# Multi-Giga Bit Optical Interconnects for Digital Processors

*ESA Round Table on Optical Interconnects – February 7, 2006*






## Outline

- Interconnect needs
- Space-qualifiable optical interconnect technology
- Conclusions
- Recommendation

# Multi-Giga Bit Optical Interconnects for Digital Processors



## Interconnect needs - ESA WDBFN contract (2004) as an illustration (1)

- Feasibility analysis of a digital receiver having an FAFR antenna, 64 beams, 128 radiating elements, 500 MHz useful per beam
- Digital functions considered: ADC, DX, BFN + local switches
- Three main integration levels:1) ASICs, 2) PCBs, 3) Units
- Three constraints to be met at each level:1) Surface 2) Power 3) I/Os
- Mapping ASICs on PCBs (1)
  - ASIC assumption: ATC18RHA 0.18 µm from ATMEL
  - Constraints 1 and 2 : Double Europe format (220*233.5 mm²)
    → Leads to 30 ASICs max per PCB
  - Constraint 3 (I/O): the blocking point!





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## Interconnect needs – WDBFN contract (2)

- Mapping ASICs on PCBs (2)
  - Using Optical links, the D-LIGHT device from D-lightsys (12*2.5=30 Gbps useful data rate)
  - One “interface set" is made of (2 ASICS + SERDES + E/O parts).
    - The surface constraint leads to 12 ASICs max per PCB
    - The power constraint leads to ***6 ASICs per PCB***.
    - → *The I/O constraint again is the strongest one* .
    - → 6*30 Gbps = 180000 Mbps possible at the PCB interface
  - Next generation of interfaces should be integrated inside ASICs and their power consumption should be reduced (90 nm, serdes in ASIC).
  - Focusing our attention on interconnects which remain the bottleneck of digital architecture

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## Interconnect needs – Other wideband studies

- ESA “DEFEND” contract
  - Development of a 250 MHz digital processor
  - Functions: ADC, DX, LCT, SW, MX, LIN, DAC
  - Input 3*264 MHz, output 24*264 MHz
- ESA “ULISS” contract
  - Development of a 96*250 MHz packet switch
- ESA “NGBSS” contract
  - Complexity estimate of future possible digital payloads having more than 100 GHz
  - of aggregate bandwidth
- CNES “FFC” contract
  - Development of a DBF processor at reduced scale




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## Commercial component offer

- Transmitter (electrical to optical conversion)
- Receiver (optical to electrical conversion)
- Transceiver
- 12 channels - 72 channels @ 2.5 Gbps
- 850 nm VCSEL Array
- w/ multimode fibres

## but

- Temperature range 0°C-70°C
- Non hermetic module
- Electrical leads not compatible with Space process

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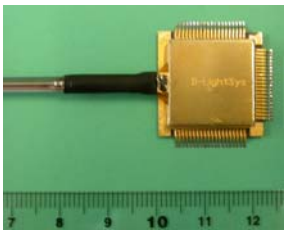
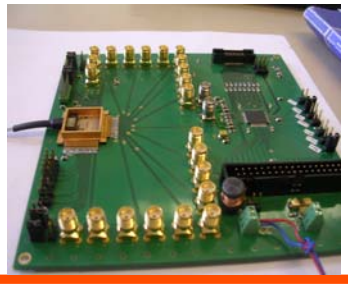
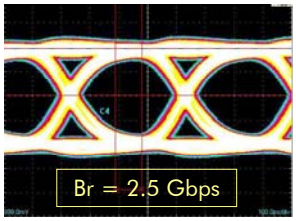
- Developed by D-lightsys (ITAR free)
  - based on multi-channel modules for harsh environment
- 12-channel Tx and Rx modules @ 2.5 Gbit/s
  - extended temperature range
  - small-size, hermetic ceramic package









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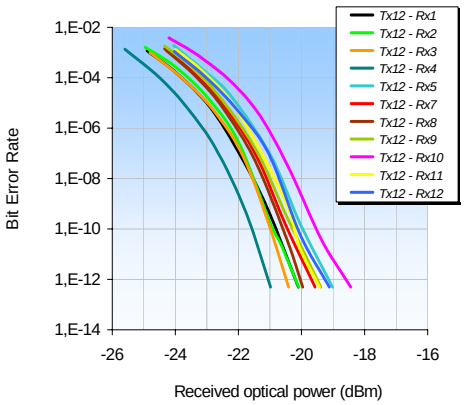
- Testing of the 12-channel Rx module
  - @ 1.25 and 2.5 Gbit/s
  - using same transmitter
  - no Bit Error Rate (BER) floor
  - detection threshold (@ $10^{-9}$ BER )

