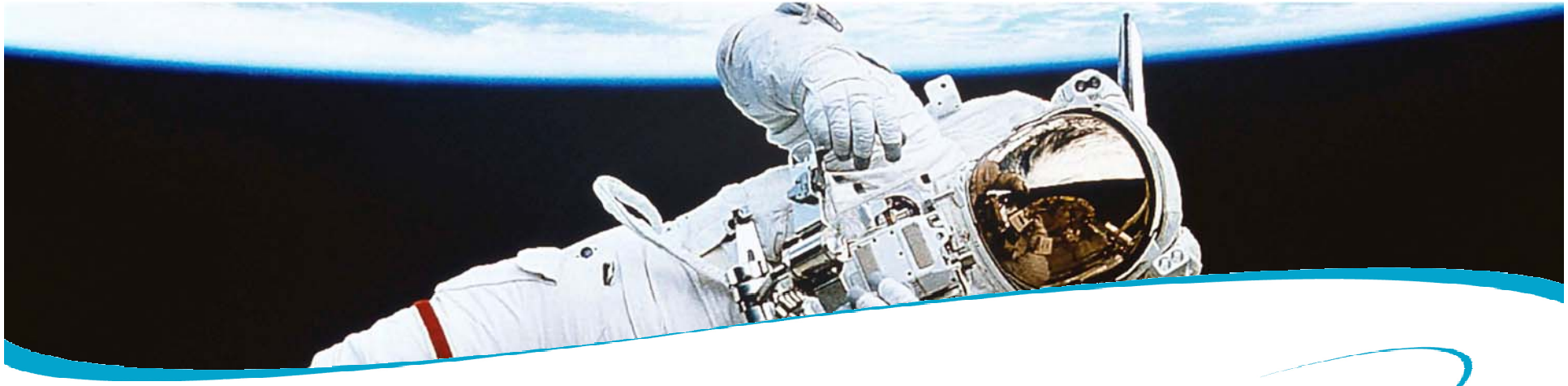

Optoelectronics: risk management of problems encountered

A. Bensoussan

Thales Alenia Space, France

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ESCCON 2011, NOORDWIJK, NETHERLANDS
March 15th-17th 2011

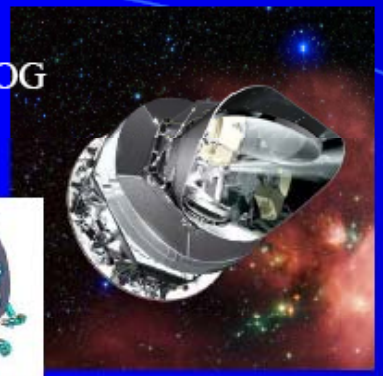
Template reference : 100181685K-EN

Content

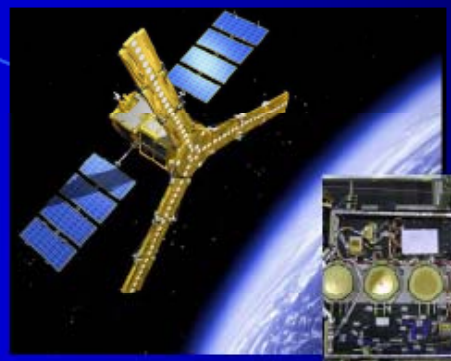
- Optical Links in Space Application
- Industrialization and Quality concerns vs Risk management
- Optoelectronic vs Reliability
- Conclusion

Optical Links in Space Application

Planck - FOG



SMOS – Optical Comms
Data and Clock Distribution



Current Applications of Fibre Optics

Demeter - Optopyro

ISS - Optical Communications

PROBA 2 – Fibre Optic
Sensor Network

esa ESTEC

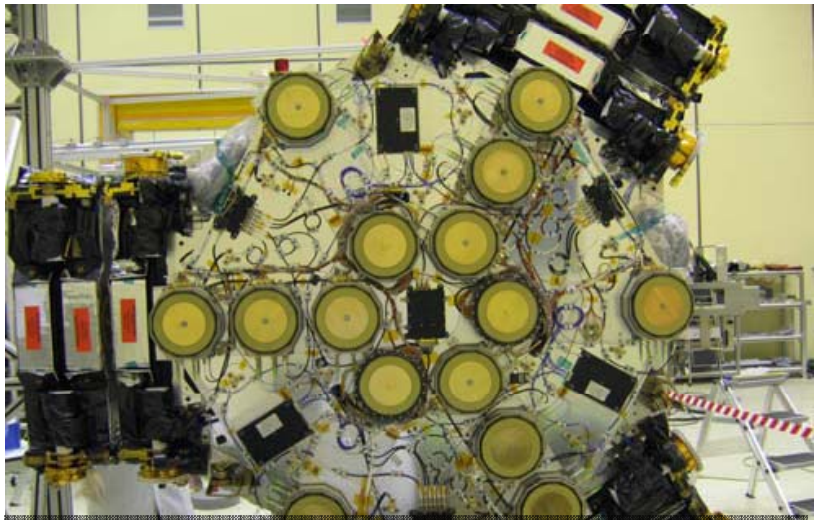
(courtesy of ESA : Iain Mckenzie and Nikos Karafolas)

Optical Links in Space Application

- **COTS Fibre Optic Components in SMOS/MOHA (ESA)**

ESA's Soil Moisture and Ocean Salinity (SMOS) earth observation satellite using fibre optics.

(photos with the courtesy of ESA: S. Hernandez)

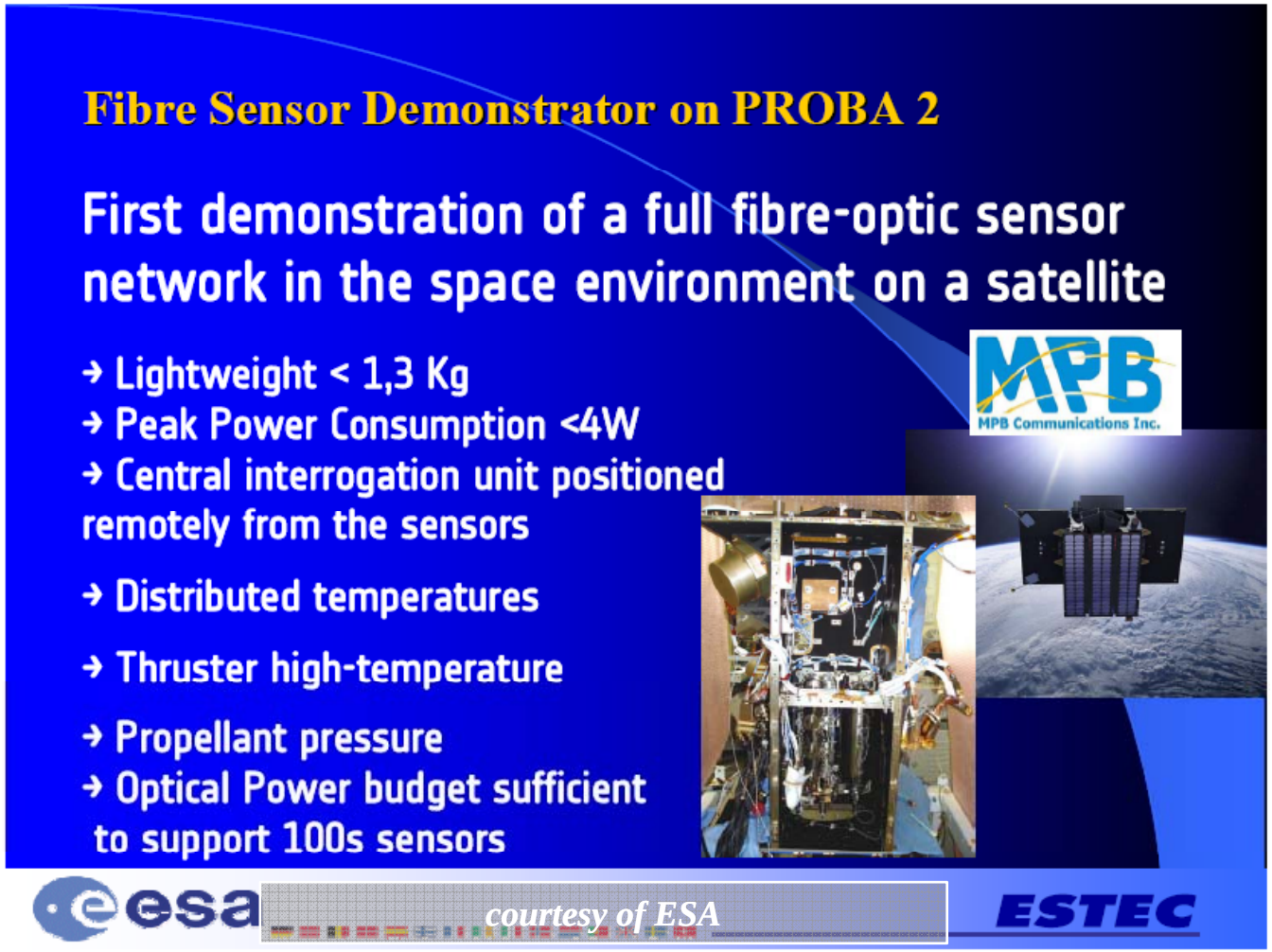


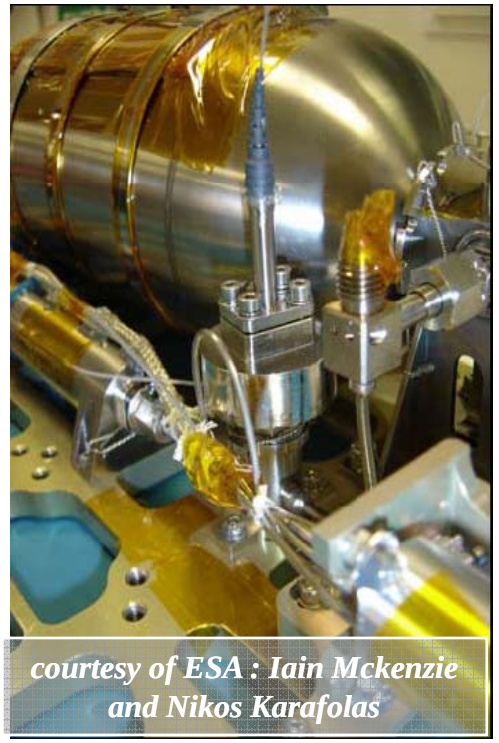
The 3-branches radiometer of SMOS encompassing more than 800 m of optical fiber

