WE LOOK AFTER THE EARTH BEAT

Digital Fibre Optic link applications and challenges: a system integrator perspective

N. Venet, H. Gachon, M. Sotom

ESA Workshop on Intra-Satellite Fiber Optic Links
Estec, Noordwijk (The Netherlands), 10th-11th of December 2015

09/12/2015

Ref.:

OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

83230910-DOC-TAS-FR-001

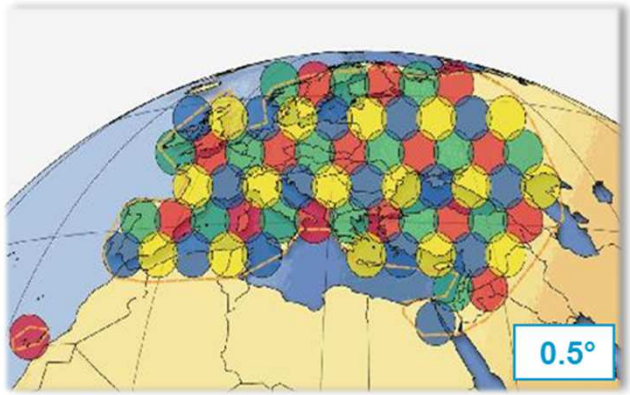
Outline

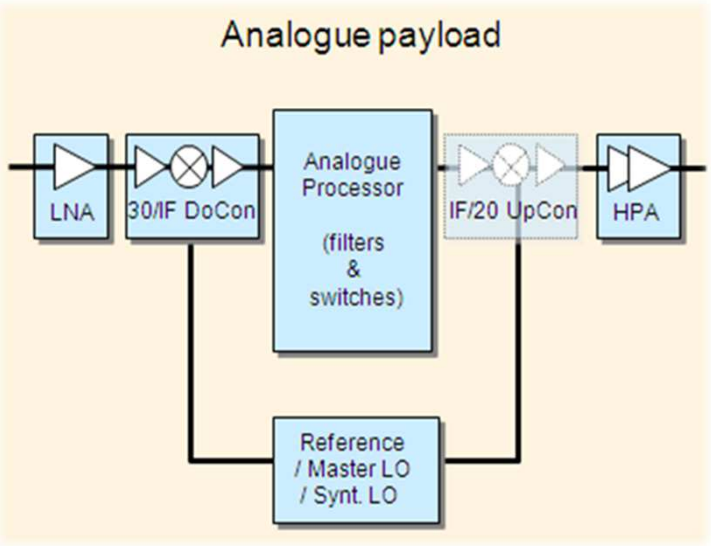
- Telecom Applications
- Remote sensing and high data rate applications
- General Requirements
- Main achievements: ESA Optical Inter-Board Interconnects (OI2)
- FP7 MERLIN Requirements
- Challenges & Open Issues

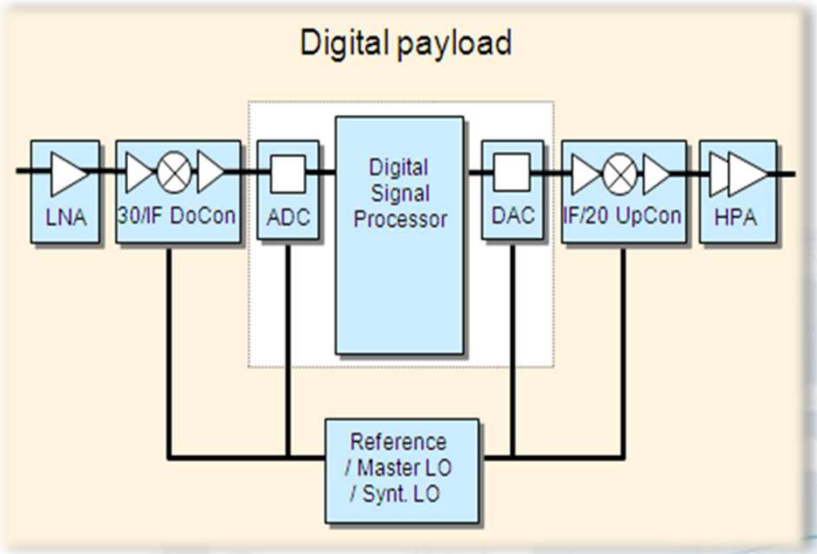
OPEN

Telecom Applications

- Future broadband telecom payloads
  - flexible in coverage, connectivity, freq. plan, BW allocation …
  - > 100 RF channels over 10's of antenna beams
  - critical requirements in mass, volume & power
  - transparent payloads (analogue or digital)





