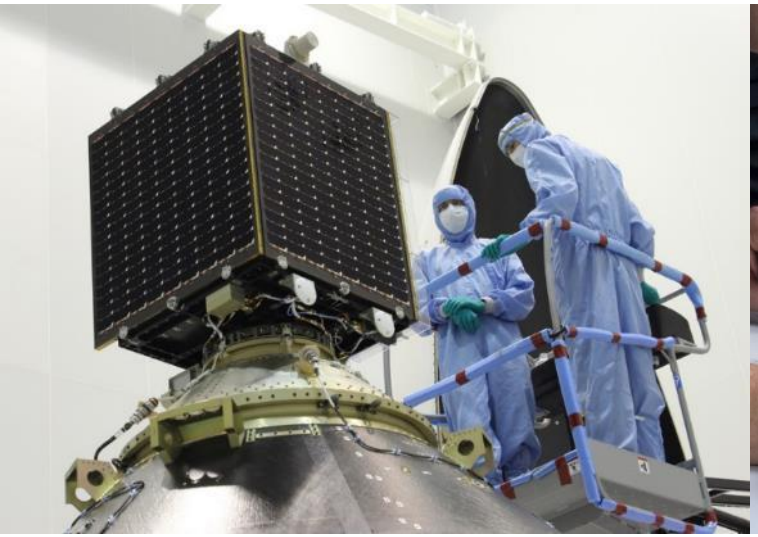
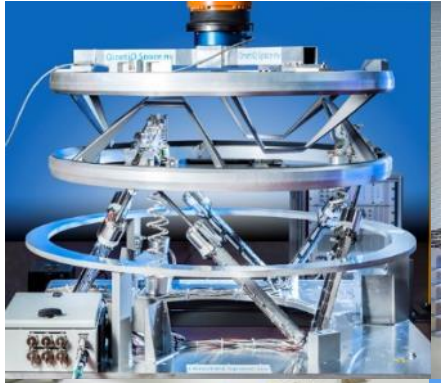
Experience with COTS on ADPMS unit





06 November 2019 – J. De Hert – QinetiQ Space

ACCEDE COTS2019

SEVILLE – SPAIN 6-8 NOVEMBER

QINETIQ

Agenda

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

COMMERCIAL IN CONFIDENCE

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

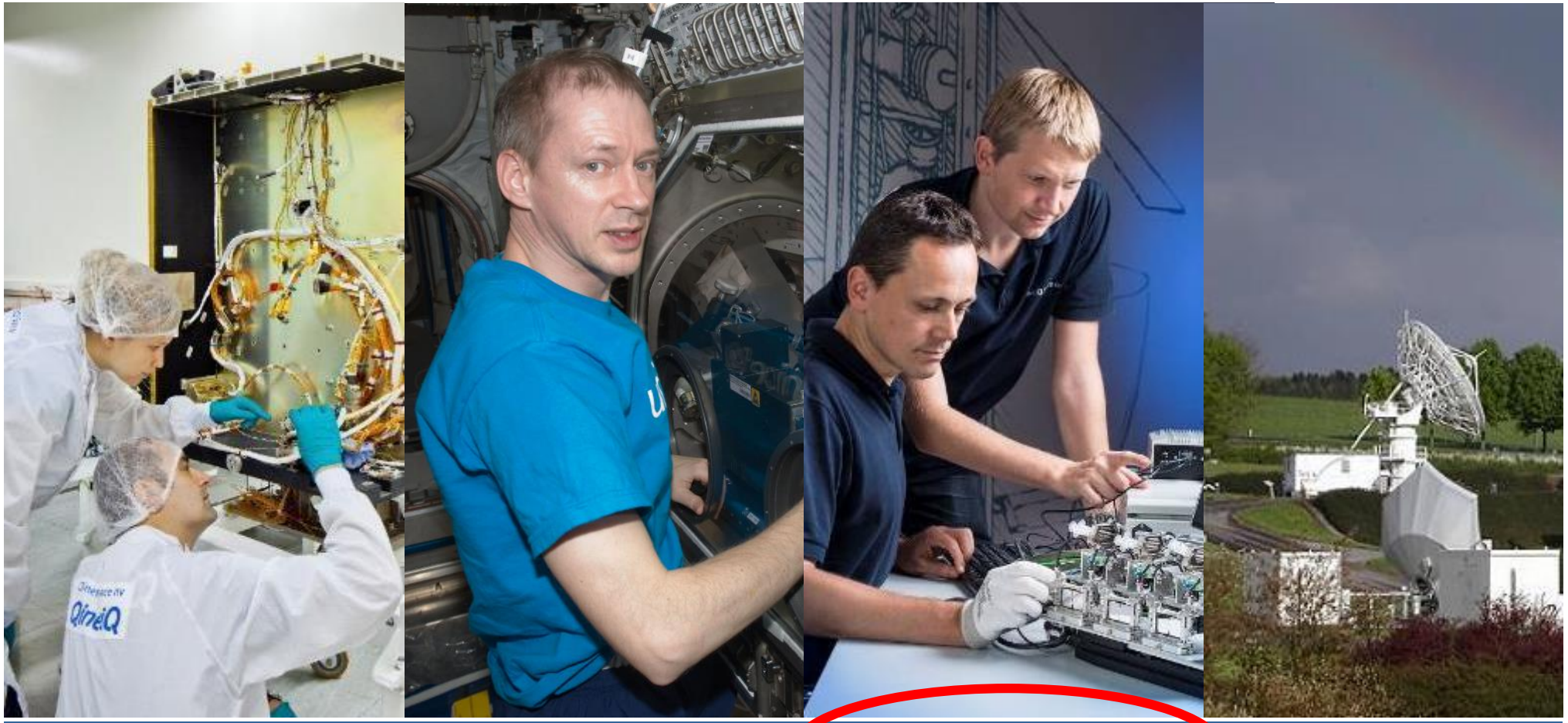
- Located in Belgium, Redu
- ESA satellite ground station
- Jointly operated with SES Astra

