SMOS – The 1st Deployment of an Optical Harness on a Satellite

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Why introduce fibre optic technology for space applications?

**Advantages**

- Compact, flexible and light weight harness.
- Low loss transmission medium, excellent for remote applications. (0.15dB/km – SM)
- Galvanic isolation, Immunity to EMI and also does not produce EM noise – reduced grounding and sheilding requirements.
- Low cost of COTs components due to a very large telecom market.
- Inherently safe and stable for use in class I, division 1 explosive environment. Large variety of coatings available, suitable for hostile environments.
- Already has heritage in military aircraft demonstrating good reliability, serviceability in a harsh environments – sensing, communications.
- Standards are under development for aircraft and space applications, ARINC, SAE and ECSS.

**Disadvantages**

- Attempting to replace well understood and reliable solutions. (Necessity is the mother of invention)
- Contamination of optical interfaces requires additional effort on the part of the integrator.
- Radiation has aging effects on most of the main components: optical fibre, laser and detector.
- Few qualified parts exist, therefore flight qualification costs are generally high.
- Fast evolving telecom market – risk of components becoming obsolete.
- Telecom market has little interest in supplying space needs due to small volume.
- Space community has limited experience of using the technology.
Current Applications of Fibre Optics

Demeter

ISS

PROBA 2

SMOS
SMOS – ESA’s Soil Moisture Ocean Salinity mission

- Due to be launched in Q1 2009 (together with PROBA 2)
- Mission Duration 3 years (5 years expected)
- Mass - 600 kg
- Speed - 7.5 km/s
- Altitude - 750 km
- Global Coverage 3 days, image every 1.2s
- Payload - MIRAS (Microwave Imaging Radiometer using Aperture Synthesis)
- 69 L-band (1.4GHz) microwave receivers

SMOS Video
MOHA distributes a 56MHz clock signal to the 69 L-Band (1.4GHz) receivers and transmits the digitised received signal back to the correlator at 112Mbs\(^{-1}\). MOHA made use of COTS components:

- AlGaInAs 1300nm FP Laser Diodes
- Fibre Optic Receiver
- Fibre Optic Coupler Assembly
- SIFAM
- Corning SMF 28 in a Gore Flexlite Cable Assembly with Diamond AVIM APC Connecters
In general space qualified opto-electronic components do not exist.

High quality commercial off-the-shelf opto-electronic components tested according to Telcordia standard or similar offer quality approaching space requirements in some aspects.

A full qualification exercise as per ESCC specification not feasible due to:
- time and cost constraints
- industry is too fast moving.
Qualification Approach: Strategy for SMOS/MOHA

- Partial evaluation of the 2 best alternatives
  - Most Critical Tests (vibration, shock, thermal vacuum cycling, radiation (gamma & proton))
  - Constructional Analysis
  - Manufacturer Assessment

- Lot Acceptance - qualification of 1 Flight Lot plus samples
  - Flight lot screening / qualification
    - extended burn-in
    - acceptance thermal cycling
    - measurement at high and low temperature
  - Flight lot acceptance testing
    - thermal cycling, vibration, shock and radiation
    - life test
    - bending, fibre pull, mating, DPA
Harness Integration Approach (Cont.)

Multipoint connectors to reduce integration time and miniaturised connectors desirable. Integration approach similar to electrical cables, minimum bend radius >25mm had to be observed. Other major challenge AIT is contamination control of fibre end face.
Lessons Learnt

- **Fibre optic cables**: Pay high attention to used cable design and harnessing and ensure its compliance with required temperature range and vibration and shock requirements
- **Fibre optic cable design**:
  - loose tube good for processing pigtailed parts / couplers
  - tight tube better for temperature performance
- **Fibre optic cable/harnessing**
  - fixation of cable (vibration and shock) – failure of potted splitter
  - connectorising of cable/pigtail – critical in demanding thermal environment
- **Temperature behaviour of laser transmitter**: (High temperature roll over could be important for power budget)
- **Electro-optic components**:
  - Humidity content in TO-can (Failure in due point test)
  - Mechanical rigidness of the assembly
- **When comparing components**: choose parts with as much similarity as possible, fibre, cable, connector etc.
Lessons Learned (Cont.)

- Most manufacturers are not willing to customise their process for a small volume order
  - Assess willingness to disclose exact processing steps, manufacture to custom requirements, help with failure analysis.
- Smaller manufacturers show greater interest and higher flexibility to customise their manufacturing and/or disclose the exact processing
- Be very accurate in manufacturer assessment (which activities are outsourced, how is the visibility)
- Products are evolving fast – try to choose the option which appears to have secure market and be fast.
- Optical connectors were time consuming to Need for multipoint connectors and miniaturised single point connectors
Conclusions

- Telecordia provides some good standards however many COTS components are not qualified to these standards.
- Space environment is a challenging one but efforts so far have shown that it is possible to qualify FO for space environments; ISS, Demeter, ATV, SMOS, PROBA 2
- Mounting and integration of optical fibre harnesses on space structures still relatively immature - main difference concerns contamination issues which needs to be addressed through appropriate strict procedures.

- Shining some light on the problem may even save you some money
Thank you for your attention!

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