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COTS AND AUTOMOTIVE COMPONENTS FOR SPACE

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Introduction - Why COTS in Space ?

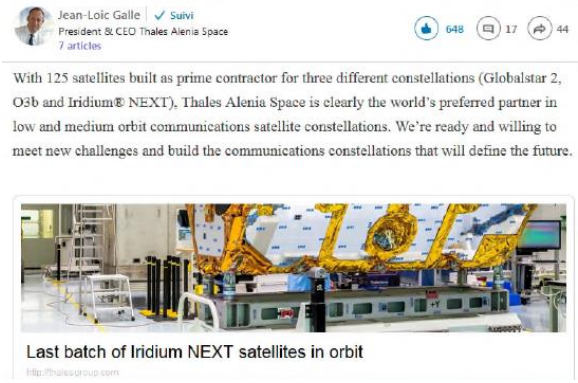
- Space market evolution due to emergence of a large number of constellations => use of COTS* in space applications increased during the recent years

- Use of COTS in equipment is a disruptive approach to minimize costs of the product and to optimize the design thanks to the very good electric performances of certain COTS that we do not find with the standard space components and thanks to disruptive technical solutions

- Potential use of COTS on constellations or recurring product lines is systematically analyzed on new opportunities.

See:
https://www.linkedin.com/pulse/iridium-next-constellation-now-fully-deployed-we-did-together-galle/

* Commercial Off-The-Shelf



Market Evolution – What happened?

Huge demand on VHTS architecture

Declining pricing

High flexibility on frequency

New RF power components

LEO & SMALLSATs

Disruptive Architecture, a New Challenge with COTS introduction

How digital transformation and disruptive innovation are challenging satellite power amplification technologies?

In recent years, the space industry has faced a disruptive breakthrough affecting its fundamentals. Digital transformation is transforming the satellite business model, creating new needs in consumer and enterprise connectivity at low cost, which implies very strong changes at all levels, involving the complete value chain. As an example, constellations or smallsats have become one of the major options for future satellite systems providing new capabilities related to high throughput connectivity demands. …

https://www.thalesgroup.com/en/worldwide/space/news/future-trends-space-market

COTS introduction on Thales Alenia Space satellites

- COTS have been progressively introduced in Telecom satellites for the following reasons :
  - Higher electrical performances compared to HiRel components
  - EEE part cost which is a major driver for the electronic equipment price : unit cost reduction from 30% (RF) to 80% (Digital, Power) => **Volume is key**
    - Example for the same Multiplexer function :
      - 600 € for a HiRel
      - 50 € for a PED
      - 4 € for a COTS (without qualification and screening) - To be validated in radiation
- Depending on radiation mission requirements and volume, up to 90% of Unit Cost reduction has been demonstrated with regard to HiRel
- Successful use of PED and COTS requires a solid and consistent methodology in various fields (EEE, Reliability, M&P Quality experts & Design) that Thales Alenia Space acquired through number of Programs such as GEO Telecom satellites and Iridium NEXT

- **Strategy**
  - Introduction of COTS taking advantage of constellations volume
  - Promotion of Thales Alenia Space COTS Preferred Parts List (Company proprietary, sensitive data) through all product lines (Thales Alenia Space JV)

Thales Alenia Space heritage (before 2012)

- For a long time, few COTS have been used by Thales Alenia Space on GEO Telecom satellites mainly for their electrical performances with Quality Assurance provisions in accordance with ECSS-Q-ST-60-13 Class 1
  - No failures due to EEE parts Quality level over the full life of the satellites

- First Thales Alenia Space constellations (in flight) : COTS were not authorized but non RadHard parts in Class 2 according to ECSS-Q-ST-60C have been used (with additional tests if necessary)
  - No failures due to EEE parts Quality level over the full life of the satellites

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Thales Alenia Space heritage (from 2012 – 1/2)

