

# The challenges and opportunities for integrated photonic sensing



EPIC Meeting on Fiber Sensors at HBK FiberSensing  
Gideon Langedijk, April 20<sup>th</sup> 2023



# Enabling smart industry by **data-driven** decisions

- There is a challenge for **robust** monitoring solutions to ensure that **safety-critical** applications remain **cost-effectively** operational.
- **High quality data** means new types of assets can be monitored, every aspect can be managed in real-time.
- Providing you with the data you need to make **informed decisions**.
- **Real-time, accurate** data is becoming a critical factor to ensure the right decisions-making processes.



## Safety & Reliability

Continue safe operations and keeping people safe



## Diagnostics & Performance

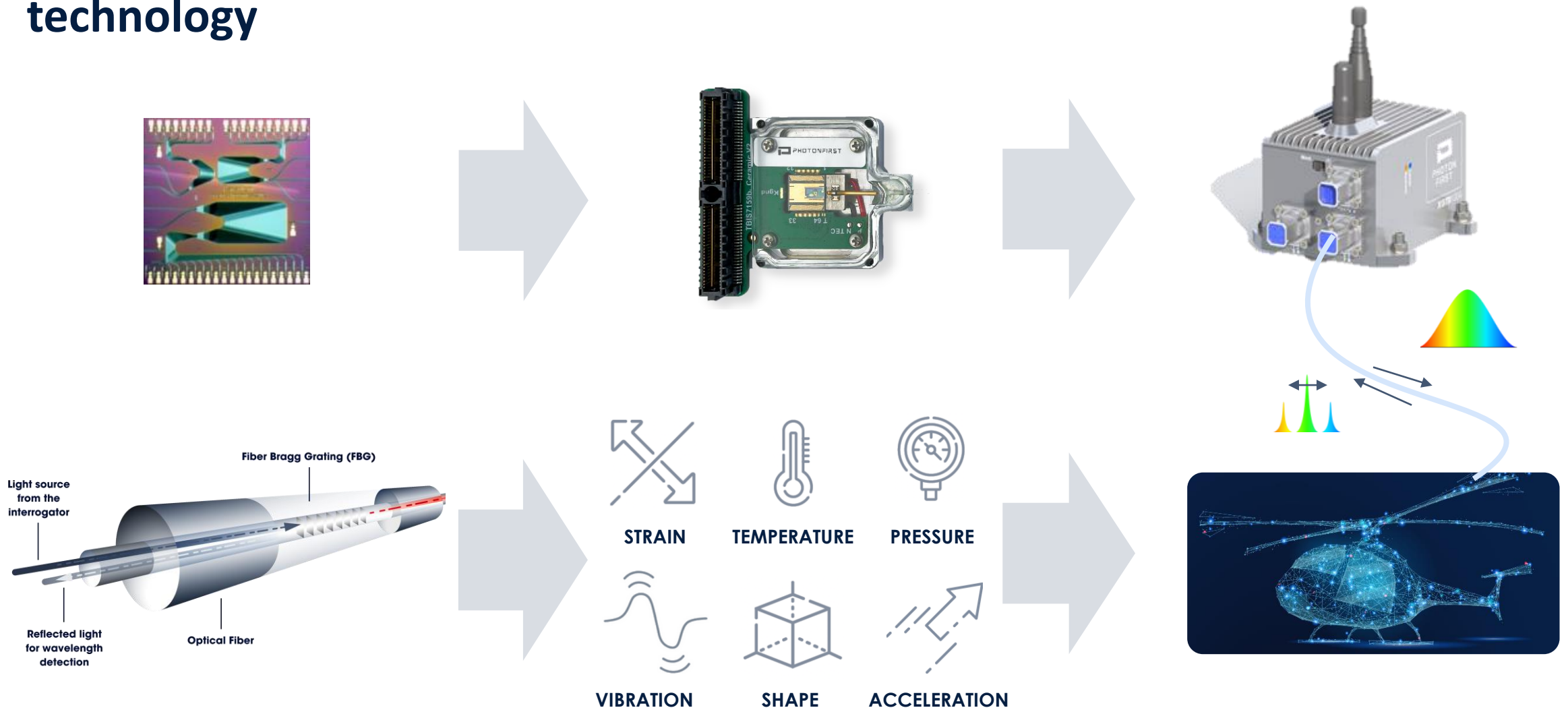
Optimize your overall equipment effectiveness



## Lifetime & Sustainability

Ensuring sustainable use of resources and optimum lifetime of a turbine.