The optical fibre is used to communicate with the 72 detectors spread over the three arms of the satellite, conveying an optical clock to the detectors and returning a digital optical data signal to the digital correlator.

Optical Links in Space Application

- **Fiber-Optic Sensor System Demonstrator for Proba-2 (ESA)**





courtesy of ESA : Iain Mckenzie and Nikos Karafolas

Attachment of FOS in the tank and pipes of the Propulsion Subsystem of ESA's PROBA II satellite.

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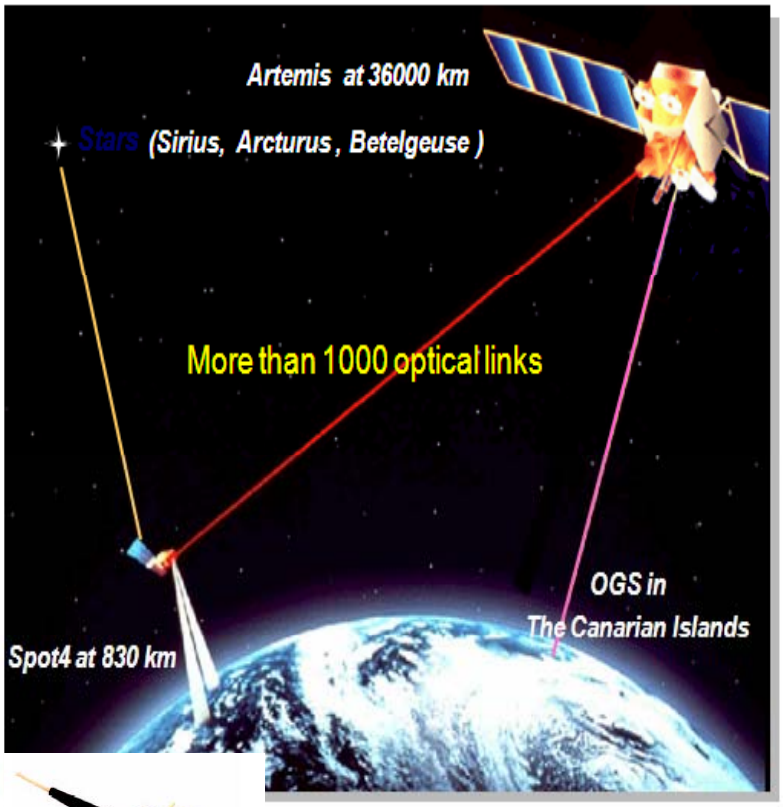
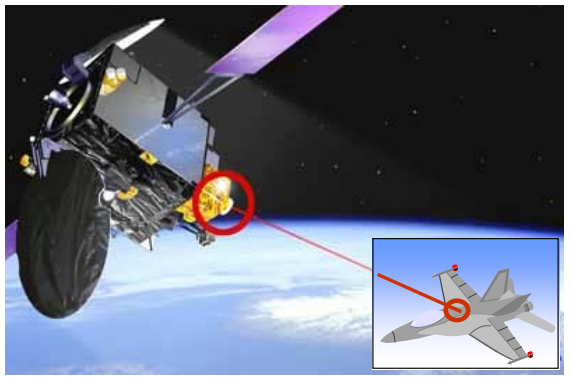
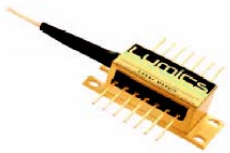
Optical Links in Space Application

- **High Bandwidth 0,85 µm laser Free Space Communication on ARTEMIS SILEX (EADS) and LOLA application (EADS, TAS)**

View SILEX Free Space Communications (courtesy EADS Astrium)





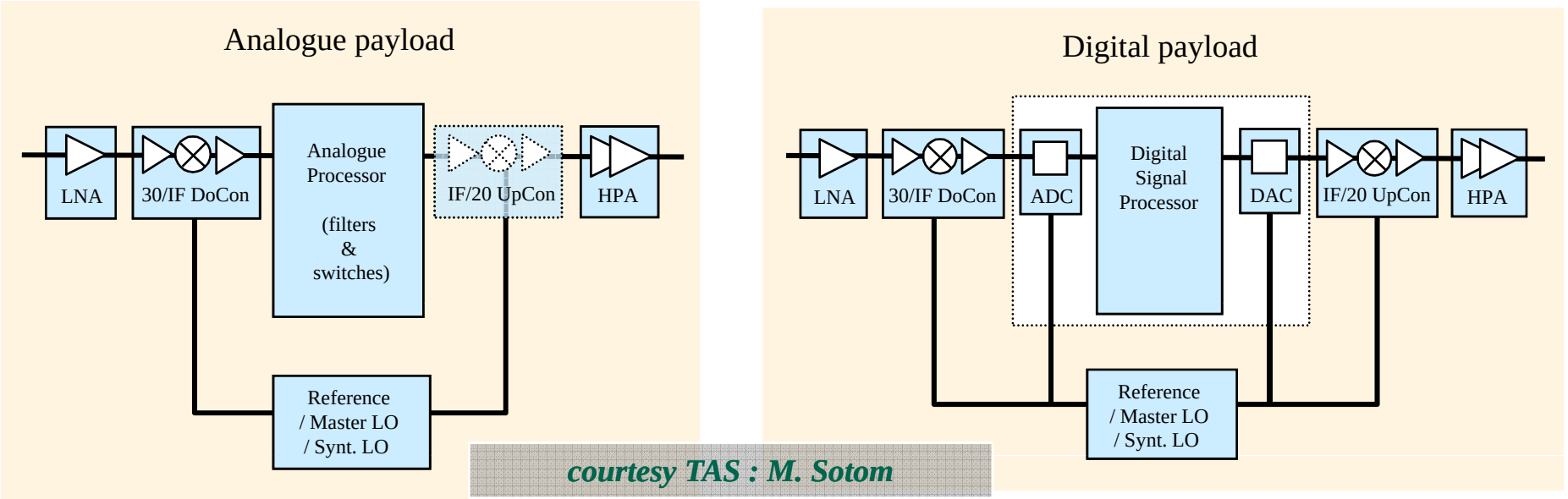


LOLA demonstrator laser diode : Operating conditions: 320 mW p-p, OOK, 50 Mbps

Advanced Photonic for Flexible Telecom payloads

Telecom satellite & payloads - Future Broadband Solutions (TAS)

- flexible complex payloads : coverage, connectivity, frequency plan, bandwidth allocation …
- > 100 RF channels (10's of MHz) over 10's of antenna beams
- critical requirements in terms of mass, volume & power consumption
- future-proof solutions = transparent payloads (analogue or digital)



courtesy TAS : M. Sotom

Advanced Photonic for Flexible Telecom payloads

• Microwave photonic repeater sub-systems (TAS)

Microwave photonic repeater concept

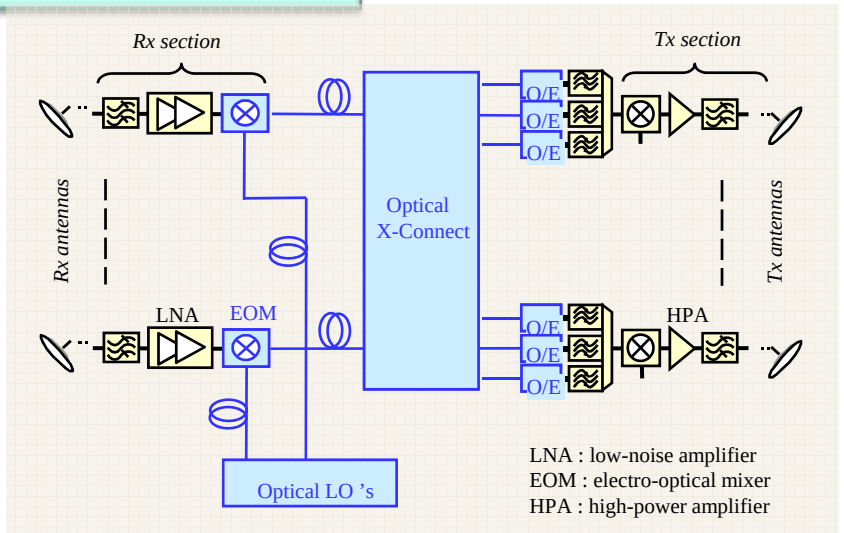
- optical generation & distribution of LO's
- optical frequency-mixing
- optical cross-connection of µ-wave signals