    < -20 dBm @ 2.5 Gbit/s
  - low performance distribution (~2 dB)
  - optical return loss ~ -13 dB

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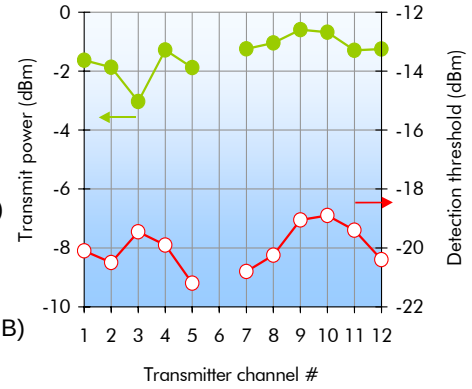
# Multi-Giga Bit Optical Interconnects for Digital Processors



## Testing of the 12-channel Tx module

- @ 1.25 and 2.5 Gbit/s
- using same receiver
- output power >-3 dBm
- detection threshold (@ $10^{-9}$ BER )

  < -19 dBm @ 2.5 Gbit/s
- low performance distribution (~2dB)









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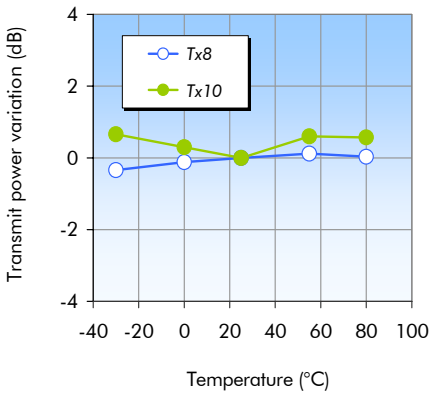
## Thermal testing of the Tx module

- operation maintained over T° range of [-30 ; +80 °C]
- transmit power variation ~ 1.5 dB
- D-Lightsys proprietary algorithm for laser control
- detection threshold variation 1.5 dB

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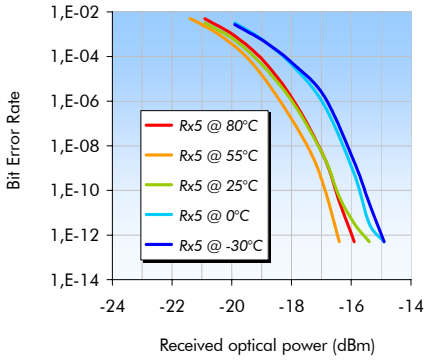
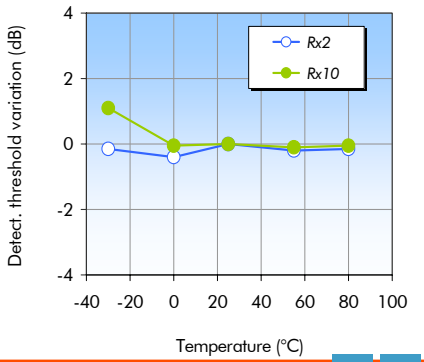
## Thermal testing of the 12-channel Rx module

- operation maintained over T° range of [-30 ; +80 °C]
- detection threshold variation ~ 1.5 dB





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## Summary

### Development of space-qualifiable O/E interface modules

- by D-Lightsys (France), based on modules for harsh environments (avionics, defence …)
- 12 x 2.5 Gbit/s : aggregate rate of 30 Gbit/s !
- designed for extended operating temperature range
- hermetic housing

### Testing of space-qualifiable O/E interface modules

- all Tx and Rx channels have similar performance
- Tx and Rx performance maintained over [-30 ; +80 °C]
- optical link loss budget (worst case) >10 dB @ 2.5 Gbit/s

## Ongoing activity

- Optical Interconnect Demonstrator
  - based on a EQM existing DTP for telecom
  - Technology test bed for :
    - space-qualifiable O/E interface modules
    - backplane optical connectors
    - flexible optical fibre circuit
  - Functional & environmental tests





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## Recommendation

- Activities to be pursued
  - Radiation evaluation
  - Component qualification
  - Development of 10 Gbit/s space-qualifiable modules

  …

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