- **New approach** : commercial Grade (COTS) active parts with Quality Assurance provisions in accordance with ECSS-Q-ST-60-13 Class 2 **and** also passive parts are authorized
- Some specific part types are mandatory in Grade 1 only (relays, oscillators, crystals, connectors,…) or in Grade 2 (some passive parts,…)
- More than 100 references (automotive and non-automotive / active & passive components) are used on Iridium NEXT(several hundred thousands) :
  - Some units use up to several hundred COTS on the same part number
- **For some equipments : up to 75%** (including automotive grade -40°C / + 85°C and AEC-Q)
  - Ceramic capacitors (0402 to 0805)
  - Chip Resistors (0402 to 1206)
  - Magnetics : inductors (0402 to 0805) and transformers
  - Microcircuits
  - RF passive
  - Discrete : diodes and transistors (MOSFETs and bipolar)

Thales Alenia Space heritage (from 2012 – 2/2)

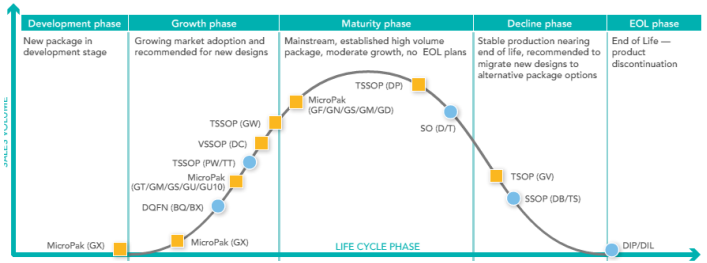
- COTS lots evaluation and validation
  - No Lot failures during Life test, HAST, C-SAM, Temperature cycling, …
- Screening / Burn-in
  - Performed at part or at board level
  - No Units failures during burn-in, qualification and acceptance tests due to COTS (no In
  - Failures were only due to design issues (electrical design not compliant with manufacturer data sheet) or mounting process not capable enough
- Constellation production and operation (75 satellites in flight – 66 in operation and 9 as spare, last batch launched in 2019, more than 45 years cumulated life time)
- Reliability of COTS from large volume production is better than the equivalent HiRel component :
  - Statistical process control (SPC) in production
  - Many automatized operations

Thales Alenia Space approach for Iridium NEXT

- Specific program requirements issued end of 2009, 4 years before ECSS-Q-ST-60-13 release
- Requirements close to ECSS-Q-ST-60-13 Class 2.
  - Mandatory information :
    - Data collection from the components manufacturer with capitalization in justification document (JD)
    - Construction analysis (5 parts per lot DC)
    - Mounting qualification (per lot DC)
    - Radiation evaluation (per diffusion lot for radiation sensitive products)
  - If collected data are considered as not sufficient :
    - Qualification at component level (per lot)
  - No screening at component level
  - Screening at equipment/unit level : burn-in and thermal cycling
  - For some units suppliers :
    - Different approaches have been chosen by some suppliers but validated by Thales Alenia Space
    - Data review by Thales Alenia Space

Thales Alenia Space COTS - Lessons learnt (Constellation and SmallSats)

- What is new compared to HiRel components ?
  - Use of non-standard packages (plastic / non hermetic : small size) unknown in space grade : TSOP, TSSOP, D2PACK, SOT23, QFN, …
  - New assembly materials : Copper wire bonding instead of Gold or Aluminum wire bonding
  - Lead free terminations : pure tin, SAC305 , …
  - New manufacturers not present on space market



https://www.nxp.com/docs/en/supporting-information/QIC-Package-Lifecycle-Phase.pdf

- Anomalies detected during lot upscreening :
  - IC in QFN plastic package with pure tin terminations : electrical failure detected at equipment level due to a poor solder alloy wetting due to terminations contamination
  - MOSFET in SOT428 (DPAK) : electrical failures during upscreening due to parts handling in test sockets (loss of electrical contact resulting in EOS failures)

Lessons learnt

- **Any handling of COTS parts (unpacking, visual inspection, upscreening, tin leading, …) shall be reduced to a minimum**