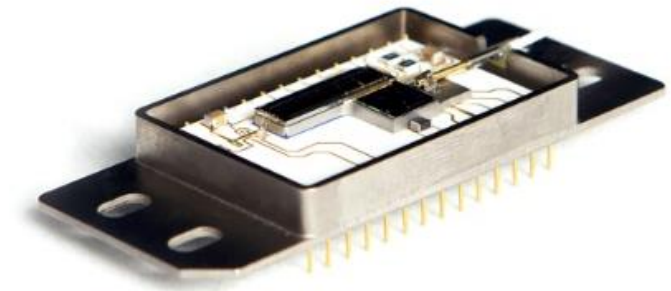
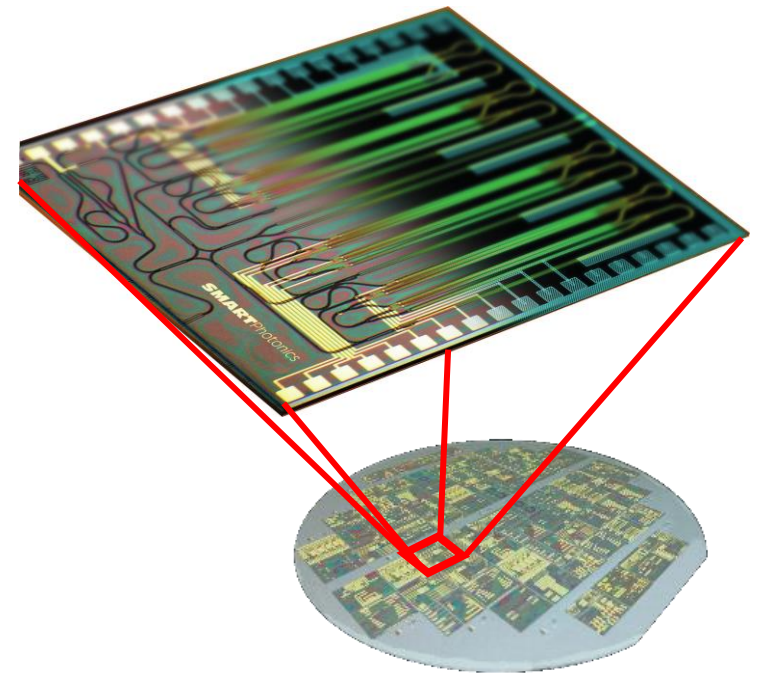
# PhotonFirst develops and produces sensing solutions, based on PIC technology



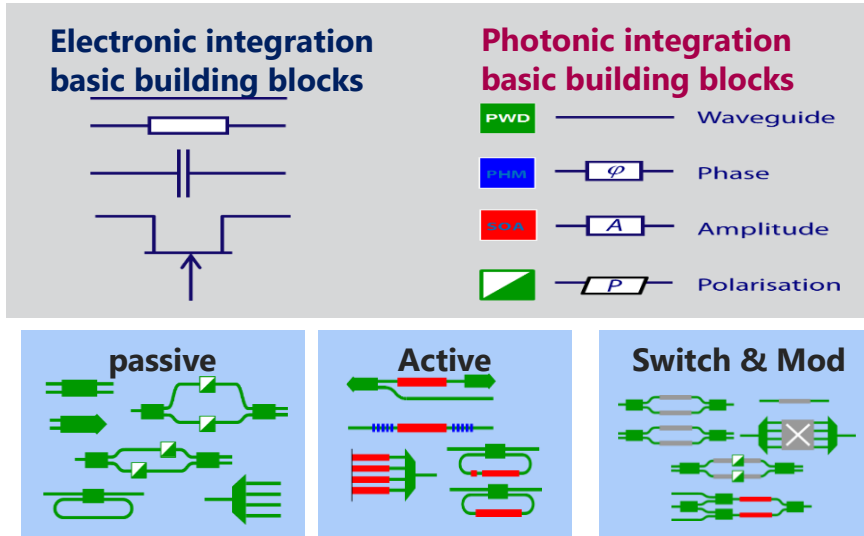
# Photonic Integrated Circuits and PIC-based **product development**

