PISEO

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FOUR THERMAL CAMERAS PERFORMANCE ANALYSIS

- INFIRAY T3S CAMERA MODULE
- TELEDYNE FLIR BOSON 640 PRO CAMERA
- SEEK THERMAL QVGA 12MM S309P CAMERA MODULE
- INFIRAY MICRO III 384T CAMERA MODULE

PRODUCT BROCHURE

2022

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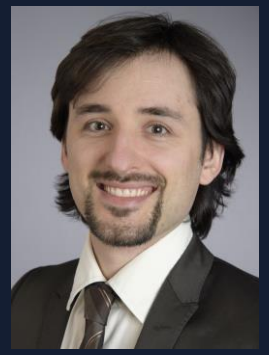
AUTHORS OF THE REPORT

Dr Olivier Andrieu – Innovation Leader and System Architect - PISÉO

Olivier ANDRIEU is in charge of technical expertise and innovation projects at PISÉO. He holds a degree in engineering and a PhD in physics from the INPG Graduate School. His career has allowed him to carry out various responsibilities in innovation in the automotive sector in connection with sensors and battery management systems as well as within Philips Lighting where he acted as system architect. He has supervised the design of numerous photonic systems for different sectors which have been commercialized. He has also performed many technical analyses of photonic systems and published several reports in collaboration with Yole Développement's teams.



Grégory Duchêne - Sr Optical Designer, illumination, detection and imaging systems - PISÉO

Grégory Duchêne is in charge of advanced optical systems studies and analyses at PISÉO. He holds an engineering degree from the Institut d'Optique Graduate School (IOGS). He has successfully designed the optics of many innovative photonic systems for PISÉO's' customers. In addition to his strong optical design skills, he has in-depth know-how of optical metrology of illumination and imaging systems. Grégory Duchêne is our Zemax expert and also teaches optical system design at IOGS.

Lionel Artinyan – Optronics and Software Engineer - PISÉO

Lionel Artinyan holds a degree from the ENSSAT Graduate School and has a strong background in photonic component and system characterization. At PISÉO he is in charge of custom test bench engineering and test realization. He has participated in the design of many different test benches that include optical devices and control programs. He has successfully tested many systems that integrate pulsed light sources such as xenon lamps, LED's, and laser diodes, as well as imaging sensors.

EXECUTIVE SUMMARY

Context

- Thanks to multiple drivers, the market for infra-red thermal imaging cameras and modules is expanding rapidly. It is expected to increase from $6,202M in 2021 to $8,761M in 2026. The estimated Compound Annual Growth Rate from 2021-2026 for thermal camera shipment volumes is 7.2%.

- Defense application demand pulls the infra-red thermal imaging camera market. There is progressively more portable equipment for soldiers, such as thermal weapon sights and night vision goggles. 'Smart city' surveillance applications are also important. Thermal camera technology is increasingly adopted by integrators thanks to cost decreases. It is also boosted by the democratization of thermal imaging in industrial thermography. Finally, thermal imaging is becoming consumerized.

- There are many products on the market. Users, integrators, and sensor manufacturers must discriminate between available products based on accurate and independent assessments of their performance and features.

PISÉO's analysis

- There are tens of thermal sensors and camera manufacturers including Teledyne FLIR, Seek Thermal, Raytheon Technologies, BAE Systems, Lynred, HikVision, InfiRay, i3system, GuideIR, Fluke, Safran and Testo. PISÉO has so far selected and analyzed four thermal camera modules, giving rise to four reports:
    - InfiRay T3S camera module,
    - Flir Boson 640 Pro camera,
    - Seek Thermal S309P 12µm x 12µm QVGA module
    - InfiRay Micro3 384T camera module.

- Thanks to its own standard, PISÉO ran deep analyses of sensor performance and the embedded image processing algorithms of each camera.

- These reports help thermal imaging camera and module market actors to better understand the characteristics of such products, enabling better strategic decision making.

- The present report is a special one, reporting the most important performance test results and analyses done on these four cameras. It is an opportunity to make fair comparisons between product features and performance.

WHAT'S IN THE REPORT

Key features

- Analysis and comparison of the user functions of the camera and the development resources of the four thermal cameras,
- Analysis and overview of the image production processes and internal architectures,
- Set-up and objectives of the camera characterization,
- A comparative analysis of the bolometric sensor performance for raw images quality, responsivity, Noise Equivalent Temperature Difference, bad pixels, thermographic function and Residual Fixed Pattern Noise profile,
- Analysis and overview of the image processing and tone mapping functions,
- Our opinion of the four thermal cameras and their marketing positioning.

