Experience with COTS on ADPMS unit

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Agenda

1. Company Introduction
2. ADPMS Introduction
3. Why COTS?
4. Examples
5. Conclusion
Company Introduction

- Founded in 1969 as product developer
- Space activities started in 1983
- Delivered 100+ systems and sub-systems for manned space stations, satellites and interplanetary missions
- Acquired by the QinetiQ group (UK) in 2005
- 170 highly educated specialists employed
- 2 sites in Belgium
- 450m² cleanroom

QinetiQ Space Ground Station
- Located in Belgium, Redu
- ESA satellite ground station
- Jointly operated with SES Astra

QinetiQ Space
- Located in Belgium, Kruibeke
- Offices: 3.742 m², Warehouses: 1.200 m²
- 2 Class 100.000 cleanrooms
Company Introduction

Satellites & Platforms  Scientific Payloads  Subsystems  Downstream services
ADPMS Introduction

- **ADPMS : Advanced Data and Power Management System**
  - Dual lane computer and power system
  - Modular digital boards
  - Intended for platform computer

- **Onboard computer for Proba satellites**
  - Design started in 2000
  - Flight heritage on Proba-2 and Proba-V (16 combined years in orbit)
  - Flight units ready for Proba-3
  - Spin-off used on IXV

- **Parts Usage**
  - General class 3 level parts
  - About 20 different types of commercial COTS parts used on a total almost 300 parts
  - Design predates the ECSS-Q-ST-60-13C
Why COTS?

• Because of functional reasons (No suitable FM equivalent available)
  – However market and availability evolves
    – Several components could now be replaced by MIL / ECSS / Hi-rel parts
  – But, unless replacement is size/function compatible, risk of change is considered too high
    – Very dense PCBs prevent updating without complete redesign
    – Loss of flight heritage / qualification
    – excellent performance of most COTS parts in space

• NOT because of cost reasons
  – Component parts cost is lower however
    – Upscreening costs
    – Parts approval flow (repeated for each project)
    – Radiation testing when applicable
    – Solder qualification
    – (relifing)
  – Difficult to assess total cost at start of project
    – Accumulated cost of PAD discussions and extra tests over consecutive projects
    – Obsolescence, manufacturer changes or batch variability (no long term assurance)
Why COTS?

• Design concept
  – cPCI compliant modular boards and backplane with rear-IO
    – Multiple types of cPCI connectors

• PCB space constraints
  – Decoupling of CCGA /MCGA devices
    – 0402 ceramic capacitors
    – Large value / small size ceramics
  – Qualified parts too large to accommodate
    – SOT23 plastic package dual schottky diode

• Functionality and performance
  – Memories required for LEON processor
    – Commercial SRAM and FLASH
  – Low power analog housekeeping
    – ADC, OPAMP and instrumentation amplifier
Design concept : cPCI connectors

• Part selection and Qualification
  – Initially parts from Tyco were selected with Sn/Pb leads
  – For each FM lot a press-fit qualification campaign was required
  – Extensive Lot acceptance testing, structural analysis performed

• Lessons learned
  – Standard PCB manufacturing with hot-oil reflow finish not ideal for press-fit mounting due to tolerance restrictions.
  – Due to obsolescence change required to other manufacturer (Harting)
    – Different tolerances and small dimension differences caused damaged connectors and pins
    – Same type of connector but internal construction is significantly different between manufacturers.

• Current status
  – cPCI equivalent connectors for space are available but limited choice and no reliable intermateability with other brands can be warranted.
PCB space constraints: Ceramic capacitors

- Part selection and upscreening
  - Commercial “Hi-rel” 0402, 0805 and 1206 caps from Kemet
    - Procured with traceability from authorized distributor
    - Manufacturer test level “C”
    - SnPb finish

- Lessons learned
  - Solder qualification and operational performance successful
  - Lifetime issues, solderability decreases
    - Solderability failed in reusing previous flight lot, new procurement required
  - Sourcing new SnPb COTS parts difficult with increased lead time (non standard product)

- Current status
  - 0402 size capacitors are now available from European space-qualified manufacturers
    - High lead time and considerable higher cost than MIL CDR types
    - Used in new designs requiring class 3 or better.
PCB space constraints: SOT23 plastic package dual schottky diode

• Part selection
  – Multiple small signal schottky diodes required on small space
  – Space qualified single diodes available but FM package too large
  – Initial part from ON-semi selected

• Lessons learned
  – Obsolete ON-Semi Flight batch failed 7-year relifing
    – Same BAS40-04 component from Infineon selected as replacement
  – Solder qualification required for all new batches of plastic parts
    – No issues for the older On-Semi part
    – Initial solder qualification of Infineon part failed due to difference in lead
  – Obsolescence and differences between commercial parts resulted in an unexpected cost and delay.

• Current status
  – Still a need for small diode packages
  – New designs with no COTS use more PCB area for same configuration
Functionality and performance: Memories

• Part selection and upscreening
  – Components were selected because some radiation data was already available
  – COTS memories have a short market lifetime. Large number was purchased. FM assembly uses only a few but quantities for upscreening and testing are significant.
  – Solder qualification required on each lot of plastic parts
  – Radiation test cost is extensive
    – Total dose testing
    – Single event latchup testing
    – Single event effects testing (SEU, SEFI)
    – In some cases proton SEE testing was required (sensitive part)

• Lessons learned
  – Combining all test costs the memories become the most expensive parts
  – Quick obsolescence and short lifespan of non hermetic plastic parts is a project risk and eventually limits the time a design can be reused.
  – Beware of variations in a “single lot” COTS parts

• Current status
  – For new projects external qualified devices (e.g. 3D-plus) are preferred
Functionality and performance : Analog Frontend

• Part selection and upscreening
  – Core is a radhard RTAX FPGA
  – Power conditioning with radhard parts
  – Critical parts for analog acquisition however are all COTS
    – Low speed ADC with SPI interface
    – Opamp
    – Instrumentation amplifier
    – Several high precision resistor divider arrays

• Lessons learned
  – To date no degradation is notable on the DAM housekeeping telemetry on both the Proba-2 and Proba-V satellites
  – No SEFI detected over the years for the ADC

• Current status
  – Qualified devices available on the market
Conclusion

• COTS can be successfully used in space
• Risk of obsolescence
• Significant differences between batches and manufacturers
• Upscreening costs per part are very high for small series

COTS comes with a COST