# Photonic Integrated Circuits for sensing solutions

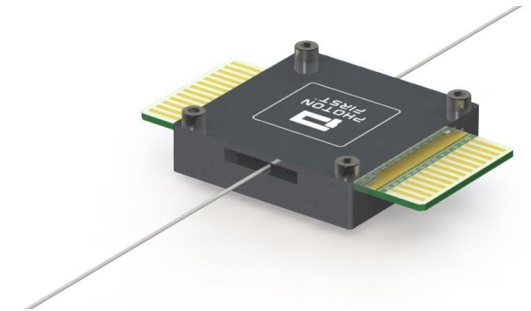
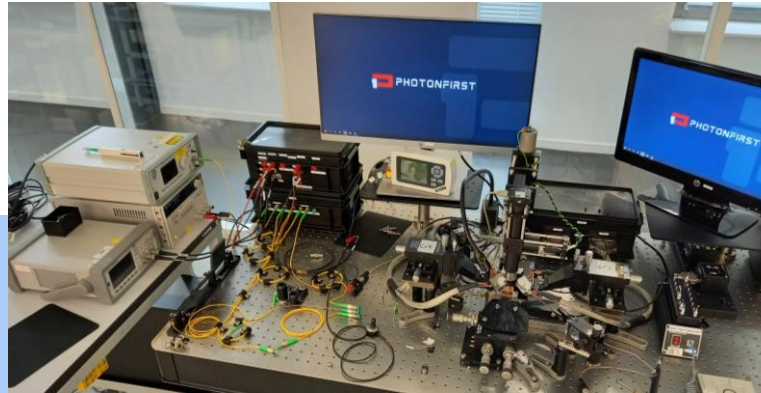
- All our photonic systems are based on PICs:  
Integration of optical **functionalities** onto a chip
- Small footprint solid-state circuitry, **mass-producible**  
on wafer scale (low C-SWaP)
- PIC packaging: **connecting** and **protecting** the PIC to and from the  
application environment
- Idea → solution and product



# Starting with the **Application Specific** Photonic Integrated Circuit (ASPIC)



- Generic test packages, ADC/DAC modules
- Test benches for opto-electronic testing

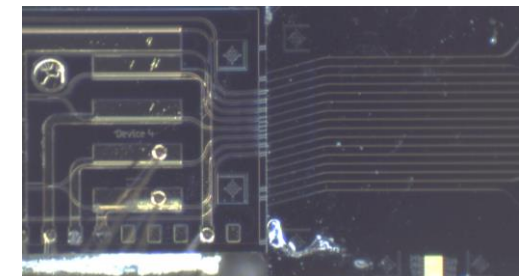
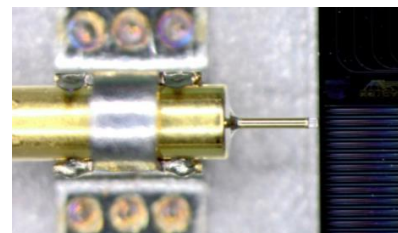
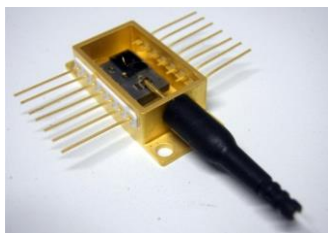


Design for assembly and test



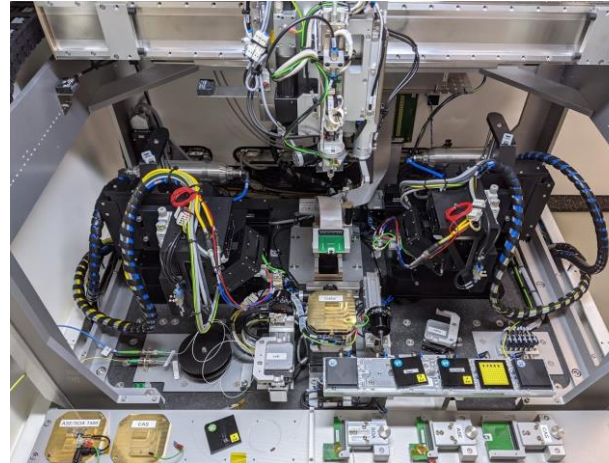
Selecting/developing the right package

- Connectivity
  - Protection
- Requirements ↔ Specifications  
Generic ↔ Tailored

