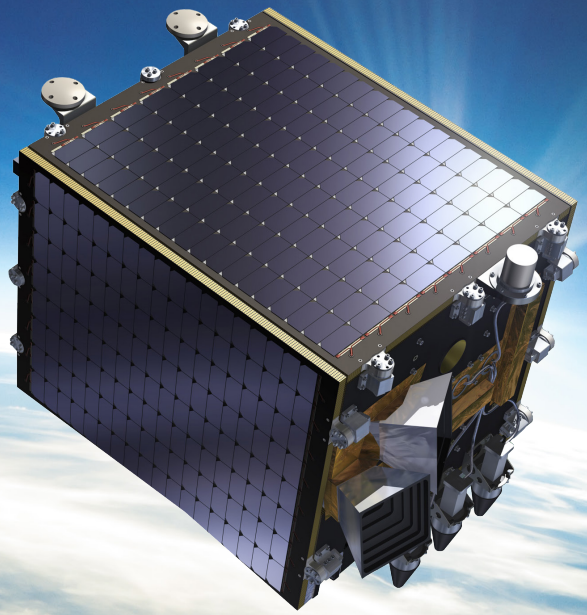
T&G
ELEKTRO

NEW TECHNOLOGY

FIBER IN SPACE

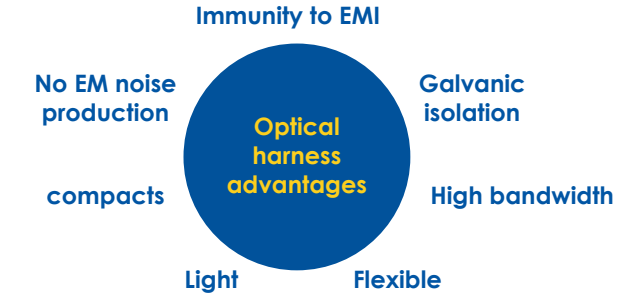


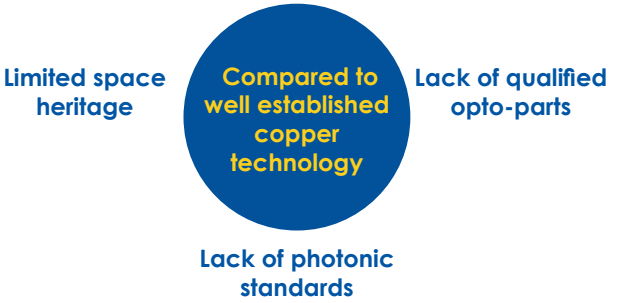
Background and Advantages

T&G Elektro AS started its fiber optical activities in 1984. Most of the activities were in the early years related to the Telecom market. Fiber optical communication related technology has been very well established for terrestrial applications. In the 90'ies the Defence and Offshore markets were interested in fiber optical harnesses and cable systems. In the beginning of this century T&G started working with fiber optical harnesses for aircrafts and missiles.

During the past years, ESA increased its interest for using this technology in orbit. In 2008, with support from the Norwegian Space Centre, T&G's step was taken further to start qualification for the Space market.

Since 2010, ESA Product Assurance Department has initiated some activities dedicated to the validation and qualification of optical fiber assembly and elaboration of standards.



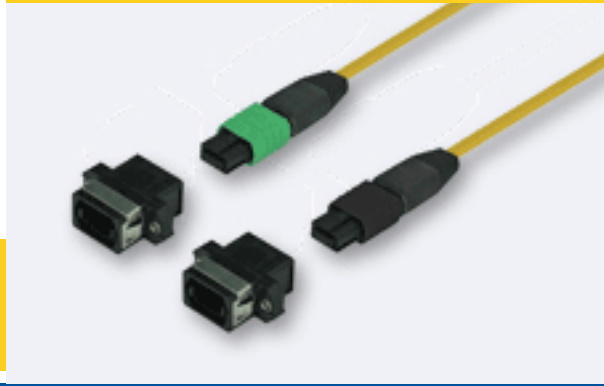


GSTP and HERMOD

- The tasks, the final presentation and the deliverables were completed in December 2014.
- Phase 1 aimed at confirming the need of the space end-users in term of optical assembly application and performing a survey of the components available in the market (connectors, cables, fibers).
- Phase 2 consisted in the assembly of the different selected technical solutions followed by on-ground validation testing. Deliverables will be used as input for future ESA standard related to optical assembly testing.
- In Orbit Demonstration (IOD) with HERMOD since May 2013.

