Photonics for inertial measurement unit to guide the future, European space missions to the Moon, Mars and beyond

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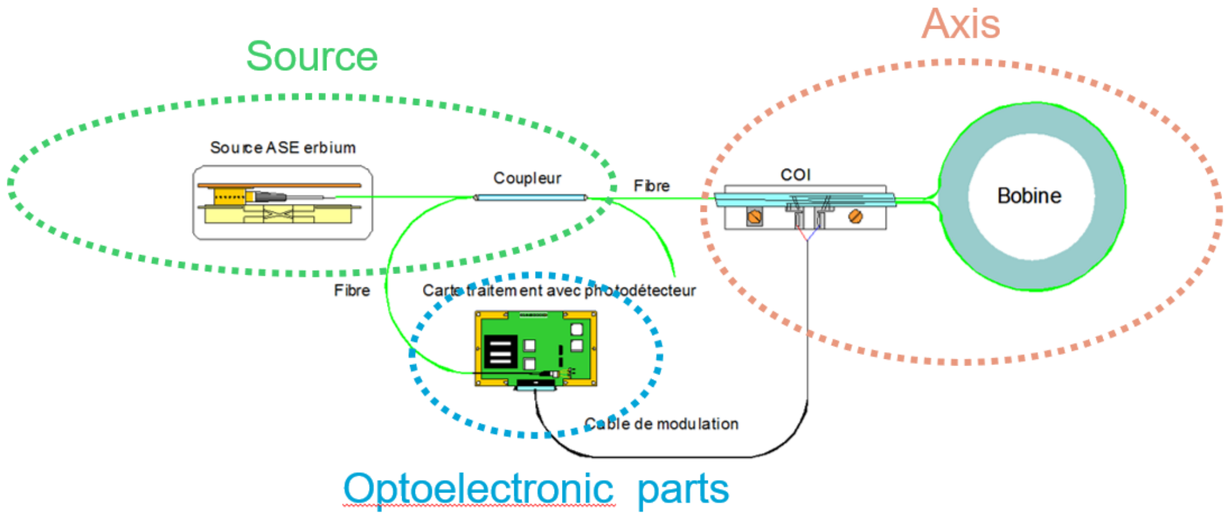
INTRODUCTION

A brief introduction to photonics for inertial measurement



- Optics at the heart of the fiber optic gyroscope
- Many critical optical components required

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A brief history of fiber optic gyroscope in space

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  - IMU = gyroscope + accelerometer + more computing power
  - 4 partners involved : Airbus Defence and Space, ETH Zurich, DLR Bremen and Exail

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 101004205.

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- **Critical issue from the beginning : no photonic components qualified for space application.**

PHOTONIC COMPONENTS FOR SPACE

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Photonic components for gyroscope

- **Passive optical components**
  - Standard optical fiber
  - Erbium doped fiber
  - Bragg fiber filter
  - Various couplers

- **Active optical components**
  - Photodiode
  - Pump laser diode
  - Optical modulator

- **Where can we find those photonic component for space?**

Make or buy ?

- Contrary to electronic components, there are rarely space-qualified photonic components
- Then, two options for Exail : make or buy the photonic components

Make or buy ?

- **Contrary to electronic components, there are rarely space-qualified photonic components**

- **Then, two options for Exail : make or buy the photonic components**

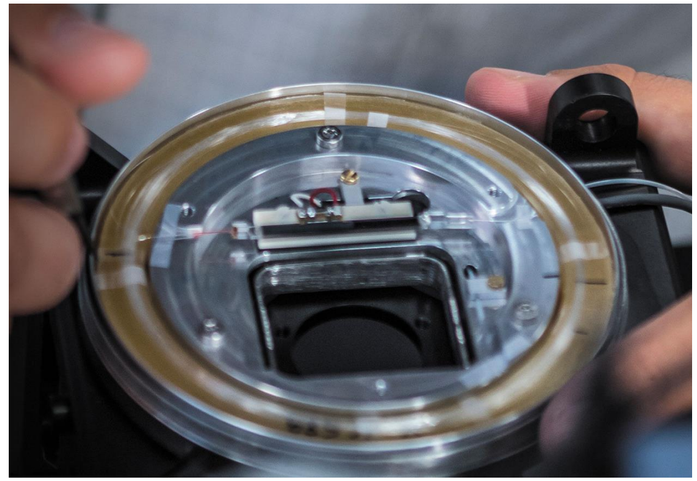
- **Components that we design, manufacture and qualify for space**
  - Standard optical fiber
  - Erbium doped fiber
  - Bragg fiber filter
  - Optical modulator