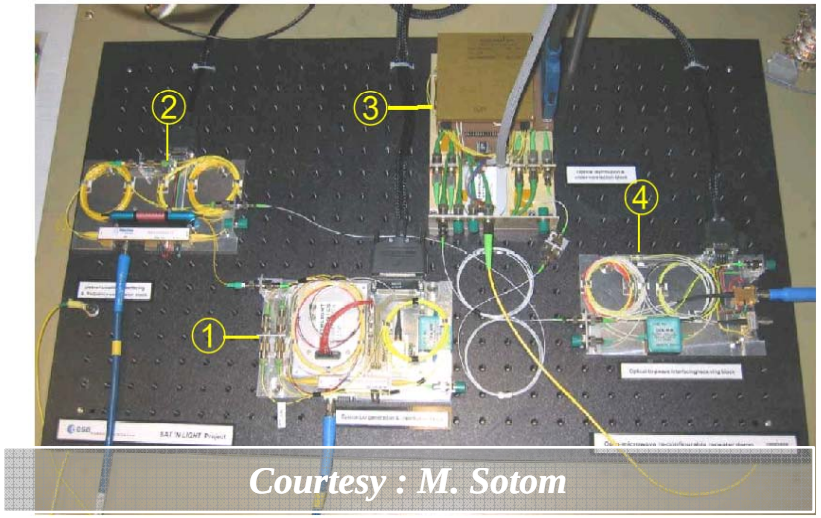
Applications : flexible analogue repeater

- Frequency-independent (C/Ku/Ka), broadband design : cost and planning advantages
- Flexible connectivity : in-orbit reconfiguration

Major achievements

- ESA *SAT 'N LIGHT* study, repeater concept & architectures
- BB demo
  - Ka-band LO distribution
  - Optical Ka/C down-conversion
  - RF channel cross-connection (by MOEMS)
- Validation of concept & performance



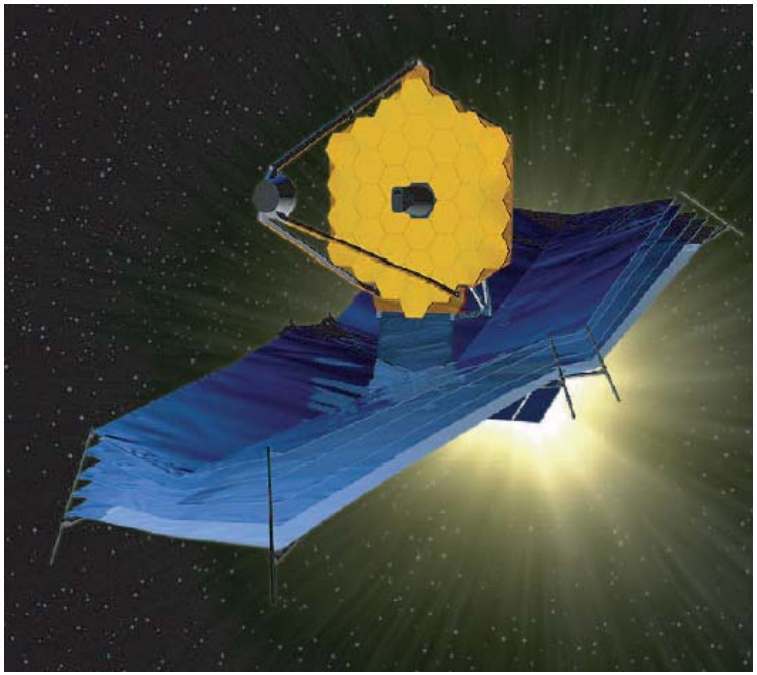


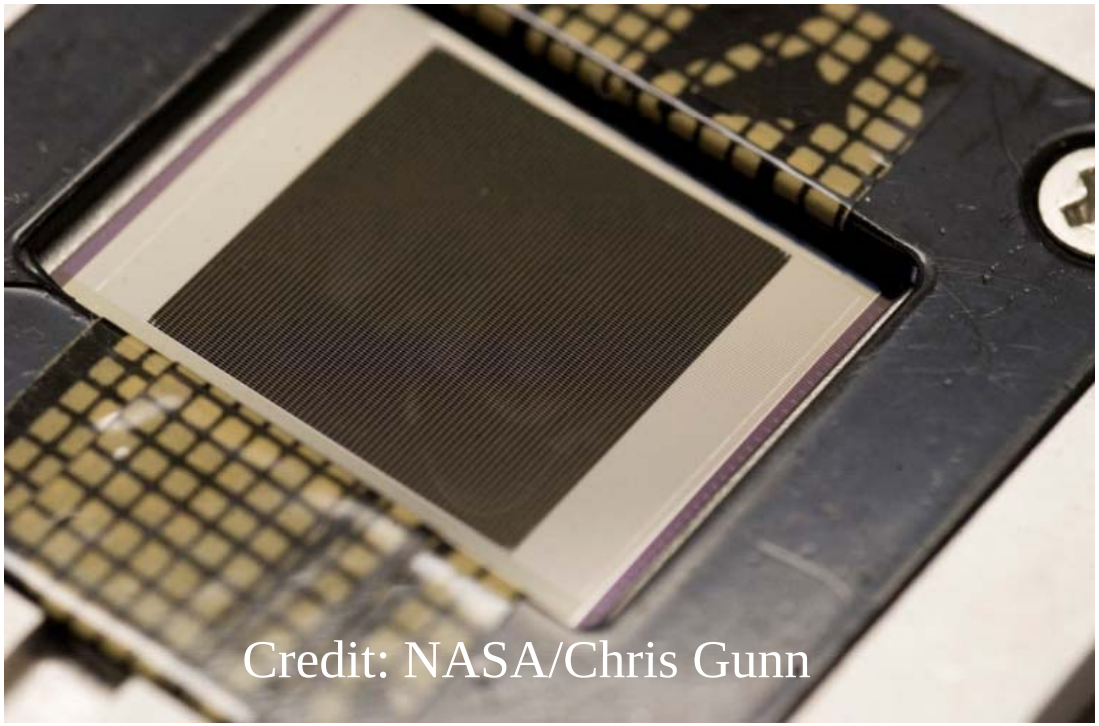
THALES

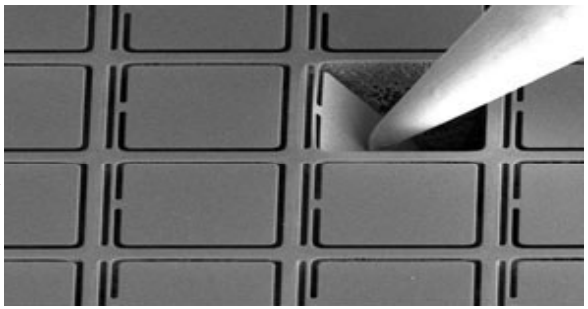
Optical Links in Space Application

In USA

- **JWST (NASA) and Smart technologies and MOEMS for Extremely Large Telescope (ELT) instruments (NASA).**





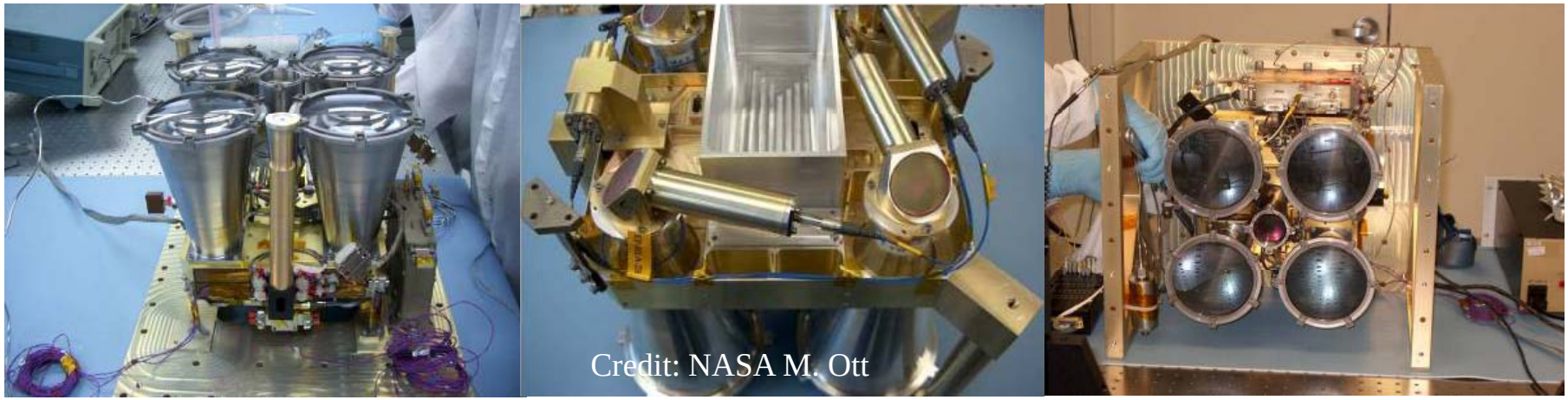


Micro-shutters manufactured by NASA/GSFC

http://www.nasa.gov/topics/technology/features/microshutters.html

NASA Lunar Reconnaissance Orbiter (NASA GSFC)

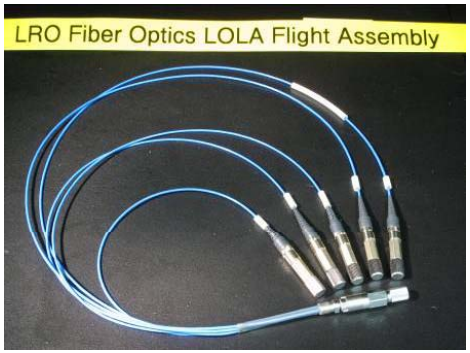
Series of missions towards the exploration of the Moon and Mars for the purpose of providing remote human habitat bases for planetary study



The Mercury Laser Altimeter consisted of four telescopes with fiber coupled from each to four individual detectors

Lunar Orbiter Laser Altimeter (LOLA) and Laser Ranging

Photos from paper M. Ott : Fiber free Space Optics.



