DAS Photonics

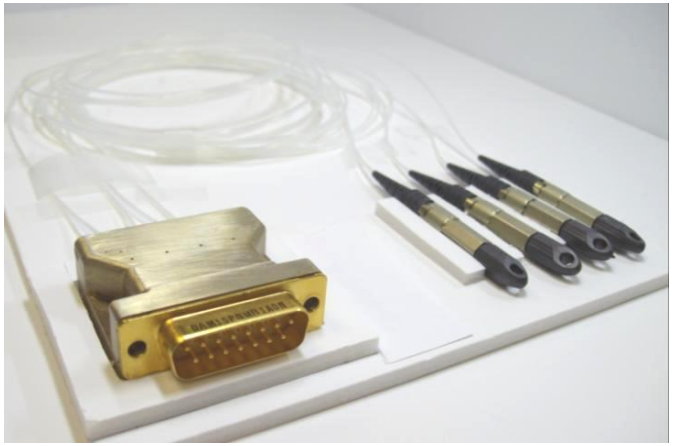
Active Optical Cable (AOC) for Satellite Harnessing Substitution

Intra-satellite Fibre Optic Links Workshop
ESTEC, 10th-11th December 2015

www.dasphotonics.com

OPTOELECTRONIC CONVERSION MODULE "SIOS"

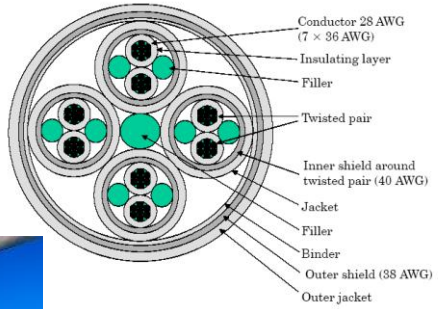
- **SIOS Optical Transceiver is a subsystem for the replacement of copper data cables by optical fibre data links without impacting current equipment**
- **Substitution of copper harness do not require current equipment requalification**



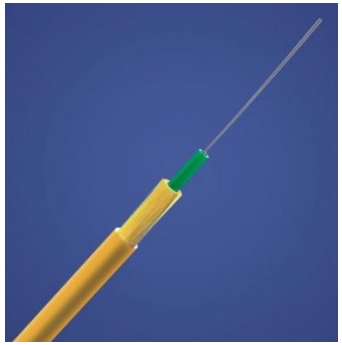
- **SIOS approach offers an AOC electrically and mechanically compatible with current harness**
- **SIOS brings the benefits of optical fiber to harness of current S/C protocols (SpaceWire, CAN BUS, etc)**
- **Optical transceivers are accommodated inside the connector back shell**

MAIN ADVANTAGES OF OPTICAL FIBRE

- **Many limitations because the use of copper wires in traditional harness**
  - Mass and volume (cable mass, e.g. 80g/m)
  - EMI issues
  - → **Increment mass due to isolating wires**
  - Limited data rate and distance
  - Ground loops



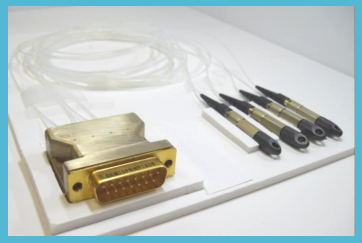
- **Optical fibre has become a potentially copper harness replacement**
  - Lower mass and volume compared with copper wires
  - Allows longer distances, flexibility in distances between units
  - Allows higher data rate
  - Immunity against electromagnetic interferences
  - Galvanic isolation



HISTORY CHART

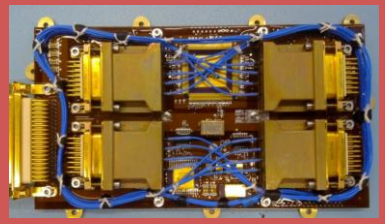
Space National Programme

2007-2008: Development of the proof-of concept and preliminary evaluation of the components