- **Components that we buy and then qualify for space**
  - Various couplers
  - Photodiode
  - Pump laser diode

Photonic components for space at Exail

We design our own components for space application

- For fibers: specific composition that withstands radiation without darkening and that doesn’t release problematic quantity of gaz
- For optical modulator: specific process to withstand vacuum and radiation
- In both cases, specific tests and product assurance during manufacturing



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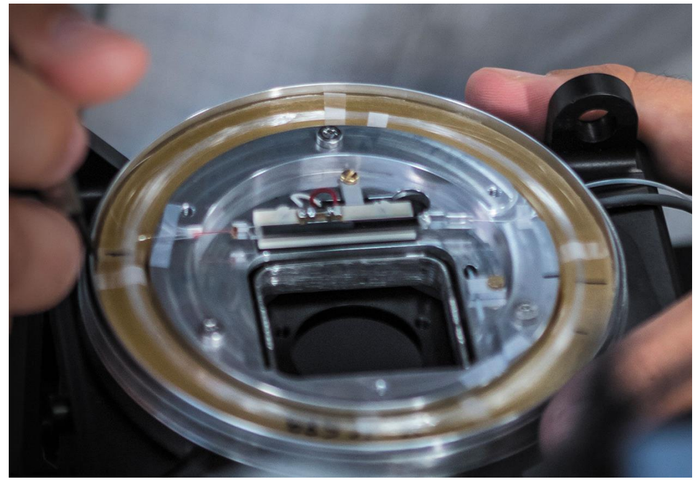

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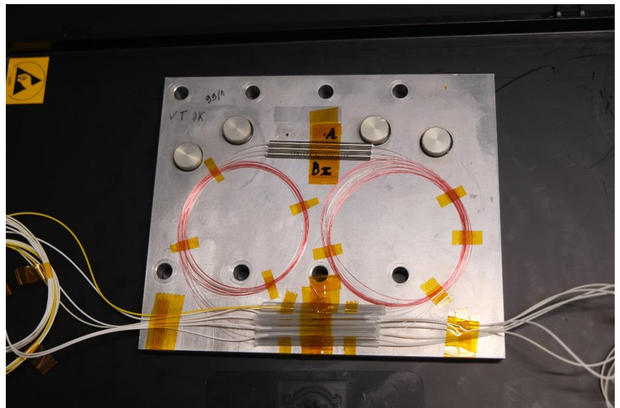
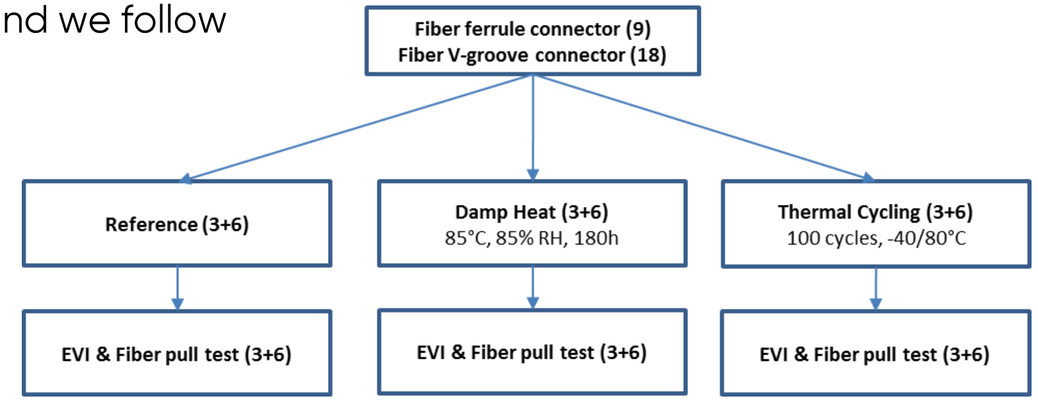
Then, we need to qualify them

- Qualification by batch with a (too !) long list of tests
- Thermal tests, mechanical tests, radiation tests, construction analysis and some specific tests depending on the application.
- Even for « New Space » application, we do batch qualification and we follow the same radiation tests.