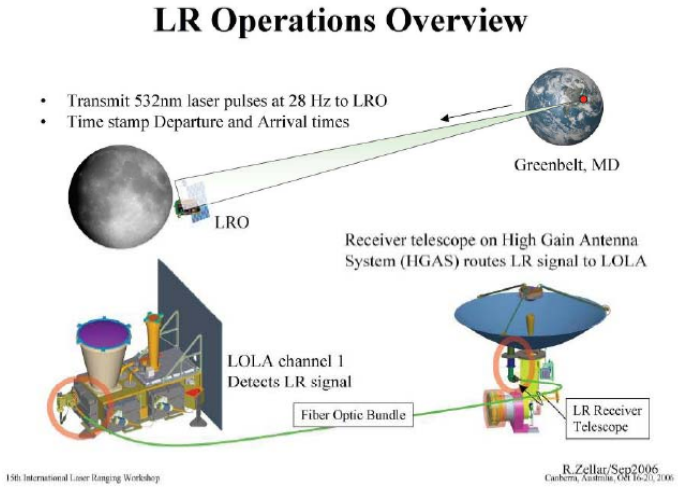
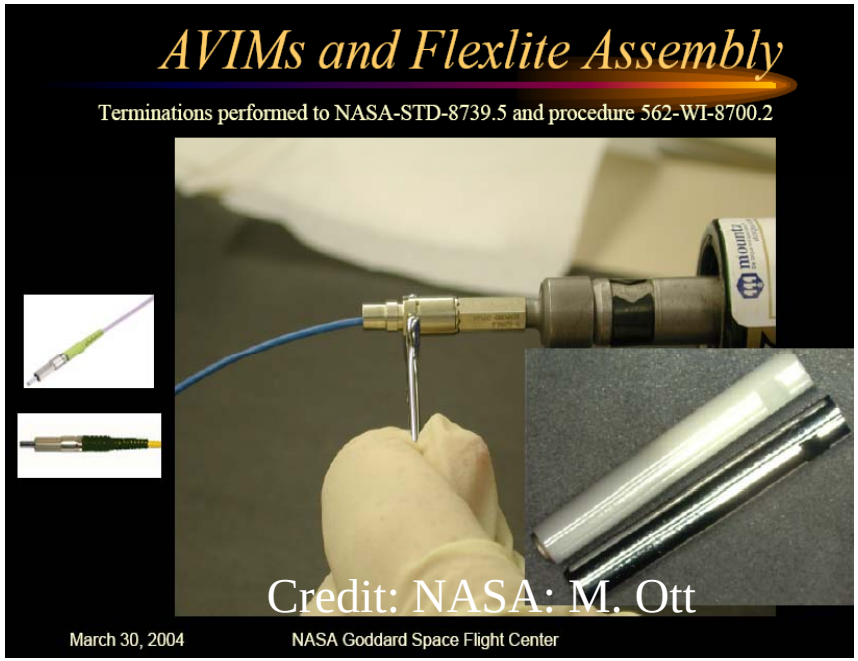


Fig. 7. LRO Laser Ranging Configuration Concept [11]

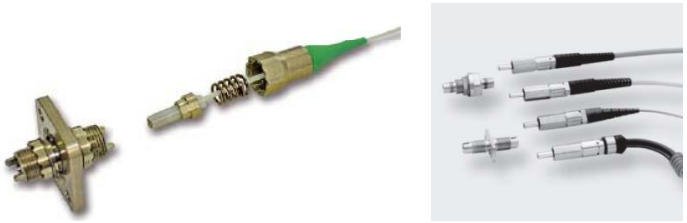
Optical Links in Space Application

DIAMOND AVIM Connectors for Space Environments (NASA and ESA)



Mini-AVIM

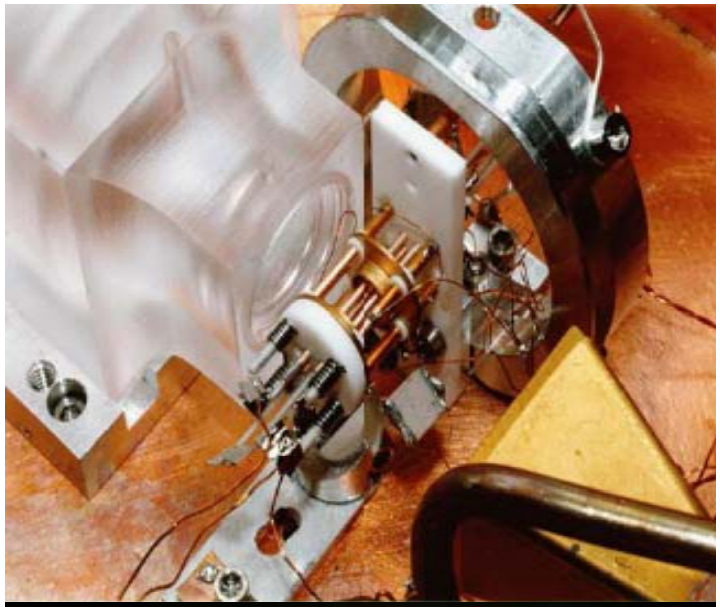
Miniature fiber optic connector for Space, MIL and harsh environment application

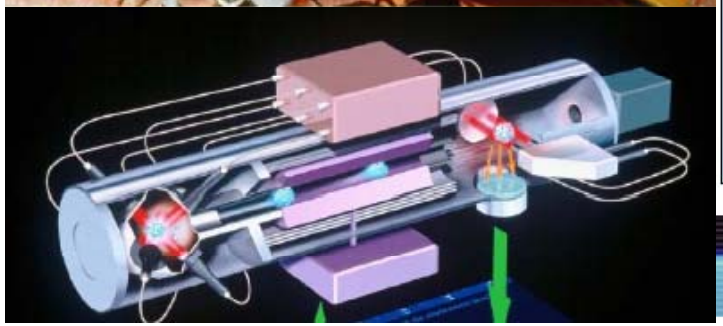


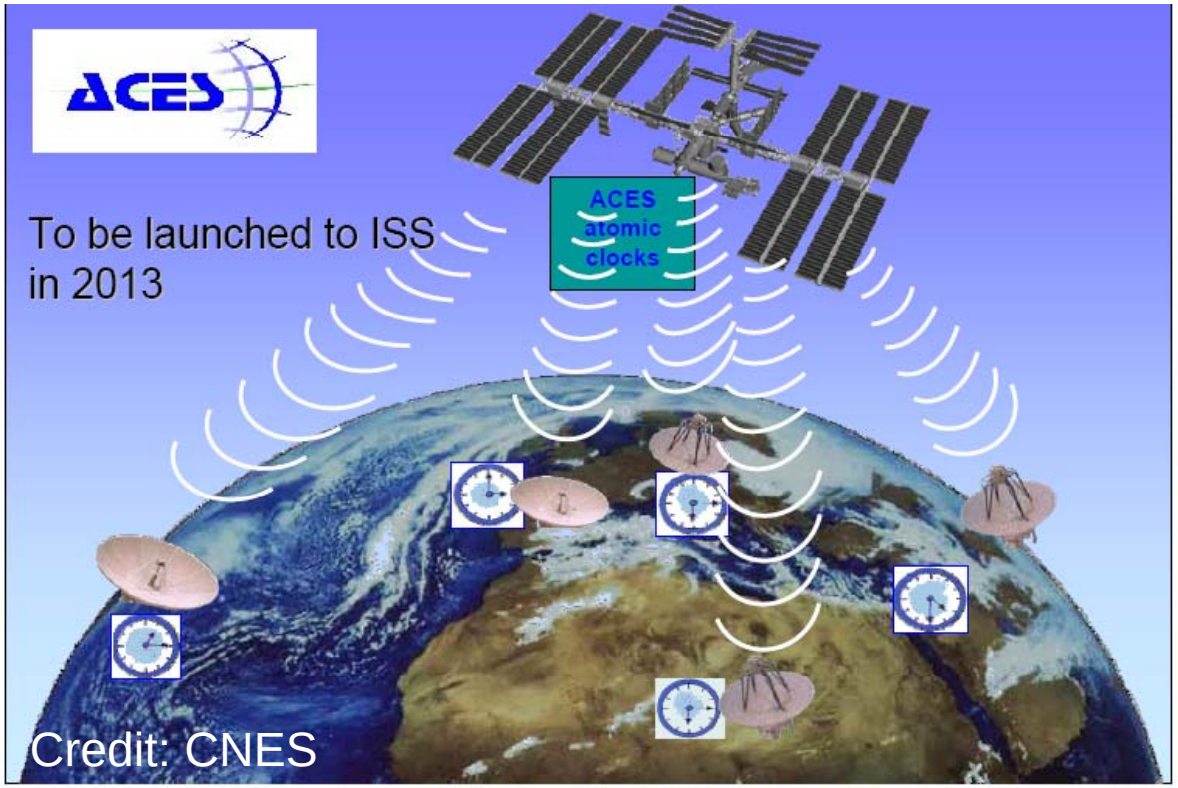
- Basic Specification ESCC 2263010, ETP for Simplex Optical Fibre Connector Sets released in 2006.
- Part of an ongoing ECI Phase 2 activity with Diamond (Switzerland), following specification will be proposed to the PSWG in 2011:
  - Revision and updating of the **ESCC Basic Specification 2263010**
  - **Generic Specification** (ESCC qualification): Simplex fibre optical connector.
  - **Detail Specification**: Simplex optical fibre connector based on type AVIM.
  - **Detail Specification**: Simplex optical fibre connector based on type mini-AVIM.
- In the frame of 2 parallel ongoing GSTP activities T&G (Norway) and Fibre Pulse (Ireland), the ECSS-Q-TM-70-51 Technical Memorandum on the fibre cable assembly will be updated (2011-2012).