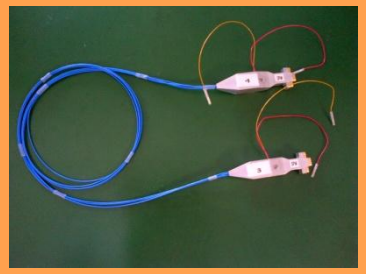
IoV: TDP8 in Alphasat

2008-2011: Lot Qualification Campaign of the non qualified components. Development of EQM and FM for low and medium data rate modules



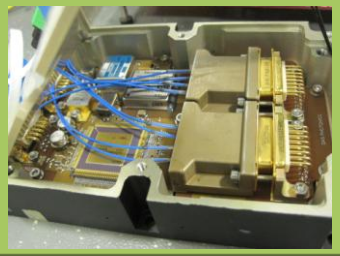
ESA-GSTP Activity

2010-2013: Development of AOCs to TRL6 for SpaceWire and CAN Bus



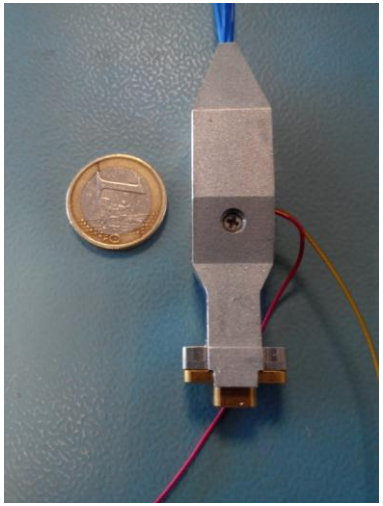
IoV: HERMOD in Proba-V

2012: Development of PFM of medium data rate modules for the validation of MPO/MTP connectors from T&G Elektro



OPTOELECTRONIC CONVERSION MODULE "SIOS"

- Handle data rates from 1Mb/s to 500Mb/s (with capability for higher data rates)
- Selectable number of TX & RX channels
- Bespoke solution adaptable to a wide range of connectors: mD-9, DB-9, DB-15, DB-25, DB-37, 38999
- Compatible with electrical levels and bit rates of current satellite buses (1553, CAN Bus) and SpaceWire
- Power supplied through a external cable or a connector pin (if available)



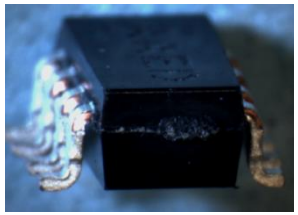
SPACE EVALUATION CAMPAIGN

Space qualified components used when available

For VCSELs, Photodiode & its drivers (unavailability of qualified components)

→Highest quality level for commercial off-the-shelf opto-electronic components adopted

→Components subjected to the evaluation campaign:



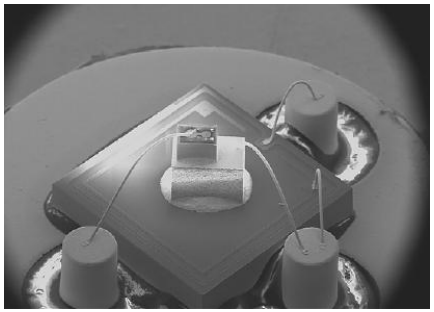
Device	Main Characteristics
850nm 2.5G VCSEL LC TOSA	Very High Reliability Excellent Performance Over Extended Operational Temperatures (from -40ºC to +85ºC) Hermetic Package
850 nm 2.5G LC ROSA	
Electronic Drivers	Compact Plastic packaging Temperature range from -40ºC to +85ºC
Fiber Optic	Draka Radhard MMF 50-62.5/125 fiber with a GORE spaceflight cable Excellent Performance over radiation

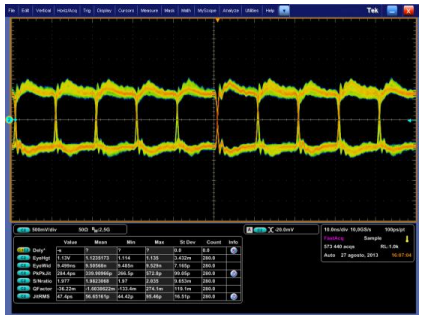
SPACE EVALUATION CAMPAIGN

Assessment campaign at component and module level in the frame of Alphasat TDP8 and GSTP activity