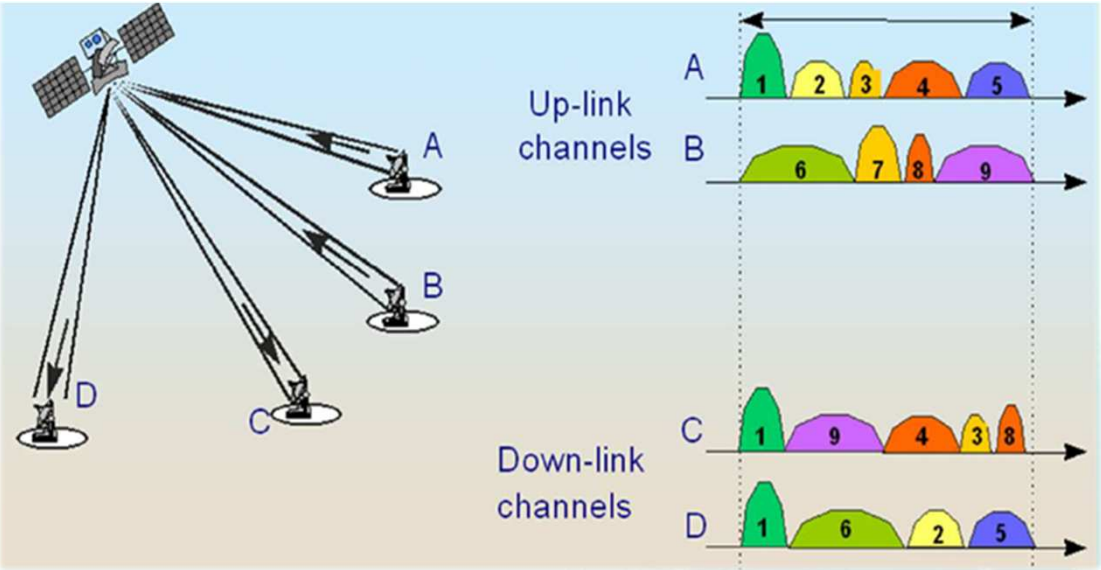


OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

Telecom Applications

- Applications to telecom on-board digital processors
  - main and most demanding applications
  - Digital Transparent Processor (DTP)
    - routing frequency / access, multicast, broadcast
    - narrow band, variable BW filtering
    - equalization …
  - Digital Beam Former
    - Additional function in the DTP if required