THALES

Qualification of a Caesium optical atomic clock in Pharao (EADS SODERN/CNES)







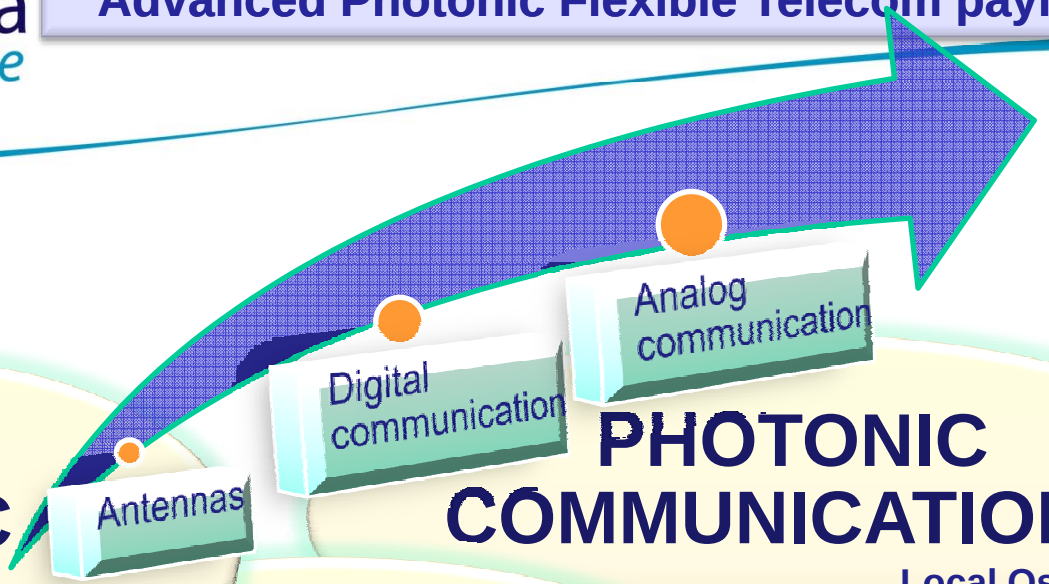
esa

- A cold atom Cesium clock in space
- Fundamental physics tests
- Worldwide access

cnes
CENTRE NATIONAL D'ETUDES SPATIALES

THALES

The key optical areas in Telecom application payloads : Advanced Photonic Flexible Telecom payloads



PHOTONIC SENSING

Structural Panels and Equipment
Antenna Reflectors
Direct Radiating antenna
Chemical propulsion
Electric propulsion
Fiber Optic Gyroscopes

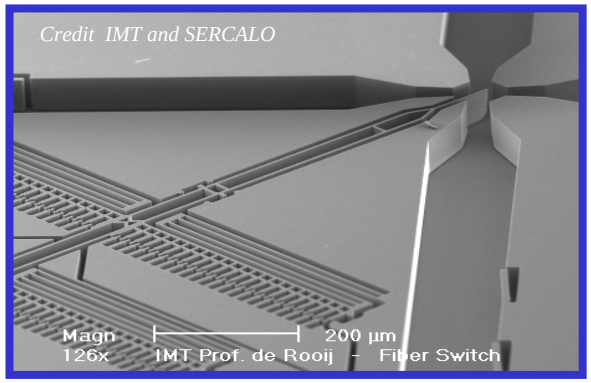
PHOTONIC SIGNAL PROCESSING

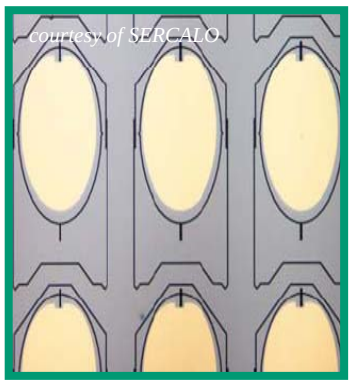
Equipment to equipment interconnects
Inter or intra-board interconnects
Inter or intra-chip interconnects
ADC to DSP and DSP to DAC interconnects
Electro-photonic fast sampling
Ultra-fast switching (ns switching time) for packet/burst switching

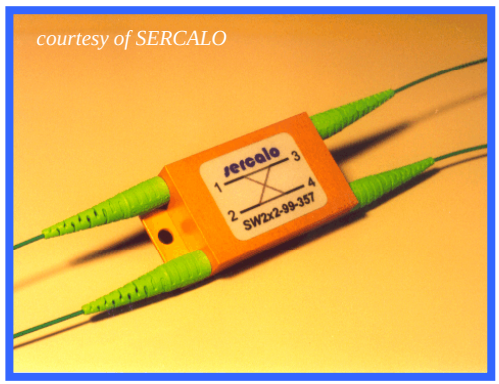
PHOTONIC COMMUNICATIONS

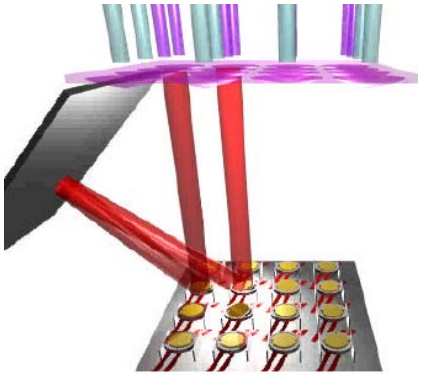
Local Oscillator Generation
Down Conversion
Switching
Analog to Digital Conversion
Beam Forming
Novel Photonic payload architecture concept
Opto-microwave transparent analog repeater