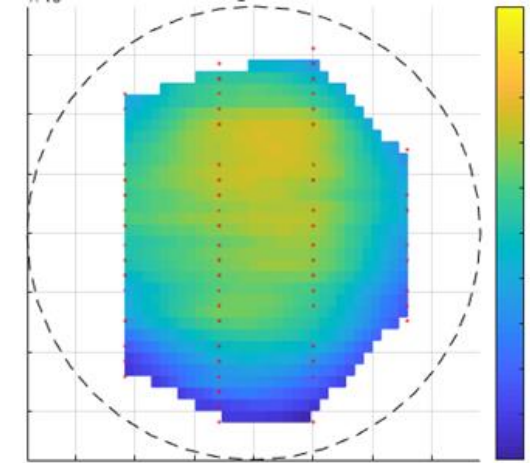


# Product(ion) optimization is required **for all ASPIC's.**

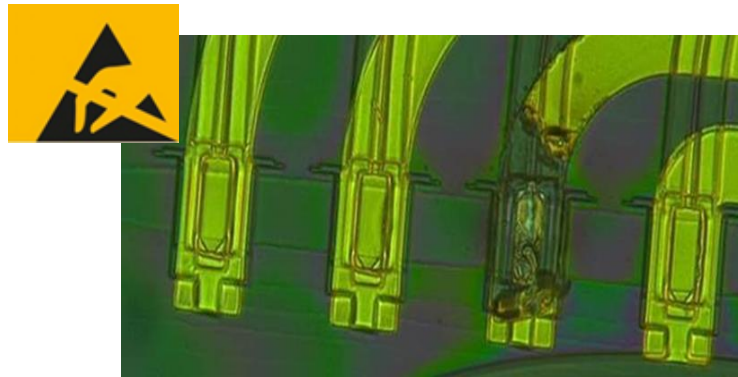
- **"A first functional PIC, does not equal a first producible PIC!"**
- Fabrication tolerances lead to variation in performance KPIs for end device.
- Production control, process KPIs, should enable the product requirements
- Validation and optimization, adaptation where needed.
- Not just the PIC → package → system context



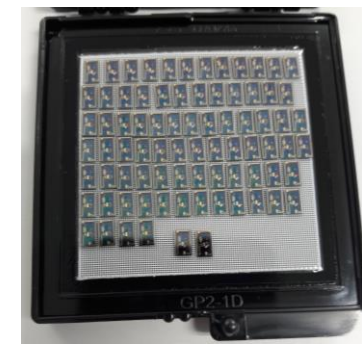
Automated Die-tester at PhotonFirst



Map of a measured device KPI across a wafer

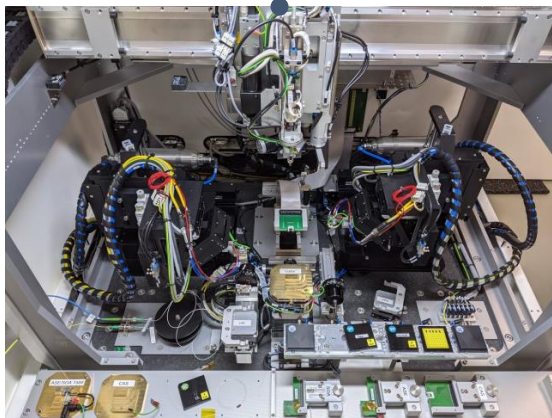
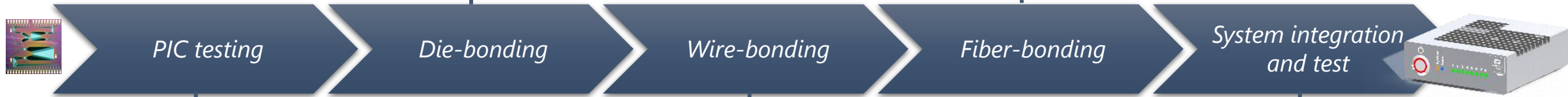
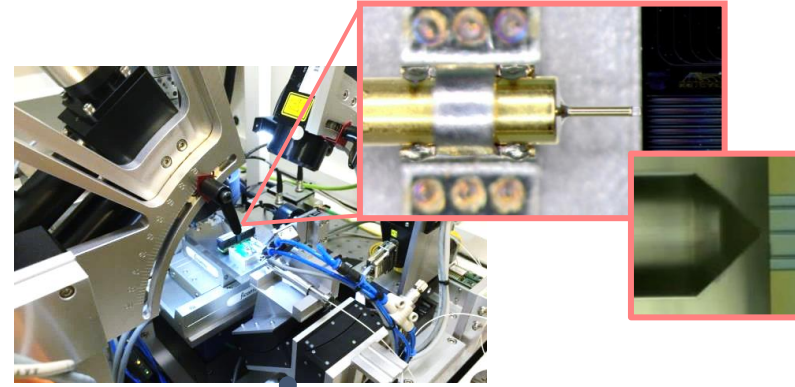
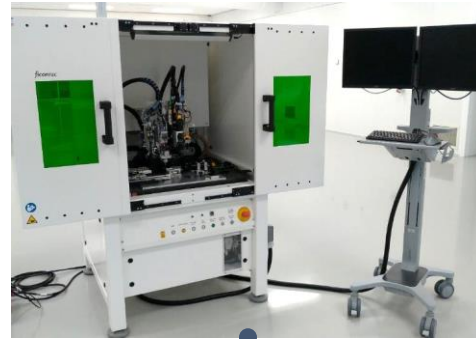