COMPANIES CITED IN THIS ANALYSIS

- InfiRay
- Seek Thermal
- Teledyne FLIR

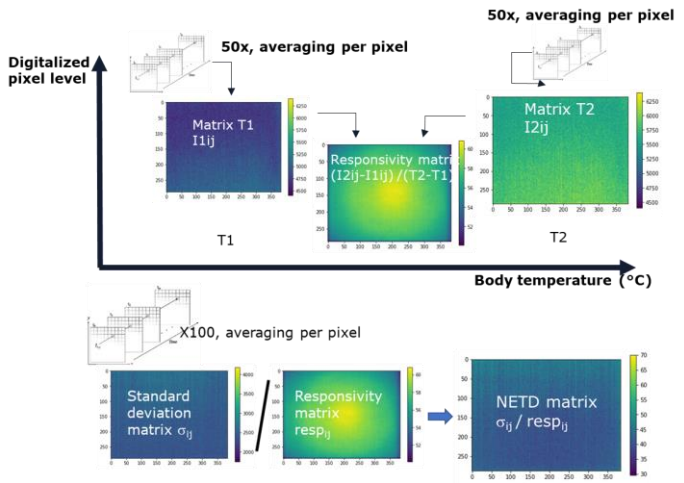
CHARACTERIZATION OF THE CAMERAS

Set-up and objectives

- The tests are realized by analyzing an image of a uniform scene provided by a blackbody controlled at various temperatures. The set-up is installed in a climate chamber in order to produce various ambient temperatures.
- By controlling the image production pipeline, tests are performed on raw images exempt from any correction function. For each camera tested, a specific and intrusive software has been written to get image stacks representing the raw sensor images.
- A selection of parameters representing the performance of the bolometric sensor have been calculated from the measurement of image stacks. All calculations are based on the same PISÉO standard set-up designed for thermal camera analysis, allowing the comparison of the output performance parameters:
    - Calculation of responsivity and the NETD.
    - Calculation of the linear scene dynamic.
    - Measurement of bad pixels, from dynamic criteria and calculation of the operability.
    - Performance after two-point NUC correction.
    - Calculation of residual pattern noise (RFPN).
    - Measurement of the thermographic function.
    - MTF measurement (slanted edge method)
- The protocol is described in the appendix of this report.