GSTP: General Support Technology Programme
STRIN: Stategic Initiatives activities
HERMOD: High dEnsity space foRM cOnnector Demonstration (Messenger in Norse mythology)

High density connector selected:
12 optical fibers MPO type



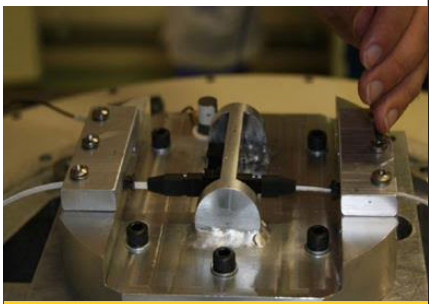
Components and Harnesses Testing

The fiber optical connectors, cables and harnesses have gone through two years of extensive testing:

- High temperature stress tests: +150°C
- Low temperature stress tests: -145°C
- Temperature cycle tests: -50°C to +100°C over 1000h
- Vibration tests: 35,4, 50 and 60 gRMS in 3 axis
- Radiation tests: 1Mrad

Radiation test

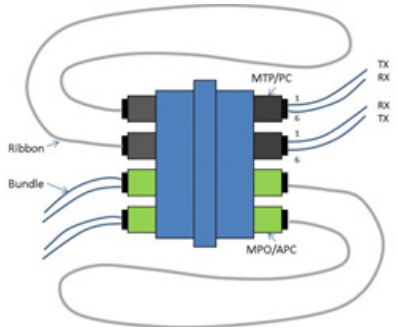
Low temperature test set 10-9 Bar liquid nitrogen



Vibration test

HERMOD Main Objectives

- In the frame of Proba-V In Orbit Demonstration, the Proba-V team proposed an unique opportunity to embark a last Technology demonstrator (5th) on-board of Proba-V.



Links including combination of MPO/ MTP connectors, polished PC or APC, ribbon or bundle cable solution.

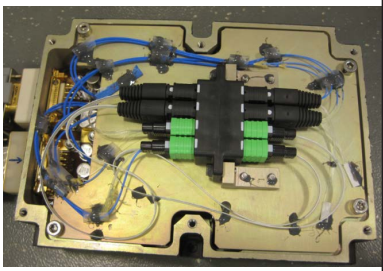
Proba-V satellite in assembly with HERMOD Photo: ESA

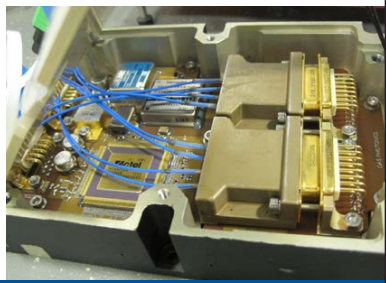
Very demanding 6 month challenge (design, manufaturing, validation and integration):

- Validate in orbit high density optical cable assembly (MTP/MPO)
- Build Space heritage for fiber optical cable communication transmission
- Confirm the ongoing on-ground evaluation activity performed on different high density assembly during a parallel GSTP activity.
- In-flight feedback on the evaluation of the degradation of the optical links by monitoring the Bit error rates of the different optical channels.

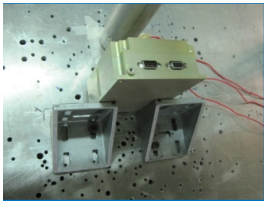
HERMOD Experiment Description

- 2 similar modules: **EBB** (validate design through functional and compatibility testing), **PFM** (validation testing and integration).
  - differences: EEE parts with lower quality level for the EBB in order to re duce procurement time.
  - T&G: in charge of the manufaturing of the optical assemblies.
  - DAS Photonics: electronic, SIOS modules and EBB-PFM assembly.
- Manufacturing performed according DML, DPL, DCL approved by ESA.
- EEE components: space grade level.
- Opto-parts SIOS modules: selected based on a previous as sessment study in preparation of the Alphasat project TDP8.
- Optical cable assembly processes (optical cable assembly, fiber splicing, cable routing,..) and selection of parts: previously validated on ground by T&G (GSTP).
- PCB manufacturing and mounting of the EEE components, ESA certified companies: Printca and Matra Electronique.