Test Plan at Component Level

- ✓ **Visual inspection and functional testing**
- ✓ **Constructional Analysis**
- ✓ **Thermal Vacuum Cycling:** 100 cycles between -60ºC and +85ºC (5ºC/min)
- ✓ **Thermal Conductance Analysis**
- ✓ **Outgassing**
- ✓ **Life testing** on 18 samples
- ✓ **Catastrophic optical damage threshold**
- ✓ **Heavy Ions** on electronic components

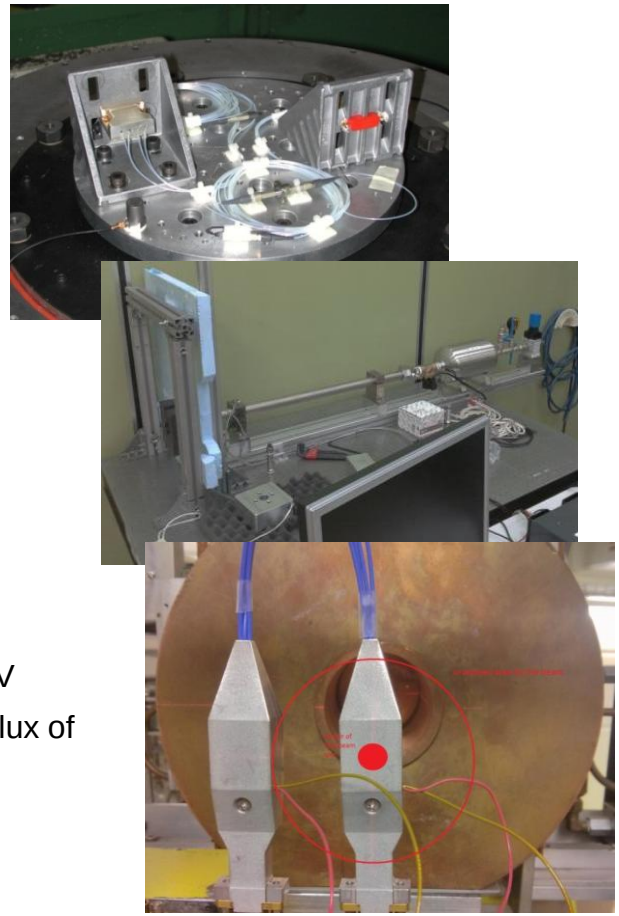




SPACE EVALUATION CAMPAIGN

Verification campaign at component and module level in the frame of Alphasat TDP8 and GSTP activity