QinetiQ Space

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

COMMERCIAL IN CONFIDENCE

Company Introduction



Satellites & Platforms	Scientific Payloads	Subsystems	Downstream services

COMMERCIAL IN CONFIDENCE

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

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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)

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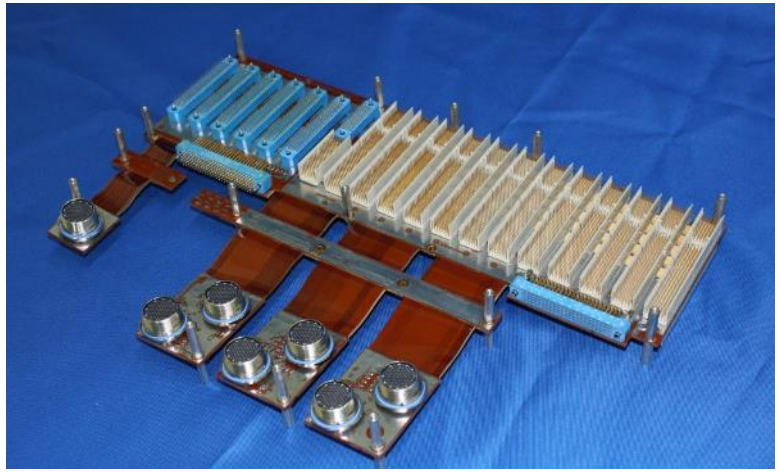
Why COTS?

- 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



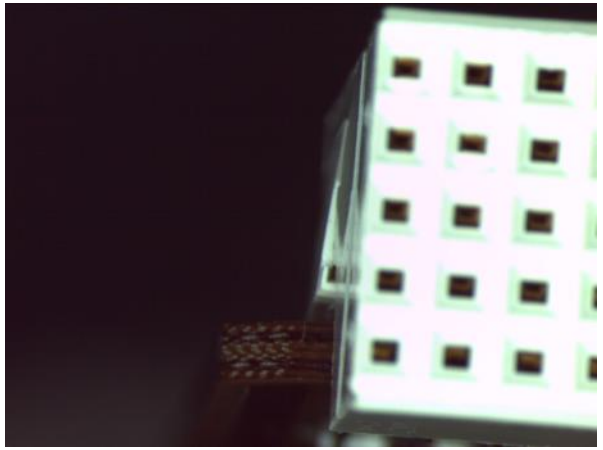
COMMERCIAL IN CONFIDENCE

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.