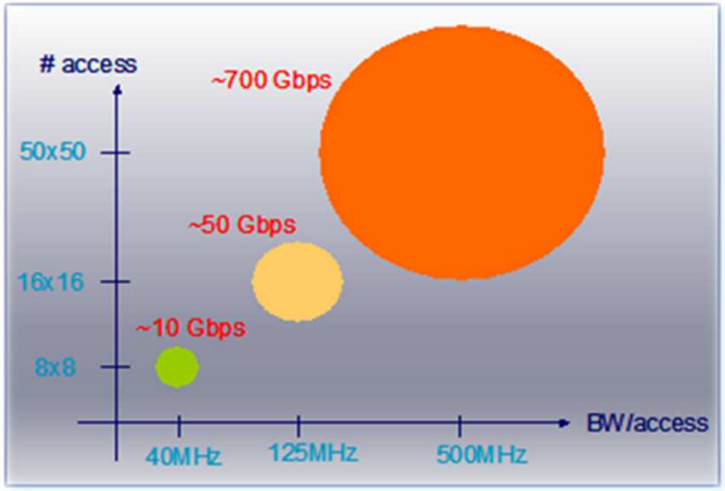


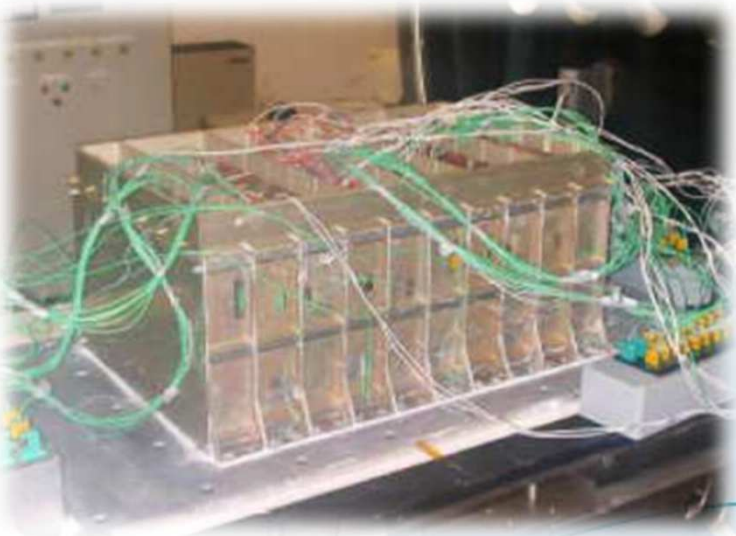
OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

Telecom Applications

- Digital Transparent processors
  - high internal throughput
    - > 1 Tbps
  - constraints and bottlenecks
    - PCB surface
    - I/O density
    - power consumption
  - enabling technologies
    - Deep Sub-Micron ASICs (180 > 65 > 28nm)
    - hi-throughput, low power I/O's both at chip (embedded HSSL) and board level
    - extended-capability heat drains