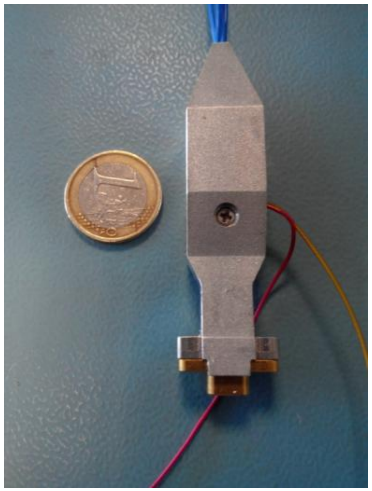
FULL ASSESSMENTCAMPAIGN AT TRANSCEIVER LEVEL

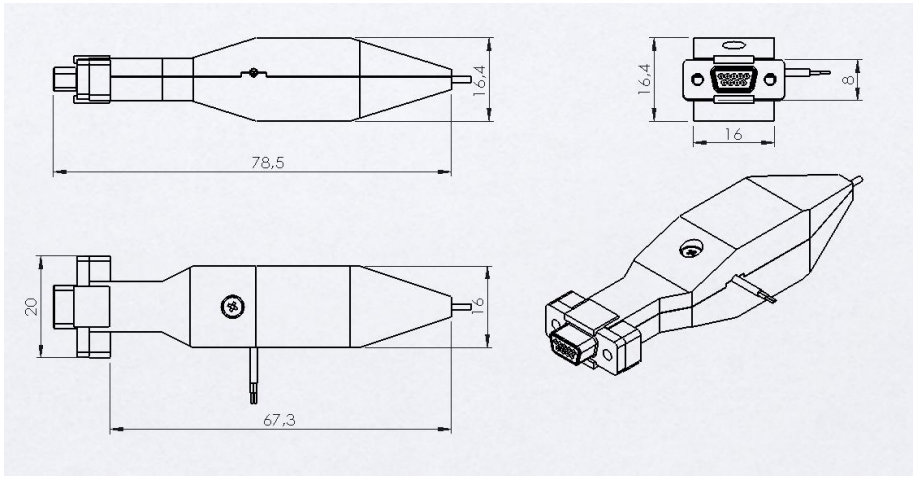


- ✓**Functional electrical**
  - •BER and eye diagram
  - •Power consumption
- ✓**EMC**

✓**Vibration sine**	6.4G peak, 3 axes
✓ **Vibration random**	23.73g RMS, 3 axes
✓ **Shock**	1500g at 10kHz, 3 axes
✓ **Thermal vacuum cycling**	8 cycles (-60º to 85º) 1E-8mbar
✓ **Radiation total dose (TID)**	150 krad @ 50krad/h 150 krad @ 360 rad/h
✓ **Proton radiation**	Energy levels 60, 100 & 200 MeV Total dose of $3E^{10}$ p/cm^2 with a flux of $1E^{10}$ p/cm^2/s
✓ **Fiber Pull**	> 10N

SPACEWIRE AOC





Pin	Configuration
1	Data In+
2	Strobe In+
3	GND
4	Strobe Out-
5	Data Out-
6	Data In-
7	Strobe In-
8	Strobe Out+
9	Data Out+

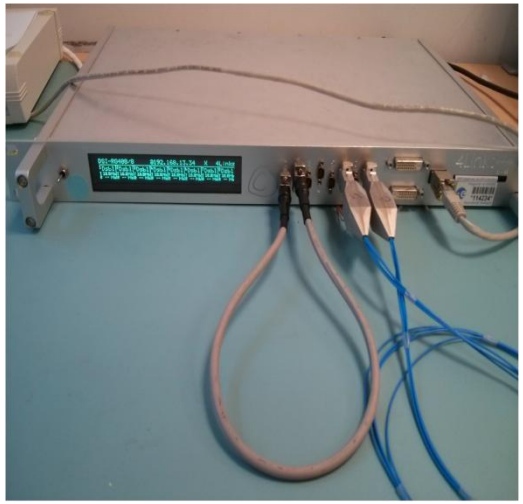
Connector mass ≅ 12 g

Input voltage = 3.3 V ± 10%

Current consumption @ 200Mbps ≅ 200mA @85ºC

190mA @ 25ºC

170mA @ -40ºC



• Tested with the Diagnostic SpaceWire Interface (DSI) from 4Links up to 200Mbps with fibre length from 1 m up to 20m without impact on the BER results

MASS ASSESSMENT FOR SPACEWIRE CABLE

Mass Assessment for a cable with MDM9 connectors

		Connector mass (g)	Cable mass (g/m)
Copper cable	Min	9,5	83
	Max	23,5	100
AOC cable	Min	12	1,2 (x 4)
	Max	15	2,4 (x 4)

The mass of a cable of 1m in copper will be around [102, 147]g whereas for optical fiber cable the mass is between [29, 39.6]g

This means a mass saving of more than a 70% per cable.

For longer cables the mass saving will be higher. For 10 m the mass saving could reach the 90%.

TRADE-OFF

	Advantages	Drawbacks
Copper cable	**Good reliability figures** Mature technology	Heavy and bulky cable Rigid cable (difficult for routing) Length limitation **Ground loops** **EMI/EMC issues**
AOC cable	Light fibre cable Flexible and easy routing Immunity to EMI **Longer cable length (very useful for ground testing)** **Galvanic isolation** **Competitive in price**	**Power consumption** **Low flight heritage (2 IoV on-going)**

Thank you!

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