Tyco

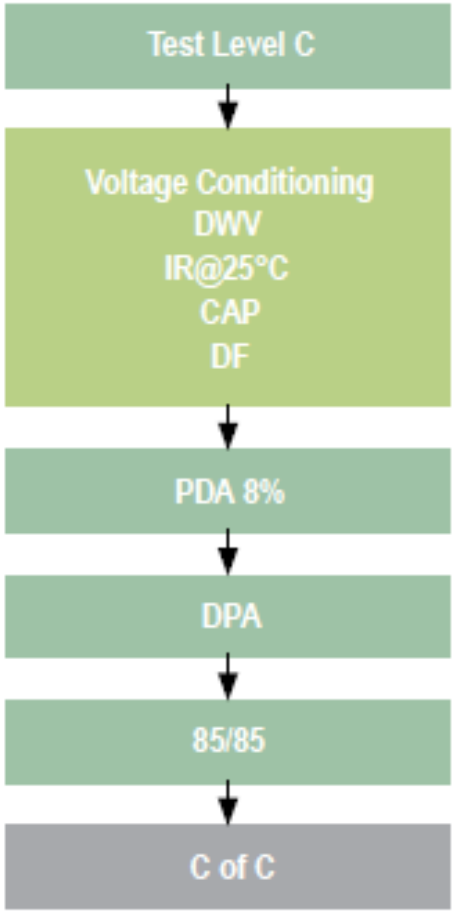
Harting



COMMERCIAL IN CONFIDENCE

PCB space constraints : Ceramic capacitors

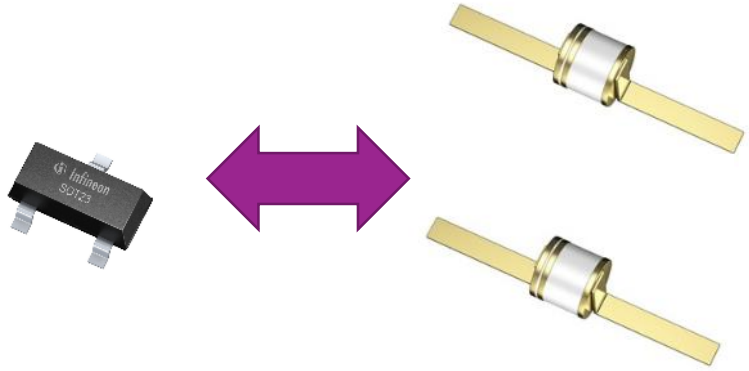
- Part selection and upscreening
  - Commercial “Hi-rel” 0402, 0805 and 1206 caps from Kemet
    - Procured with traceability from authorized distributor
    - Manufacturer test level “C”
    - SnPb finish
- Lessons learned
  - Solder qualification and operational performance successful
  - Lifetime 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.

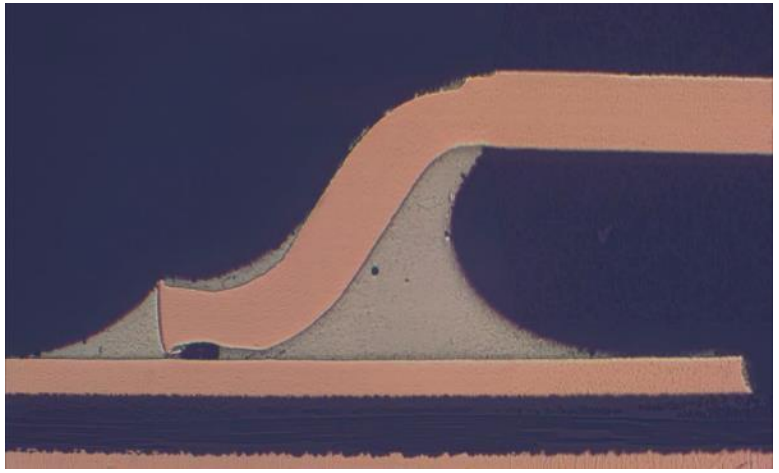


COMMERCIAL IN CONFIDENCE

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

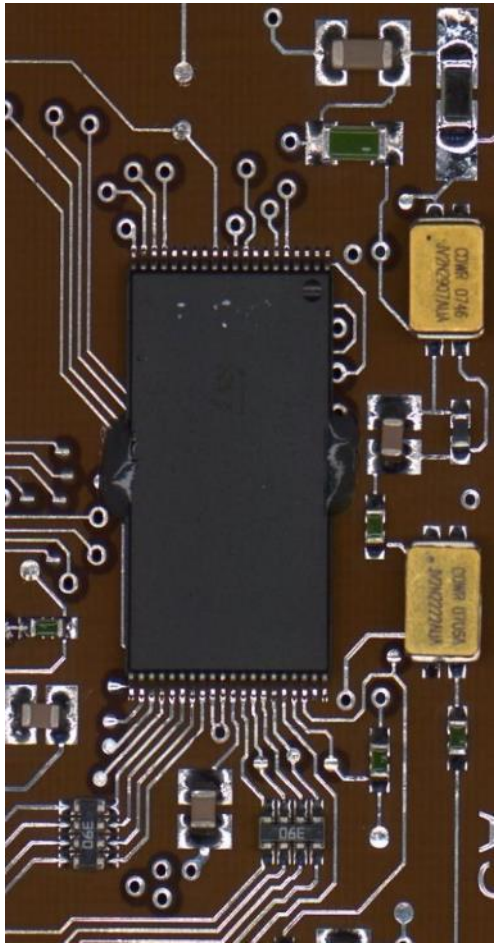




COMMERCIAL IN CONFIDENCE

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



COMMERCIAL IN CONFIDENCE

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

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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

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