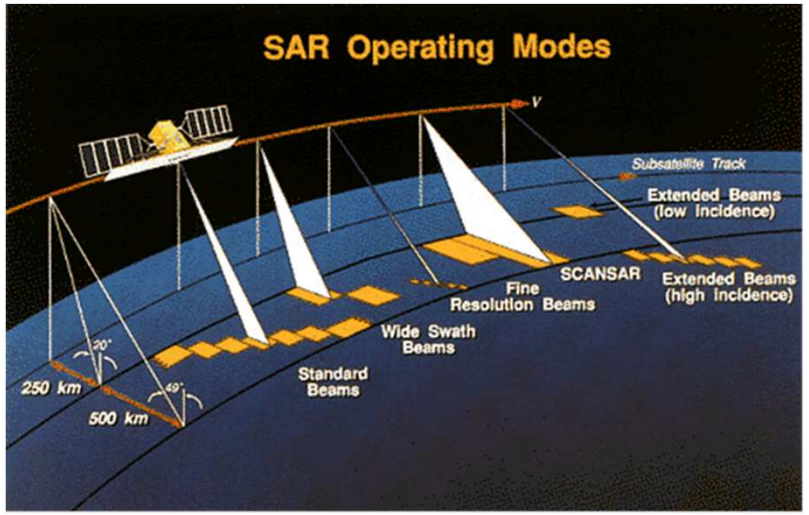


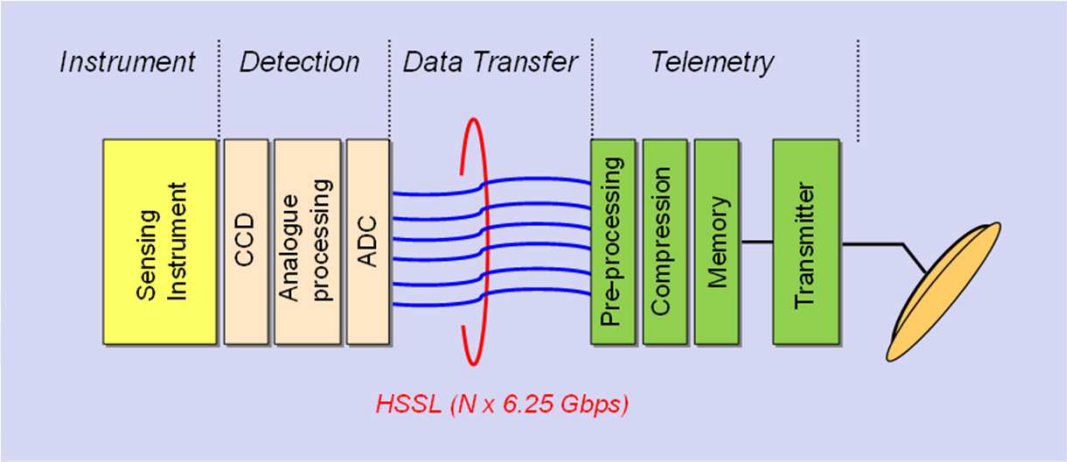
OPEN

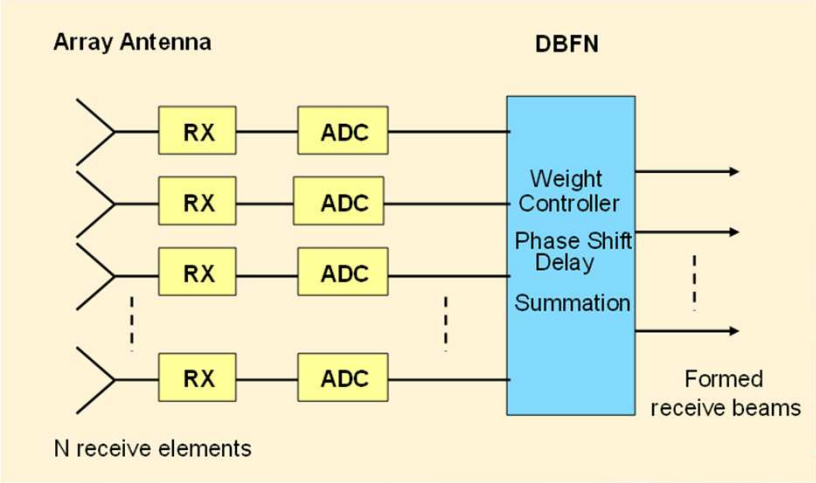
ThalesAlenia Space
A Thales / Finmeccanica Company

Remote Sensing & High Data Rate Applications

- Digital processing in Remote Sensors
  - synthetic Aperture Radar
  - digital Beam-Forming (DBF)
    - dynamic control of antenna pattern
    - new scanning/tracking modes ...
  - mass memories & data handling units
- SpaceFibre application