ESD damage on PIC Photodiode



Production PIC batch in gel-pack

# PIC-based product assembly at PhotonFirst

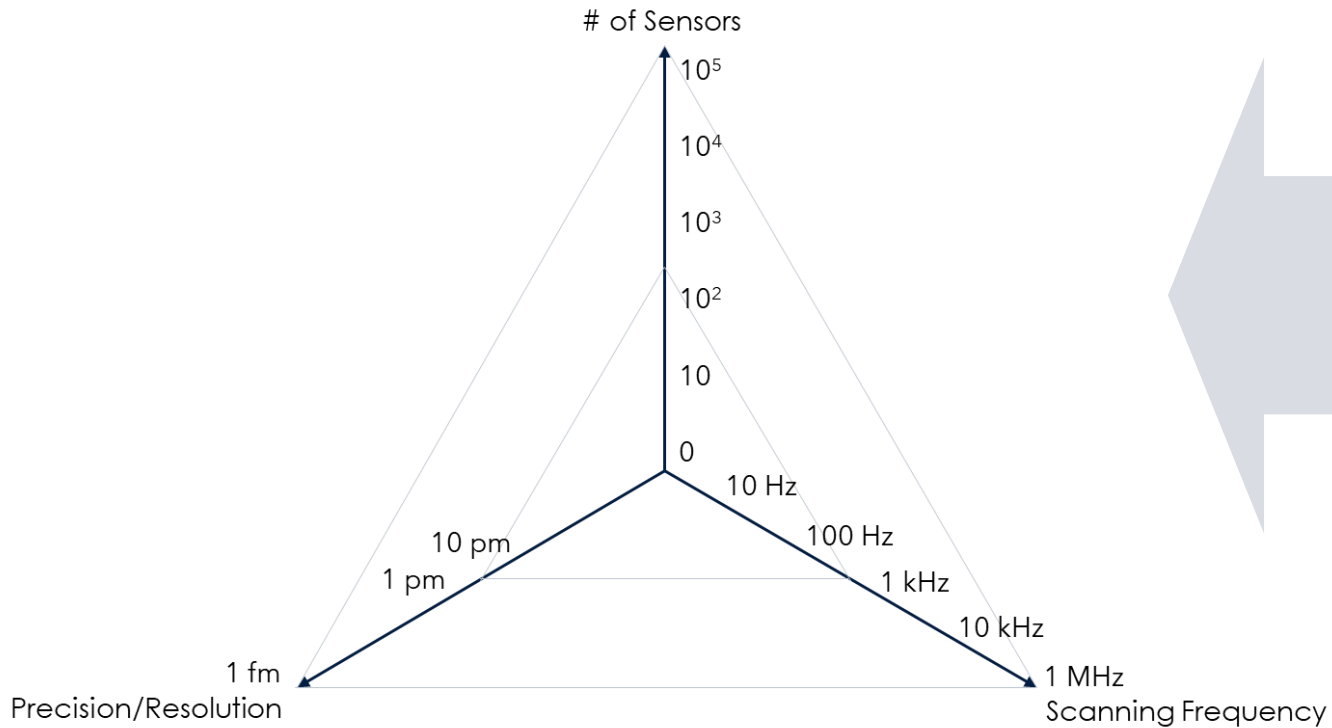




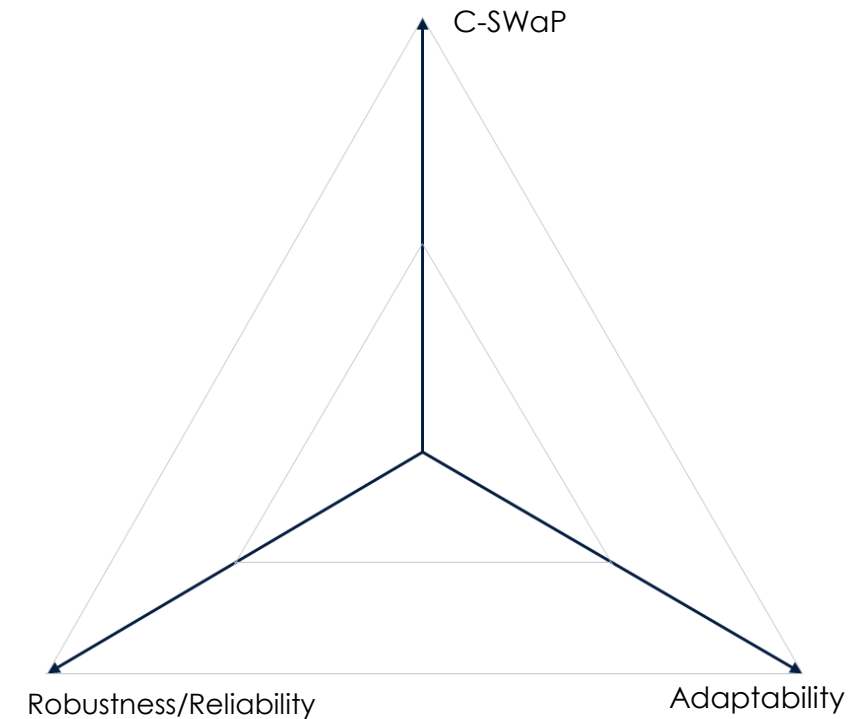
Application cases:  
Pushing **beyond** boundaries

