COTS
are
flying

Many launched projects
with COTS on board
(from Class 1 to Class 3)

No in-
orbit
failure

Up to now, no in-orbit
failure due to COTS use
was mentionned

COTS
also
for
cost

COTS in Space
equipments started for
performance needs but
it's now a massive
introduction of COTS
also for cost

How to keep the knowledge on COTS products ?

Collection of data acquired through projects on an internal **database**

Anomalies system to prevent anomalies and failures already encoutered

Traceability is the key to use available/previous data (data validity, obsolescence, PCN)

❑ COTS use (IC and Transistors) through microsatellites heritage :

NewSpace
- 95-100% of COTS

Microsat :
- 40-50 % of COTS

Minisat :
- 40% of COTS

Grade 2 sat :
- 15% of COTS

Grade 3, 2 sat
- 0-20% of COTS

→ Several core functions built around COTS have made it through specifications evolutions and are still used today for grade 2 and 3 designs.

❑ Example : DSM NAND Flash Memory

- Used for the first time for minisat:
    - Life Test (1000h)
    - Radiation characterization
    - Bad-block specific management protocol
    - ➢ All tests were successful

- Procurement of a new lot for grade 2 satellite:
    - Full COTS LAT according to RNC-CNES (except for the radiation tests heritage)
    - Same bad-block management

➢ Minisat programs opened the way to the use of previously inconceivable components/technology