Overview Project Qualification Activity

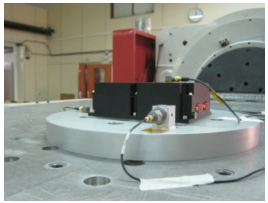


Shock

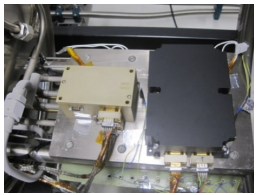
Evaluation of cable assembly

Validation of HERMOD

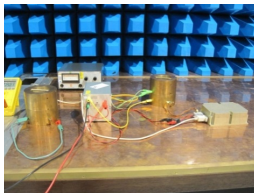
Model	Visual inspection	Functional tests	Shock	Vibration (Sine and random)	TVC	EMC	Compatibility testing
Optical assembly	MPO-01	MPO-02	MPO-03	MPO-04	MPO-05 (TC)		
EBB	EBB-01	EBB-02	EBB-03			EBB-04	EBB-05
PFM	PFM-01	PFM-02		PFM-03	PFM-04		PFM-05



Vibration



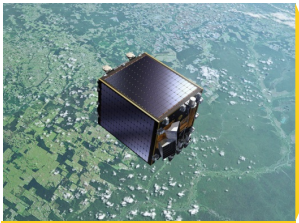
TVC



EMC

Integration

First Results



Data 5 technological payloads + platform information

Downlinked S-band channel

Redu-3 Ground Station Belgium

Data de-commuted

Mission Control Center (Redu)

Secured Webserver

Script (run on daily basis)
Download, Extract data, convert, concatenate in a single file

Liftoff of Vega VV02 on May 7, 2013 with HERMOD
Photo: ESA

Time stamp	Year	Day	Hour	Minutes	Board status	Ch1 errors	Ch2 errors	Ch3 errors	Ch4 errors	Date (timestamp)	Date (polling time)
648355.0753	0	7	12	6	1	0	0	0	0	14/5/13 17:02	14/5/13 17:02
648415.0749	0	7	12	7	1	0	0	0	0	14/5/13 17:03	14/5/13 17:03
648475.0773	0	7	12	8	1	0	0	0	0	14/5/13 17:04	14/5/13 17:04
648535.0746	0	7	12	9	1	0	0	0	0	14/5/13 17:05	14/5/13 17:05

Board status equal 1

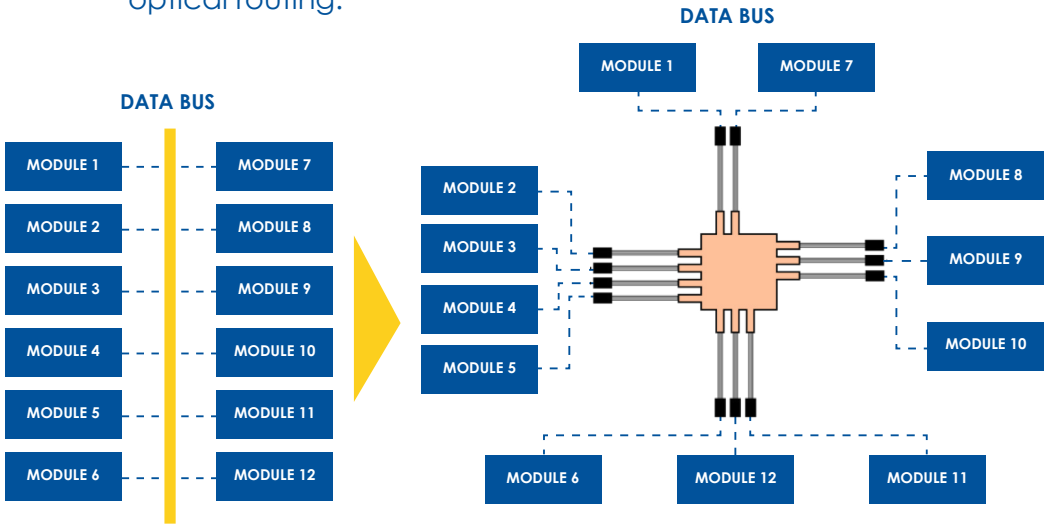
- No errors in the channels
- Polling time 1 minute
- Coherence in the different dates (timestamp, polling time, file date on the server).