# Pushing the extremes with PICs for fiber sensing capabilities for our customers

## Sensing KPIs



## Solution KPIs



Many applications with different benefits from PIC-based sensing solutions

**PhotonFirst examples** of extreme enabled KPIs

# # Sensors: Versatile FBG sensor multiplexing in a modular platform

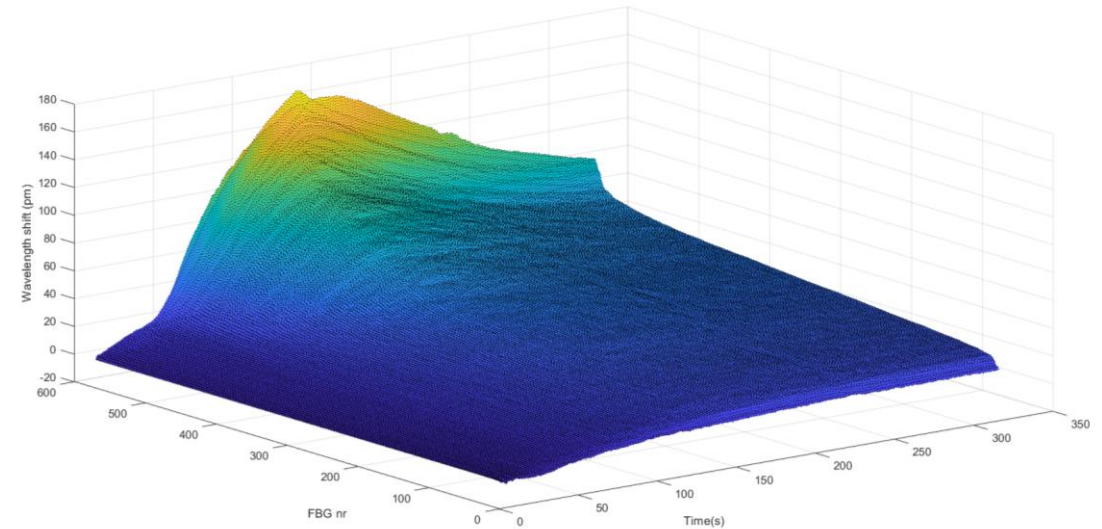
Measure vast nrs of sensors with one interrogator, combining multiplexing forms through our modular platform

Wavelength Division Multiplexing (WDM) +  
Switch Channel Multiplexing (SCM) +  
Time Domain Multiplexing (TDM)