KEY OPTICAL TECHNOLOGIES AND PRODUCTS

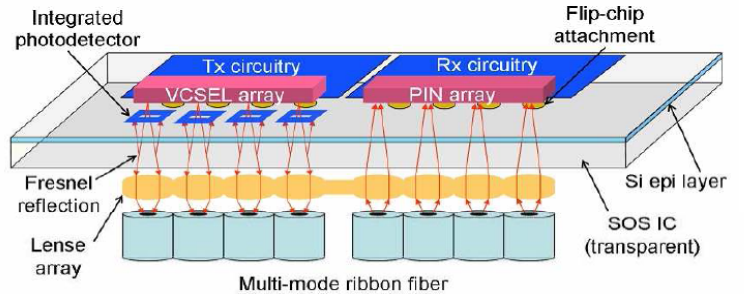


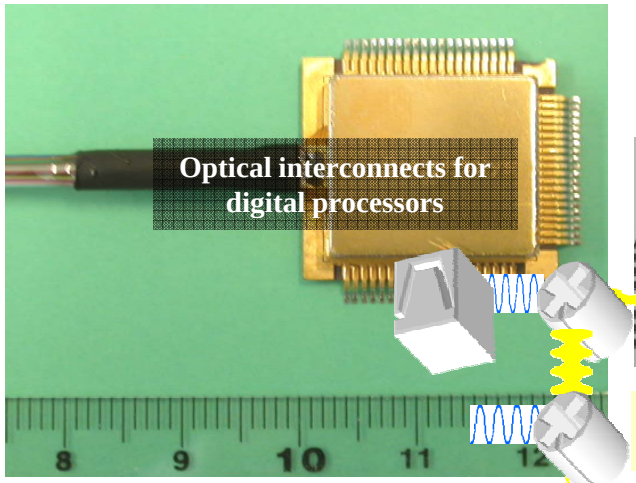


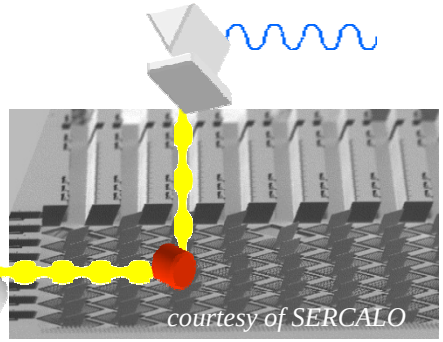




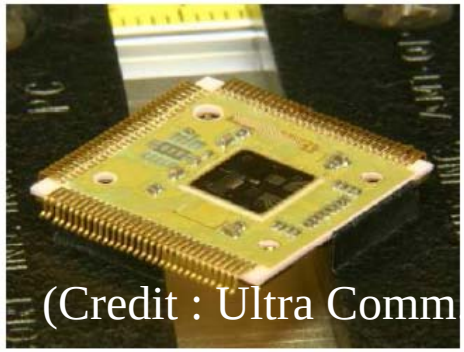
courtesy of LUCENT Technology

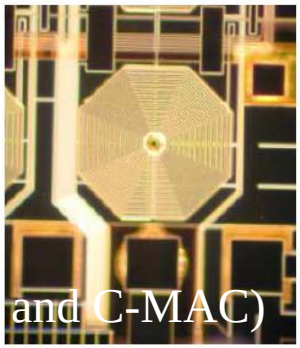






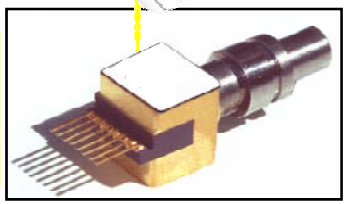
Opto-Microwave Repeater concept
MOEMS switching matrix





(Credit : Ultra Comm and C-MAC)

Flip-chip assembly with the flip-chip VCSEL/PIN .



ROSA photo-receiver

THALES

Optoelectronic innovative payloads.

Who is going to use Optoelectronic system architectures as innovative solutions and for what specific and strategic reasons ?

How to be ready to adopt new technologies ?

- In High tech, products are often more costly and complicated
- Therefore market adoption of a technology product is dependent upon helping customers reduce perceived risk.
- In the risky world of high tech, the customer will not rely only on the word of the provider.

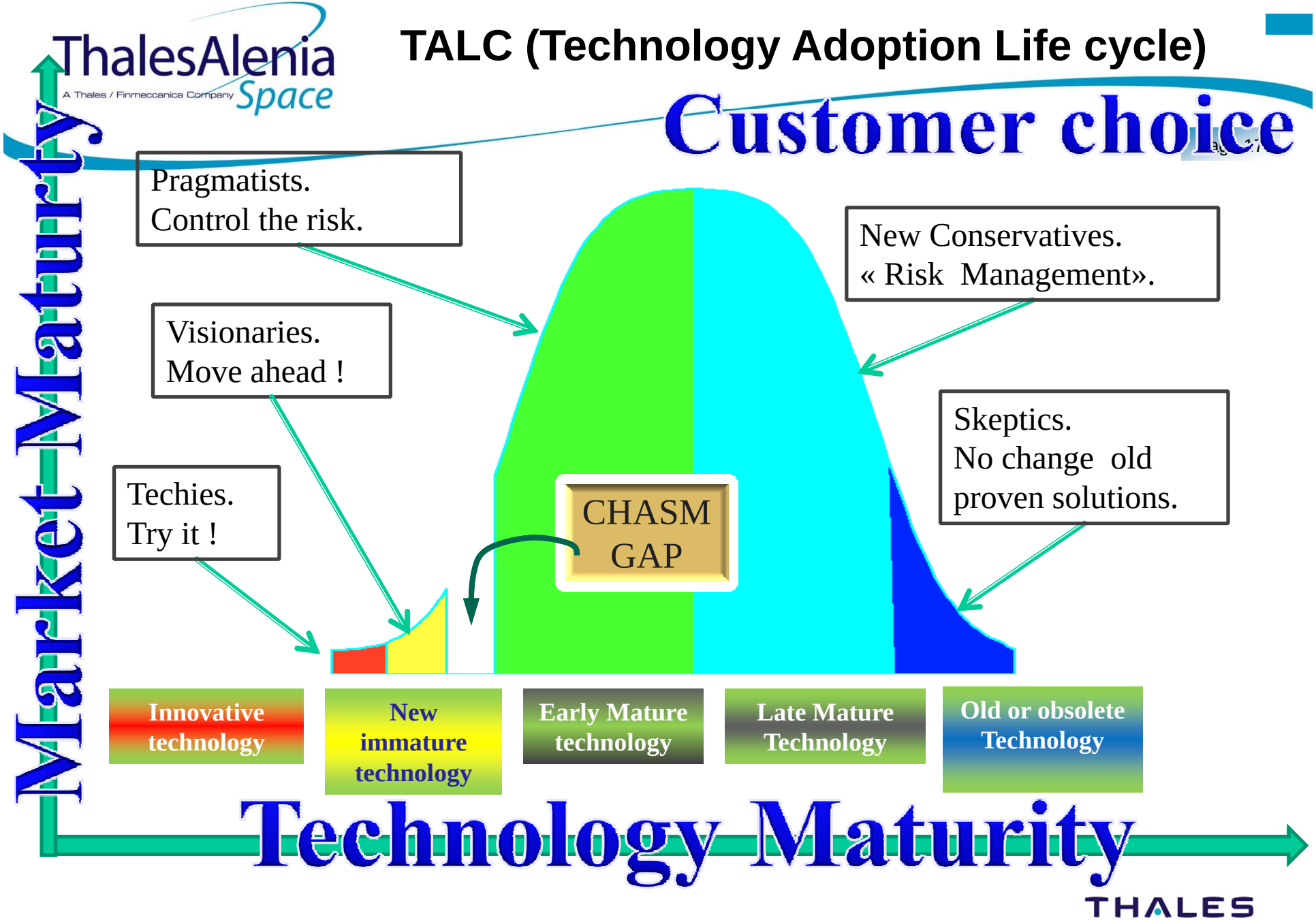
These new technologies are disruptive for Space application.

How to manage their introduction ?

The TALC (Technology Adoption Life cycle)

in the High-Tech Space market.

TALC (Technology Adoption Life cycle)



Discontinuous innovations require an infrastructure to prosper and proliferate.

Discontinuity has significant (and sometimes unintended) consequences.

Proven benefits

Existing infrastructure

New Benefits

New infrastructure

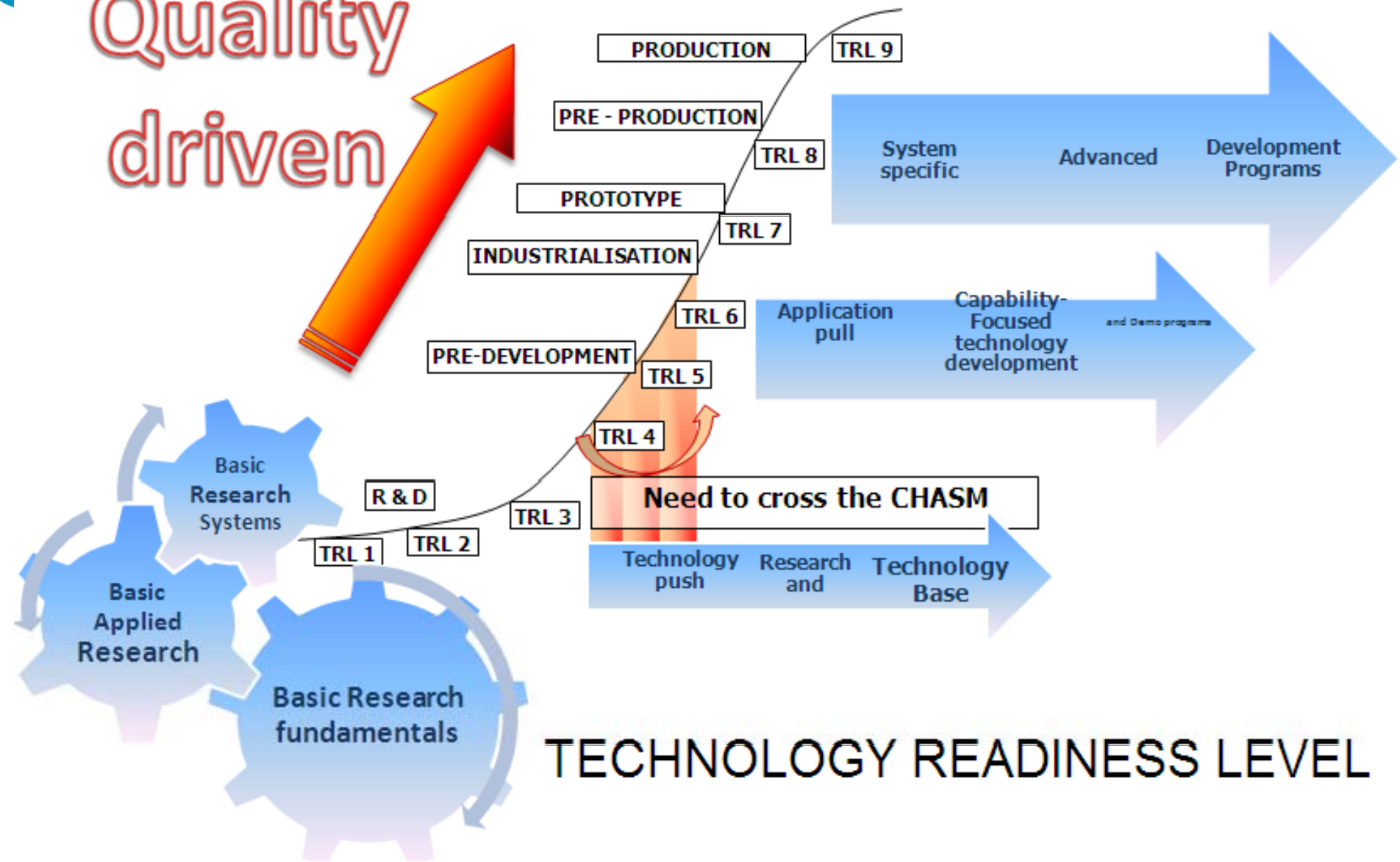
Discontinuous innovations foster new power structures … *if they get adopted.*

HOW, WHO, WHEN TO MANAGE SUCH DISCONTINUOUS INNOVATIONS ?