Thales Alenia Space approach for New Space (1/3)

New Space approach based on Iridium NEXT REX

COTS selection policy

- COTS from Thales Group Parts Database are preferred (Company proprietary, sensitive data) : availability of several thousand references on active and passive components.
- COTS shall be selected to withstand all environmental conditions concerning handling, storage, mounting processes, ground testing, launch and space environments.
- Selected COTS shall meet operation stability, safety, long term reliability and tolerance to radiation exposure defined for the duration of the mission.
- This approach shall be approved by the customers

Thales Alenia Space approach for New Space (2/3)

COTS Policy according to ECSS-Q-ST-60-13C

- 3 different classes defined in ECSS-Q-ST-60-13C :
  - **Class 1** : a full upscreening is requested and the upscreened part can be used on Class 1 programs
  - **Class 2** : based on collected data in justification document, upscreening is optional and lot test can be reduced
  - **Class 3** : based on collected data in justification document, evaluation and lot test limited to radiation, construction analysis and mounting qualification.

Thales Alenia Space COTS policy

- 3 different grades can be considered :
  - **Grade 1** : equivalent to Class 1 of ECSS-Q-ST-60C (*)
  - **Grade 2** : equivalent to Class 2 of ECSS-Q-ST-60C (*)
  - **Grade 3** : Commercial parts (COTS)
    - Parts selected from one of the following standards :
      - NASA EEE-INST-002, Parts category 3, Project Level 1
      - ECSS-Q-ST-60-13C Class 2, Commercial Components
      - AEC-Q100, Q101 or Q200
      - Parts compliant with Thales Alenia Space EEE Quality Assurance Requirements
- Users can select Hi-Rel grade 1, Hi-Rel grade 2 or commercial components (COTS)
- Based on its unique heritage with commercial parts, Thales Alenia Space proposes the selection of additional parts families to the list of ECSS-Q-ST-60-13C (passive components are authorized).

(*) Required for some specific product families

The proposed approach for commercial components is in line with ECSS-Q-ST-60-13C Class 2 and, for some specific cases, with Class 3 (with a very good justification file)

Thales Alenia Space approach for New Space (3/3)

Targeted qualification system : AEC-Q

- Leitmotiv : No failure, no failure, no repetitive failure

⇒ A COTS is a commercial part, chosen mainly in automotive **AEC-Q qualified parts** :

  ⇒ high volume per day

  ⇒ under Statistical Survey

- ***With this definition, a COTS*** is not worse than the HiRel part it replaces .

Is COTS Failure Rate comparable to HiRel Failure Rate ?

YES ! Because :

COTS = Produced good from first + very few screening

HiRel = variable Production outcome + 100% screening

Thales Alenia Space COTS selection flow (*)

New design => New need
COTS selection from major suppliers : high volume, reliability test program with SPC, website with access to datasheets, application notes, PCN, obsolescence notifications, traceability, …

COTS Choice

Justification Document

- **Radiation evaluation**
- **Data collection** : product and package qualifications, reliability data, construction analysis, traceability, …

Final validation by Experts : Radiations, M&P, RAMS and EEE Parts Experts

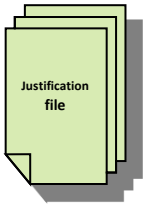
Parts Selection Team (PST)

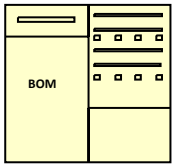
COTS valid for design

Implementation in bill of material

Procurement
If needed : evaluation, radiation tests, CA, mounting qualification, screening
Update of justification document

COTS valid for production!





(*) Approach proposed and to be adopted by the customers

Conclusion

The disruptive approach of **COTS usage in space applications** offers very attractive perspectives in term of performances and competitiveness nevertheless their selection must be very carefully managed by technical experts from different domains in order to evaluate risks and ensure equivalent (or better) reliability figures than standard space components.

This approach is valid only if COTS parts are selected from major manufacturers, with high volume production and reliability data availability.