- > 10.000 unique sensor points
- cm sensor spatial resolution

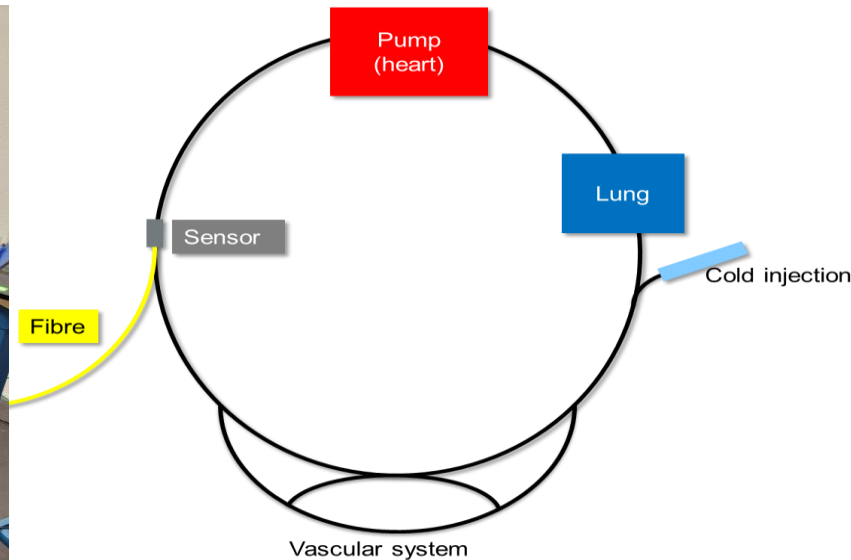
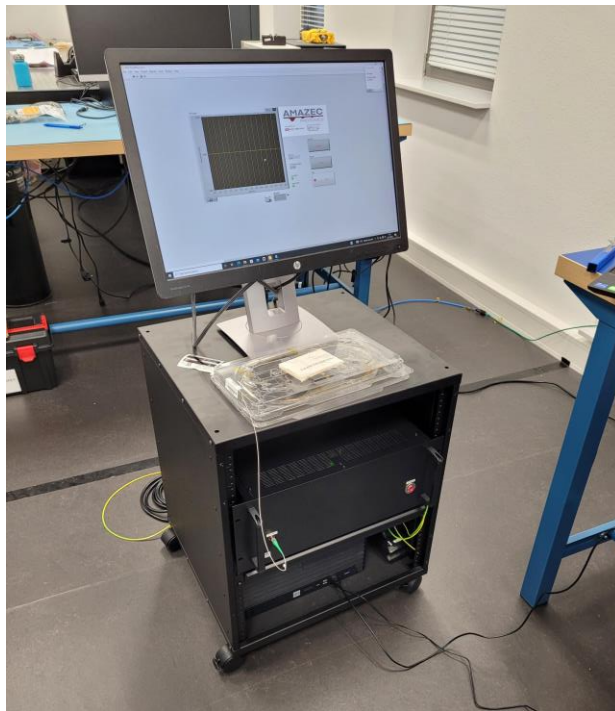
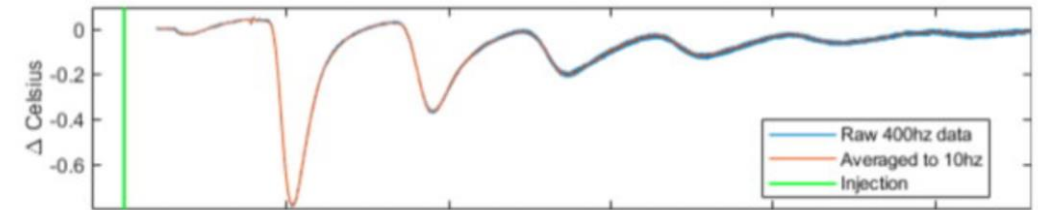
Enabling applications as

- 2D Thermal / strain / pressure mapping
- Shape sensing
- Linear asset management



# High Precision: Enabling new applications for PIC sensing

- Revolutionary approach for non-invasive cardiovascular health monitoring, sensing mK Temperature changes
- PIC based **fm-level** precision FBG sensing, stable and implementable to be form-fit, economic and suitable for medical product certification



# Robustness: Interrogators performing in Harsh Environmental Test Campaigns



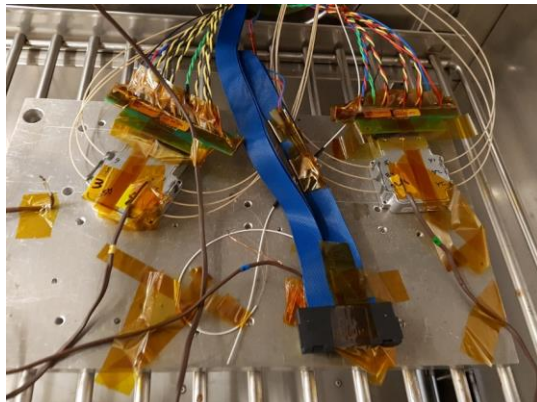
DO-160 Environmental tests

- Extensive test campaigns conducted on
- Chip level (lifetime, ESS, functional testing)
  - Package/module level
  - System level

Industrial, MIL, DO-160 test categories, HALT



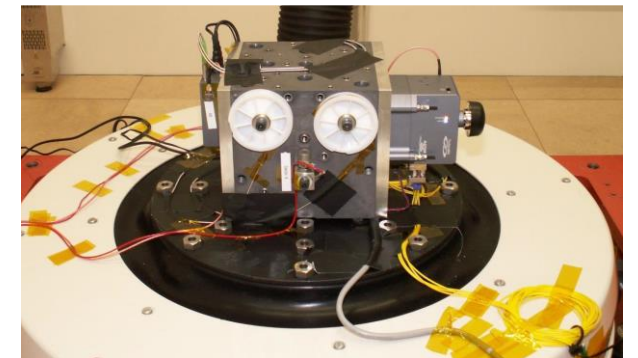
Proton radiation tests on PIC Interrogator modules