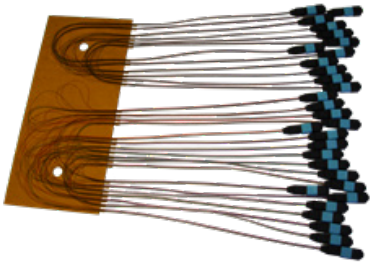
Confirmation HERMOD working correctly

Fiber Optic Circuit Board

Fiber Optical Flexible Routing Assembly (FOFRA)
T&G's new product to solve complex and compact fiber optical routing:

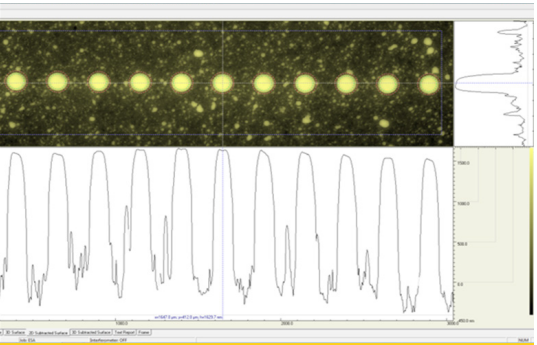
I²C and FPGA
Data Transmission



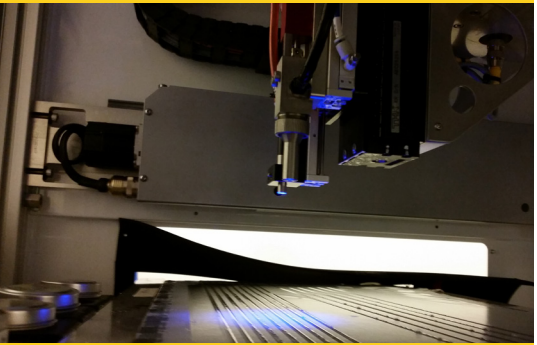


FOFRA with 180 channels/
360 contact points

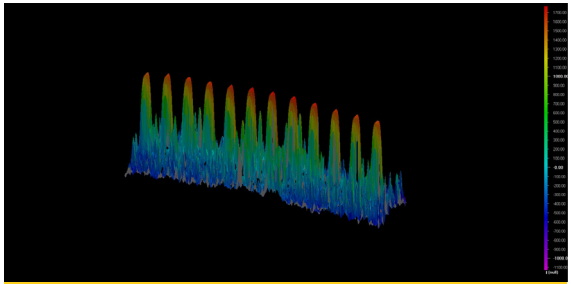
Production and Measurement



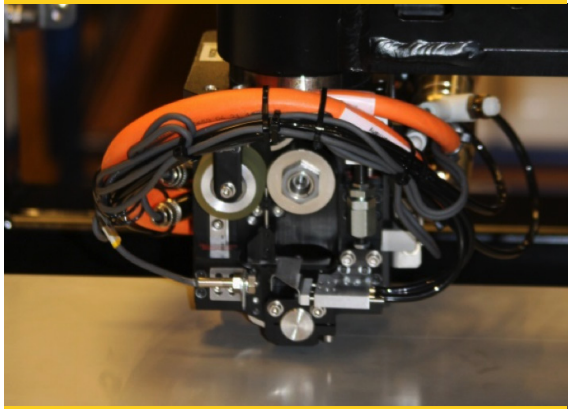
Interferometry measurement 2D



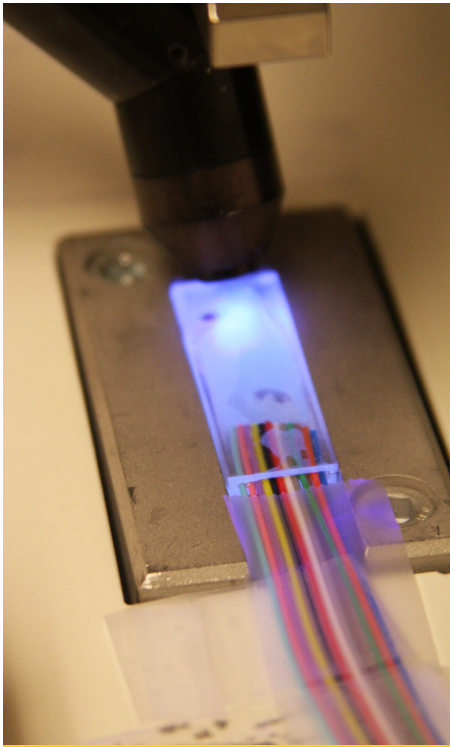
Fiber ribbonizing



Interferometry measurement 3D



Fiber routing



Splitting element

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