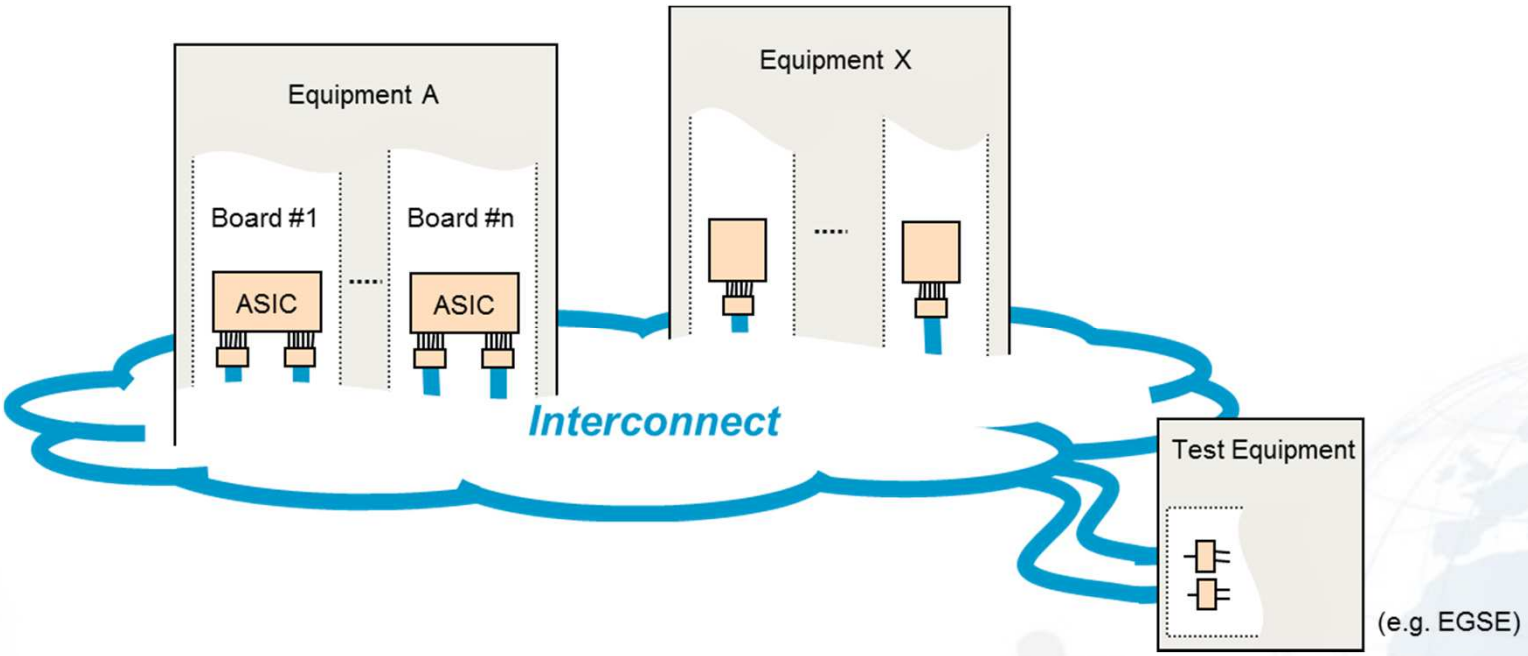




OPEN

General Requirements

- Fibre Optic links as a universal medium/means for supporting
  - all intra-equipment,
  - all inter-equipment,
  - and external, broadband connections



OPEN

General Requirements

- General features of a disruptive interconnect solution
  - generic for intra- and inter-equipment
  - reconfigurable connectivity
  - unlimited distance
  - modular growth
  - unlimited throughput
  - high-density (connector and cabling)
  - no EMI
  - supports redundancy
  - low power consumption
  - supports point to multi-point
  - suited to electric I/F (and evolution)
  - transparent to data rate (supports multiple rates)
  - provides means for non-intrusive monitoring

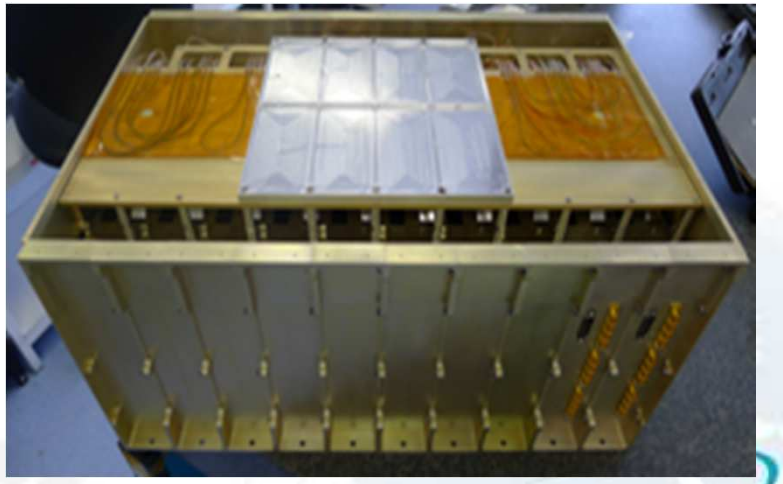
OPEN

General Requirements

- Optical interconnects in digital processors
  - solution to I/O density bottleneck
  - scalable to high throughput
  - enabling
    - flexible function partitioning
    - monitoring capabilities
- data rate (per channel)
  - compatible with ADC/DAC serial link needs
  - compatible with HSSL SERDES (1- 25 Gbps)
  - lowers consumption (in mW/Gbps)
- throughput
  - # of channels per O/E module as a trade-off (integration vs. modularity …)
  - throughput (per board) grows by adding modules
  - hi-density connector w/ modular design
  - total throughput > 1 Tbps

Main achievements: ESA Optical Inter-Board Interconnects (OI²)