Damp heat climate test chamber



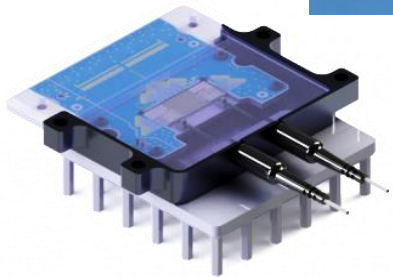
Blade monitoring application example, using a gator system equipped with ext. sync option  
(Courtesy NLR, Integrate)



Vibration & shock testing systems for rotorcraft applications

# C-SWaP: Reduction of Cost- Size Weight and Power

- PIC integration enables a paradigm shift in the interrogator footprint reduction (C-SWAP), while maintaining functionality
- Automated assembly → Highly scalable
- Technology potential is still not fully leveraged.

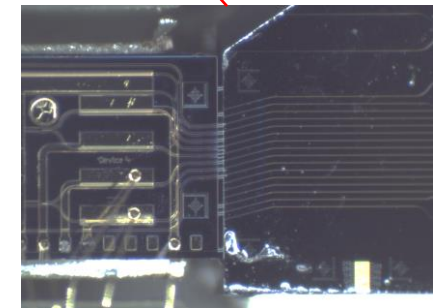
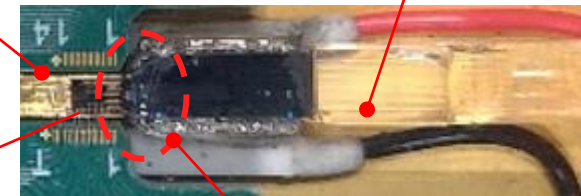
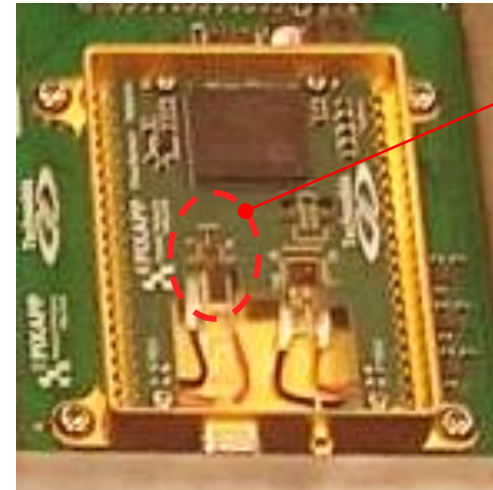


- Less than 0.8 kg
- Small size (~A4)
- Aerospace compliant
- Multi-channel, high speed (20 kHz)

Optical Switch

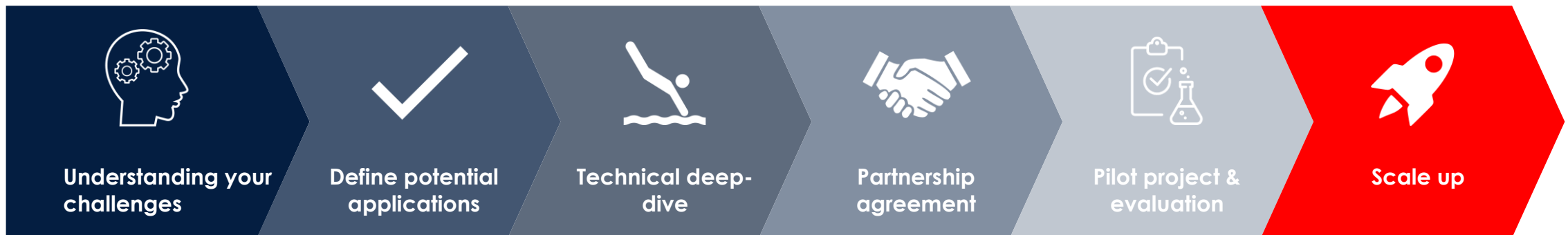
Triplex Interposer

16-ch Fiber Array



# Key take-aways

- **Integrated photonics** is an enabling technology for the development of application specific sensing solutions, beyond the lab.
- To truly harness it, a challenging journey through phases from **idea** to **product**
- The examples in pushing the boundaries of sensing show the boundless opportunities ahead of us
- It is crucial for a ground-breaking, effective and reliable product to choose the right supply chain partner(s) to develop, design, manufacture the solution





Thank you for your attention.  
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