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AND THEN EQUIPMENTS

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Qualification at the equipment level

- As for all space equipment, on top of the qualification at the component level, we must do a qualification at the equipment level
- Another long list of tests and validation is mandatory (see example on the right).

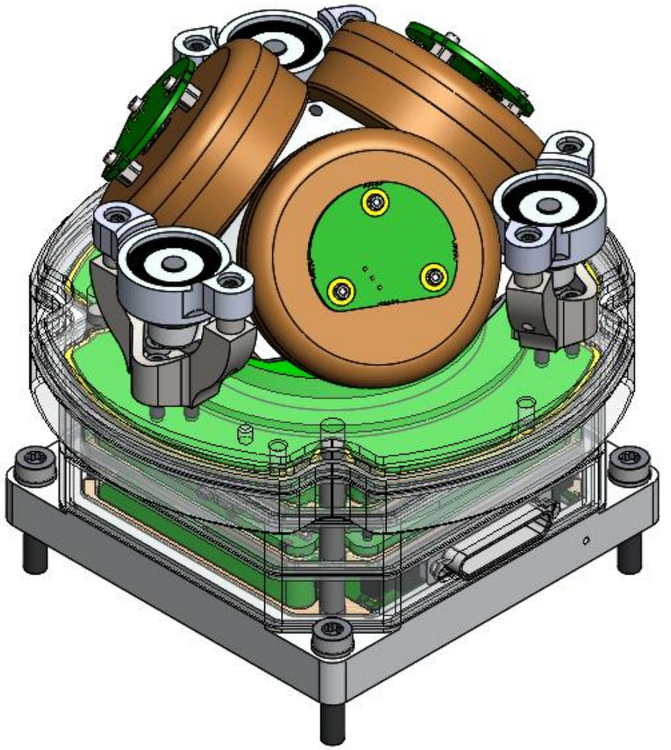
Chronological sequence #	Topic	Tests/inspections (independent order inside each topic)
1	Functional	[VVR_ASTRIXNS_0010.C] Astrix NS Weight [VVR_AstrixNS_0080.B] Astrix NS grounding [VVR_AstrixNS_0110.D] Power consumption [VVR_ASTRIXNS_0000.B] Good health control
2	Performance	[VVR_AstrixNS_0160.C] Scale Factor [VVR_AstrixNS_0180.C] Scale Factor repeatability [VVR_AstrixNS_0195.C] Bias [VVR_AstrixNS_0196.C] Bias ON/OFF repeatability [VVR_AstrixNS_0197.C] Bias thermal sensitivity [VVR_AstrixNS_0050.C] Misalignment [VVR_AstrixNS_0230.D] Allan variance – standard performance version [VVR_AstrixNS_0250.D] Magnetic Sensitivity [VVR_AstrixNS_0260.D] Dead Zone [VVR_AstrixNS_0246.D] Angular resolution
3	Sine vibration	[VVR_ASTRIXNS_1020.D] Critical frequency sweep [VVR_ASTRIXNS_1030.B] High-level sine vibrations
4	Random vibration	[VVR_ASTRIXNS_1040.D] Random vibrations [VVR_ASTRIXNS_1020.D] Critical frequency sweep
5	Shock	[VVR_ASTRIXNS_1050.D] Shock test
6	Thermal vacuum	[VVR_ASTRIXNS_1060.D] Thermal Vacuum test
7	EMC/ESD	[VVR_ASTRIXNS_2010.D] EMC and ESD tests
8	Functional	[VVR_ASTRIXNS_0010.C] Astrix NS Weight [VVR_AstrixNS_0080.B] Astrix NS grounding [VVR_AstrixNS_0110.D] Power consumption [VVR_ASTRIXNS_0000.B] Good health control
9	Performance	[VVR_AstrixNS_0160.D] Scale Factor [VVR_AstrixNS_0180.D] Scale Factor repeatability [VVR_AstrixNS_0195.D] Bias [VVR_AstrixNS_0196D] Bias ON/OFF repeatability [VVR_AstrixNS_0197.C] Bias thermal sensitivity [VVR_AstrixNS_0050.D] Misalignment [VVR_AstrixNS_0230.D] Allan variance – standard performance version [VVR_AstrixNS_0250.D] Magnetic Sensitivity [VVR_AstrixNS_0260.D] Dead Zone [VVR_AstrixNS_0246.D] Angular resolution