- Hi-throughput Optical Interconnects demo
  - 10 slices of 3 different types
  - Rx/Tx slice (2 stacked)
    - multi-channel Tx & Rx modules from D-Lightsys designed to support 12 x 10 Gbps
    - multi-channel Tx/Rx from VTT designed to support 4 x 10 Gbps
  - Passive coupler slice (1 stacked)
    - optical coupler array from DAS Photonics
    - supports 12 individual 1x2 optical splitters
  - Dummy slices (7 stacked)
  - Optical interconnections based on flexible optical fibre circuit
    - able to manage 320Gbps in / 320 Gbps out

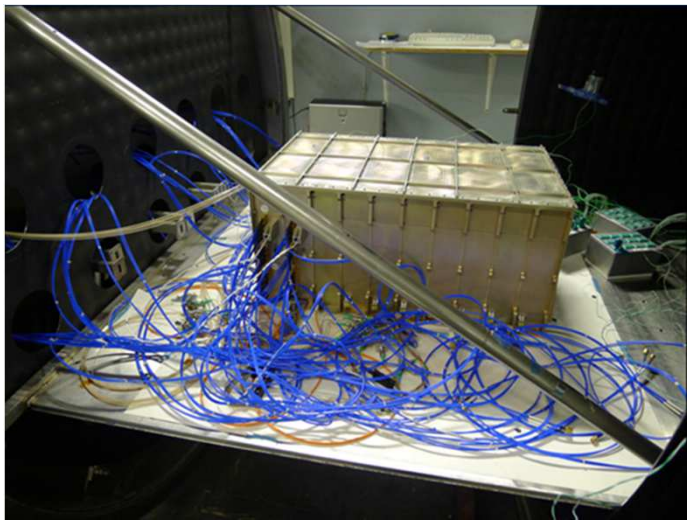


OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

Main achievements: ESA Optical Inter-Board Interconnects (OI^2)

- Environmental tests
  - first at ambient temperature and at atmospheric pressure
  - then in thermal vacuum chamber at 25°C, +70°C and -30°C
  - in thermal chamber at atmospheric pressure same range of temperature
  - and after vibrations (same conditions as for a digital processor EQM)
- Results
  - the performance of the optoelectronic and passive modules are close to target specifications (BER of of 10^{-12})
  - no degradation proving that the OI^2 breadboard was quite robust
  - the results of the test campaign provides higher confidence in the introduction of optical interconnect technology



OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

FP7 MERLIN Requirements (as an example)

- Functional requirements
  - transceiver (TRx) type: Tx + Rx
  - embedded intelligence
  - control interface
  - temperature monitoring
  - hermetically sealed package
  - mountable on PCB
- Performance requirements
  - 850 nm wavelength
  - TRx multichannels
  - 25 Gbps rate
  - differential I/O (CML compatible)
  - output power > 0 dBm (Tx)
  - laser RIN
  - extinction ratio (or OMA)
  - 10^{-10} BER detection sensitivity (Rx)

OPEN

ThalesAlenia Space
A Thales / Finmeccanica Company

FP7 MERLIN Requirements (as an example)

- Environmental requirements
  - operating T° (-40 / +85 °C)
  - radiation tolerance: Gamma (100 krad) and protons
  - vacuum (10^{-6} bar)
  - outgassing
  - vibrations
  - shocks
  - lifetime (> 15 years)
- Physical interface & packaging requirements
  - multimode fibre
  - MCF/SCF fibre
  - number of I/O fibres
  - power consumption
  - mass
  - small footprint
  - SPI interface

OPEN

Ref.:

ThalesAlenia Space
A Thales / Finmeccanica Company

Challenges & Open Issues

- Fibre Optic links industrialisation
  - identification of supply chains for Space applications
  - consolidation of the supply chain
  - sustaining the supply chain
- Applicable Standards
  - confirm that ECSS-Q-ST-60-05 (related to hybrids) is applicable
  - other standards / other rules ?
- Qualification activities
  - to be launched

OPEN

Acknowledgements

- Part of this work was carried out in the frame of the ESTEC contract «Optical Inter-Board Interconnects for High-Throughput on-Board Processors».

- The authors thank Nikos Karafolas as a Technical Officer for having initiated and stimulated this activity.

- The authors are also grateful to their partners for fruitful collaboration, and to ESA the European Space Agency, and CNES the French National Space Agency for their support.