All is about risk assessment: TALC and Valley of Death version applies to discontinuous innovations, meaning the product forces the user to change behaviour.

ThalesAlenia Space
A Thales / Finmeccanica Company

Quality driven



How to adopt new technologies ?

Customer's decision process is based on finding objective information from reliable sources, something the vendor cannot provide.

Have you ever had someone call and ask you what kind of computer to buy ? This is a common method of lowering risk by gathering objective evidence.

Industrialization concerns

Quality constraints

We must consider :

- **THE COMPLEXITY AND VARIETY OF PRODUCTS OR FUNCTIONS**
- **HIGH TECHNOLOGY LEVEL PRODUCTS (from micro-electronics, Quantum Physics, Photonics, interaction light with matter (2D and 3D)),**
- **RAPID EVOLUTION OF THE TECHNOLOGIES AND PRODUCTS**
- **CONSTRAINTS AND STRESS ENVIRONMENTS (Thermal management, radiation, vacuum, mechanical including vibration and acceleration, …)**
- **BUILT AND DESIGN INNOVATIVE APPLICATIONS (new functions for new concepts, risk management, quality control and proof, design for performance and long term lifetime, …)**

Industrialization concerns
Quality constraints

For a pragmatic approach.

For what purpose ?

Which level of integration ?

On which parameters ?

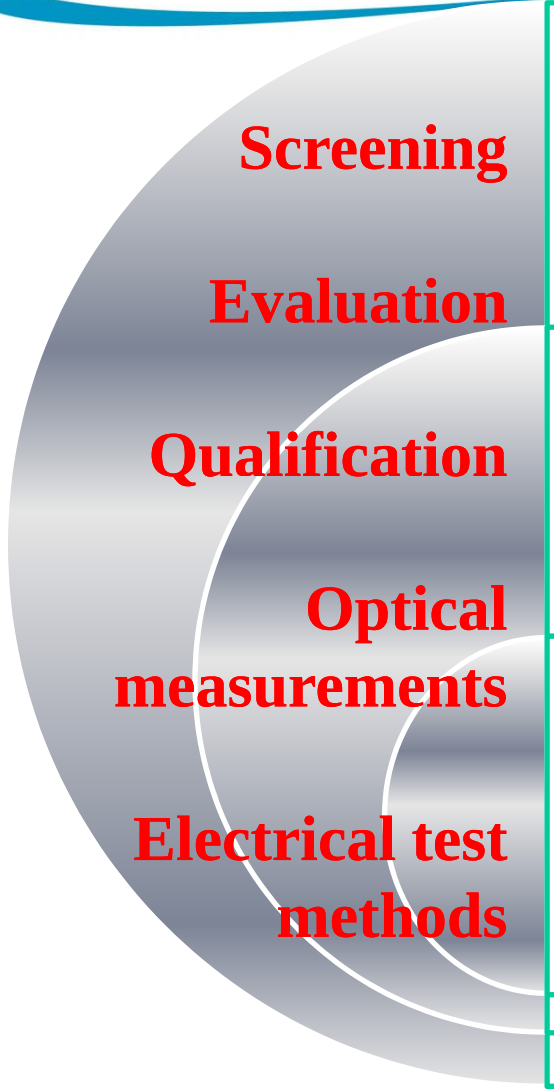
How to define stress conditions ?

Who will be responsible ?

Which methodology ?

Industrialization concerns

Quality constraints



SUB-SYSTEMS	• Lev 3 : Product qualification
MODULES	• Lev 1 : Endurance qualification • Lev 2 : Packaging qualification
ELEMENTS	• Lev 1 : Characterization and qualification • Lev 1 : Environmental qualification

Existing Quality assurance tools for Micro-Opto-Electronics

European Space Agency

- ECSS-Q-ST-60-05: Generic procurement requirements for hybrid microcircuits.

JEDEC

- JEDEC JESD49 Procurement Standard for Semiconductor Die Products Including Known Good Die
- JEP149 : Application Thermal Derating Methodologies
- JEDEC-13 committee approved formation of Fiber-Optic Test & Qualification for Harsh Environment Applications Committee - JEDEC 13.6/SAE Committee
  - ✓ Objective: Bring fiber optic community to a standards level enjoyed in the semiconductor marketplace – i.e. QPL/QML for fiber-optic components.

MILITARY

- MIL-PRF-19500, General Specification for Semiconductor Devices
- MIL-PRF-38534, General Specification for Hybrid Microcircuits
- MIL-PRF-38535, General Specification for Integrated Circuits Manufacturing
- MIL-STD-883 Microelectronics Test Methods, and Procedures,
- MIL-HDBK-781A: Handbook for reliability test methods, plans and environments for engineering, development, qualification and production.

OTHER

- TELCORDIA GR-468-CORE : Generic Reliability Assurance for Optoelectronic Devices used in Telecommunications Equipment

First step before to implement Quality and Reliability Standards is to collect best practices from Manufacturers, Industries, Agencies and Laboratories in an Optoelectronic and Reliability Handbook

To prepare Quality Standards assurance documents, it is needed :

- **to prepare an handbook document**
- **to synthesize and to present the best practices on design, testing, industrialization, usage, quality control and production on optoelectronic products for end-use in Space Application.**

A tentative was initiated to work on a common document titled :

“OPTOELECTRONICS and RELIABILITY HANDBOOK”

Today, this initiative was agreed to be enlarged and more deeply activated thanks to the effort of the existing Space community and supported by the CTB Photonics WG.

THALES

The guide is foreseen to be a high technical synthesis for :

- ✓ understanding the various aspects of Opto-Electronic devices
- ✓ behaviors under Space Environment constraints
- ✓ Semiconductor material properties and device structures along with the final products (Emitters, Receivers, Sensors, Opto-Electronic functions, passive Opto-Electronic functions)
- ✓ Performance and reliability aspects of Opto-Electronic devices.
- ✓ Failure mechanisms and analysis
- ✓ Quality assurance and qualification methodologies overview.

It will present in details Opto-Electronic device designs, packaging, development, manufacturing, industrializations, application usage, test and controls, screening sequences, qualification procedures and test methods, environment effects (Radiation, vacuum, thermal, mechanical, long term and end of life, …) and will help the reader to understand the means of developing suitable qualification plans and demonstrate high reliability equipment achievement using optoelectronic products.