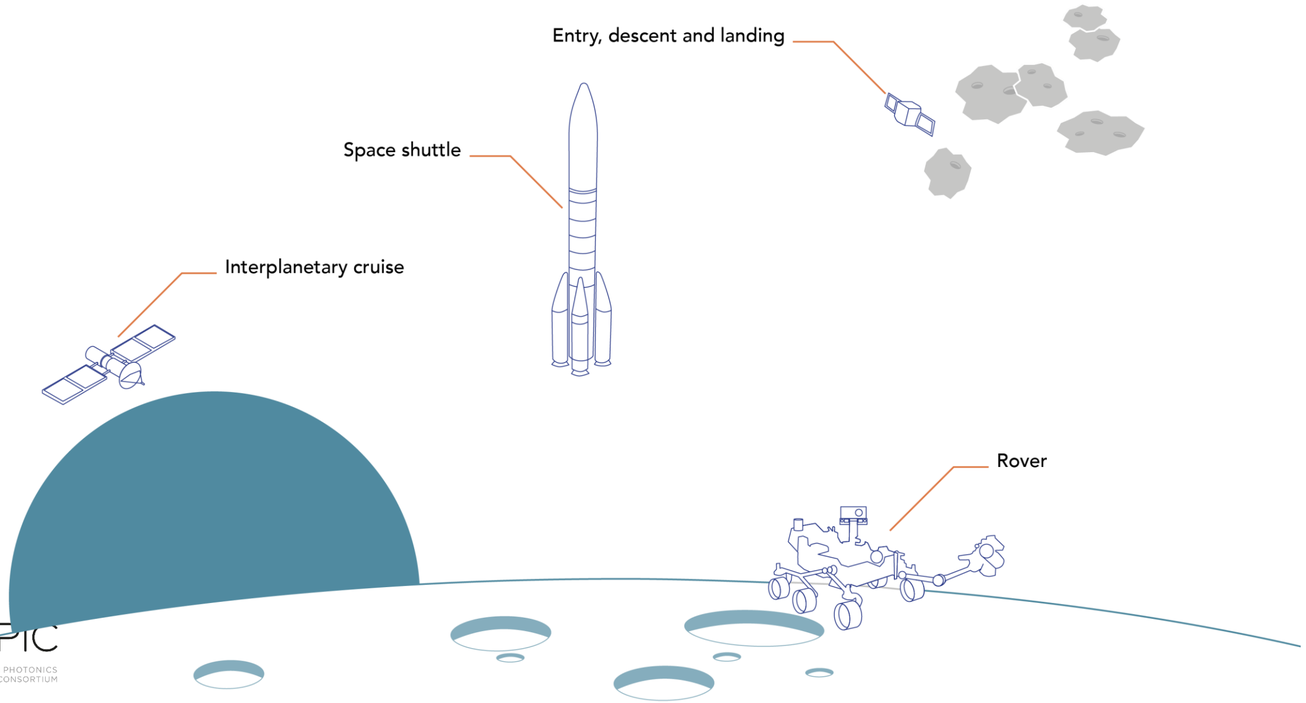
Astrix NS : space gyroscope for new space applications and more

- Astrix NS is the latest space gyroscope of the Astrix family
- Missions : telecommunication, Earth observation and some specific scientific missions
- Mainly for compact satellite platforms and « New Space » applications
- As of today several equipments have already been ordered by customers and 12 EM have been produced and delivered

EURISA: a European IMU for exploration missions

- Strong need for an European equipment for non-dependance reasons
- In the future, many missions will require space IMU including flagship missions like the Moon and Mars exploration.





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THANK YOU FOR YOUR ATTENTION

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