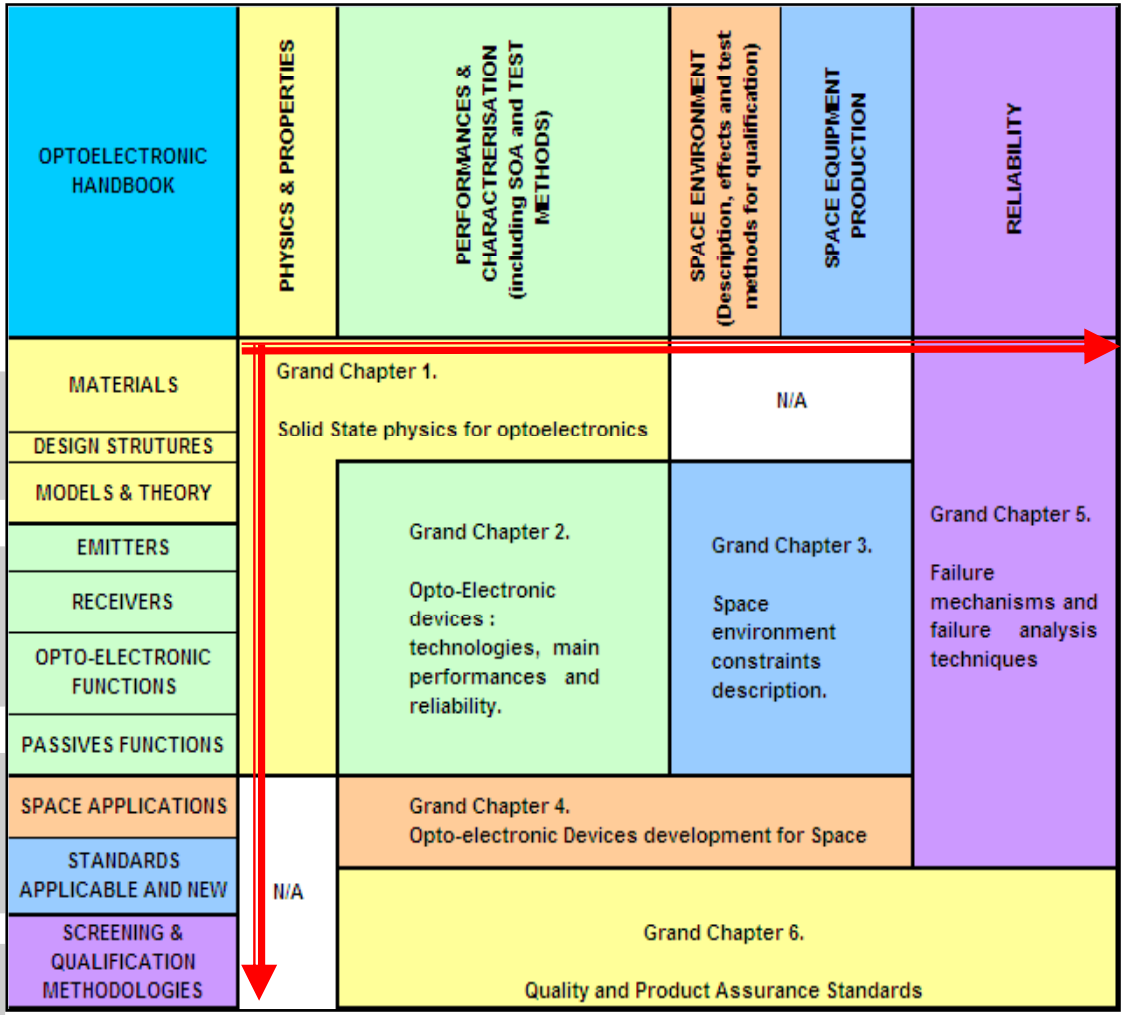
THALES

CONTENT OF THE HANDBOOK

The content of this handbook is composed of chapters written by the contributors acting as honorary, benefactor or active members.

Optoelectronic handbook

- Grand Chapter I — Solid State physics for optoelectronics
- Grand Chapter II — Space environment constraints description.
- Grand Chapter III — Opto-Electronic devices : technologies, main performances and reliability.
- Grand Chapter IV — Opto-Electronic Devices development for space
- Grand Chapter V — Failure mechanisms and analysis
- Grand Chapter VI — Quality Assurance Space Standards



Transverse thematics

Basic thematics

How to prepare this handbook ?

It is proposed a WIKI platform.

Open to anyone would like to participate in a partnership build up based on **ECM** : **E**nterprise **C**ontent **M**anagement : a collaborative platform open to all external partners.

A secured browser :

https://www-ecm.thalesaleniaspace.fr/ecm

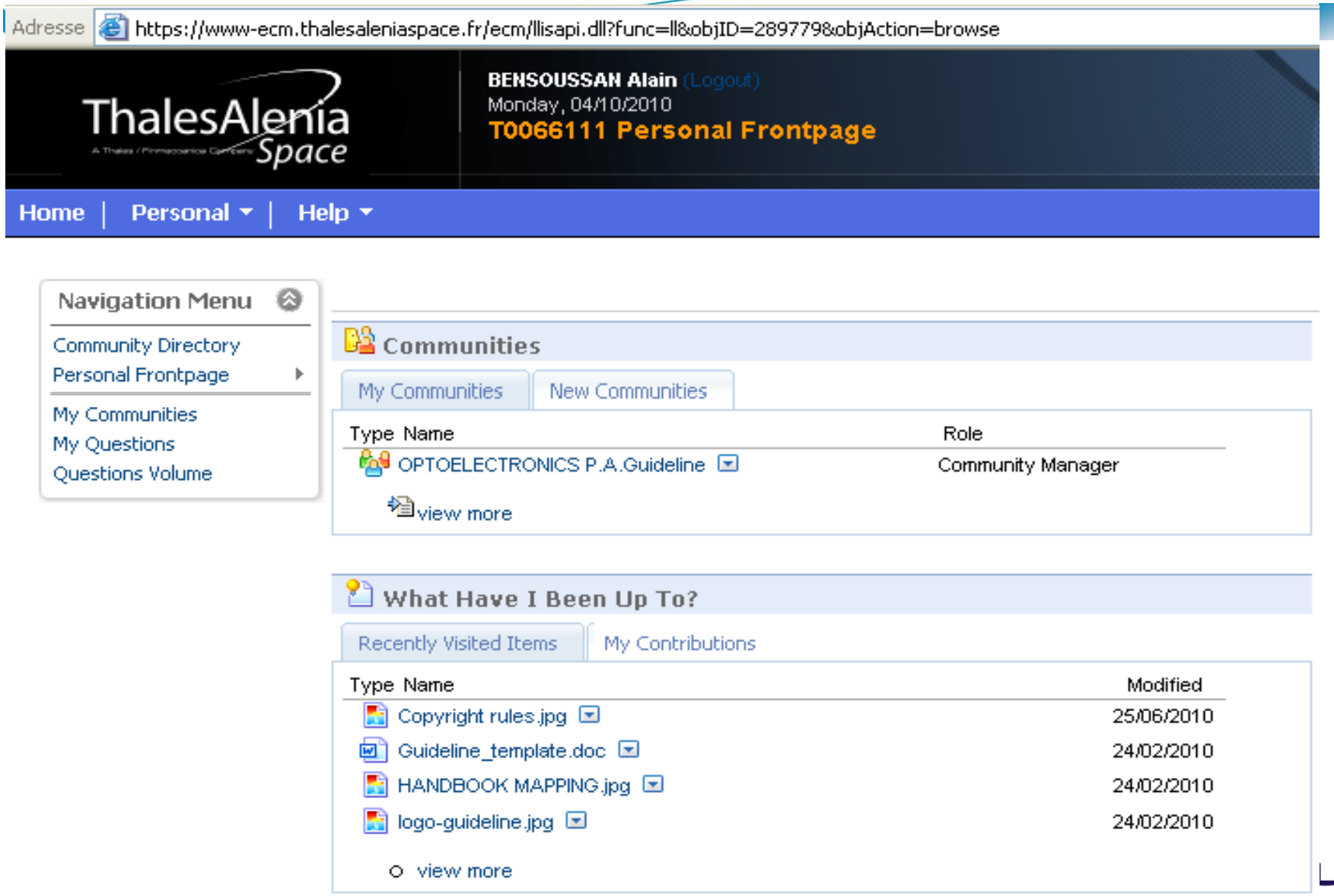
A secured browser :

https://www-ecm.thalesaleniaspace.fr/ecm

Please ask me for a free access, you will have a dedicated login and individual password attributed.

E-mail : alain.bensoussan@thalesaleniaspace.com

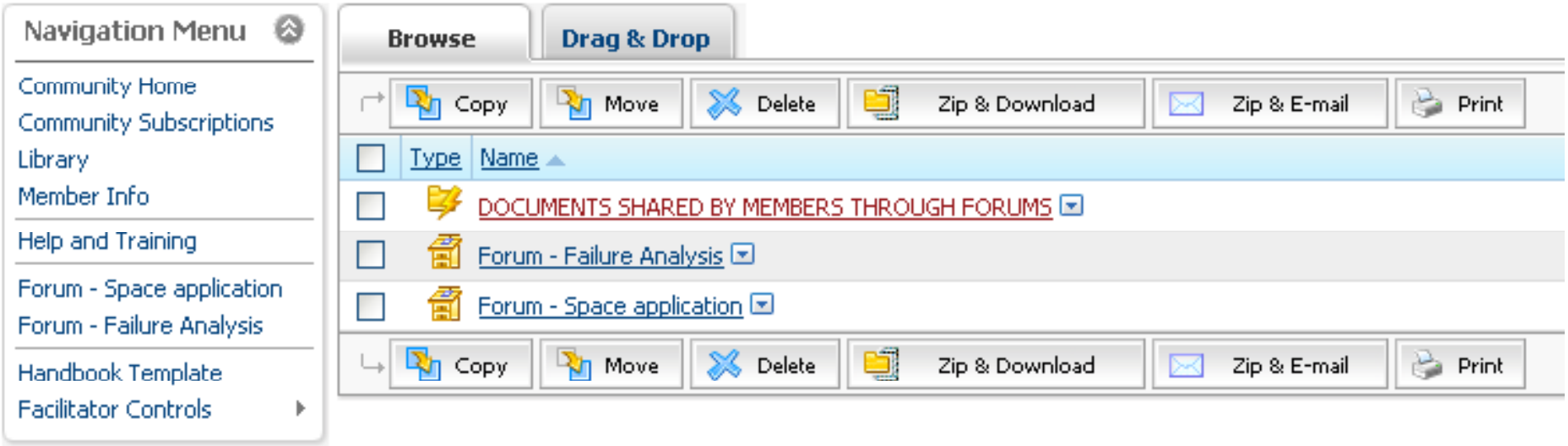
"OPTOELECTRONIC and RELIABILITY HANDBOOK"



Livelink ECM

NEW FORUMS will be implemented soon!

DOCUMENT SHARING PLATFORM



Conclusions

- Optical Links in Space Application
- Industrialization concerns and Risk management
- Quality and Reliability Needs
- Optoelectronic and Reliability handbook

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