Typical IR Camera test set-up @PISÉO's lab

Source: PISÉO

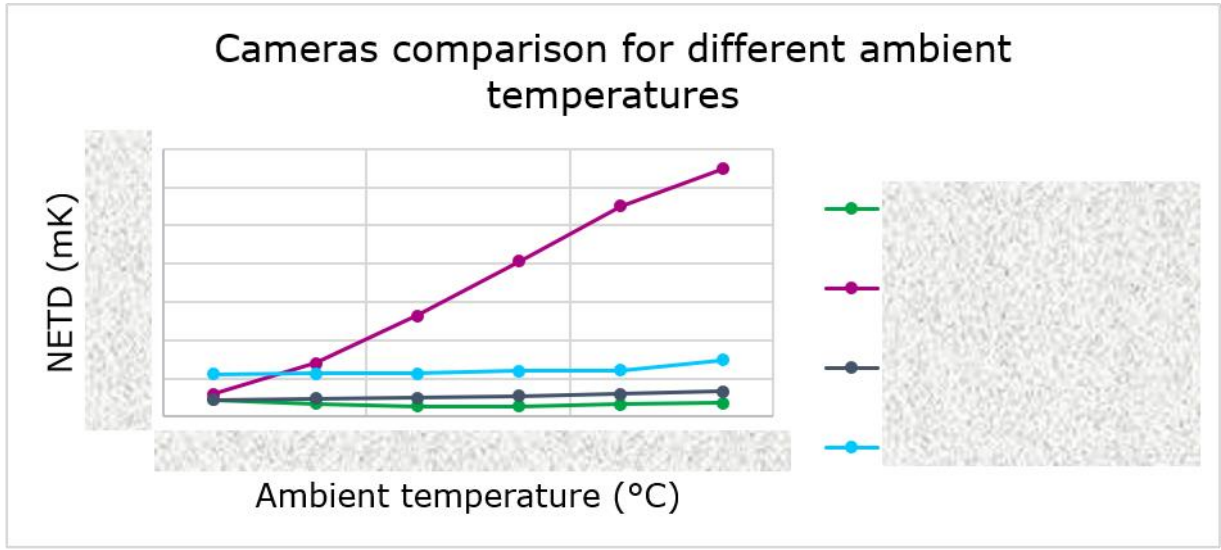


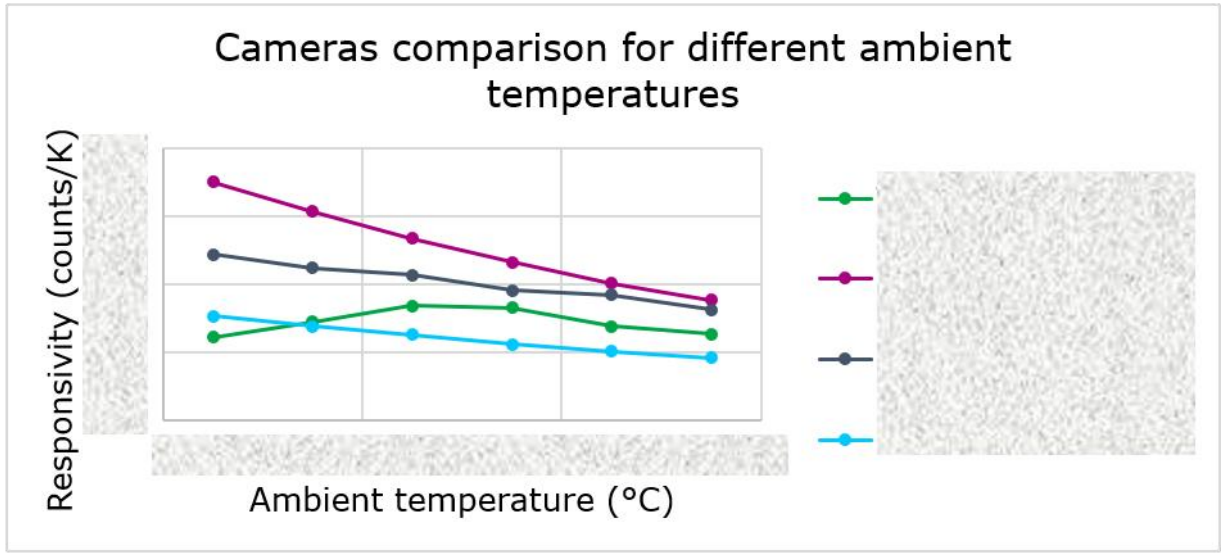
Examples of resulting matrix of pixel signal

RESPONSIVITY / NETD / SCENE DYNAMIC

Figures

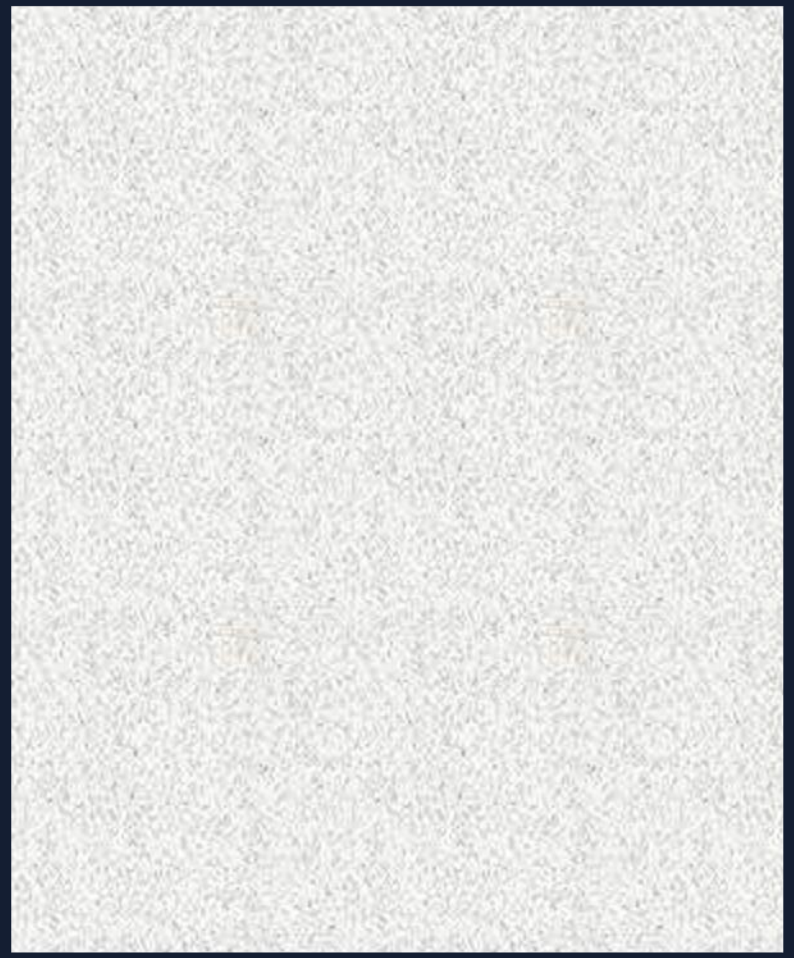
All 4 cameras have typical Responsivity profiles over temperature.

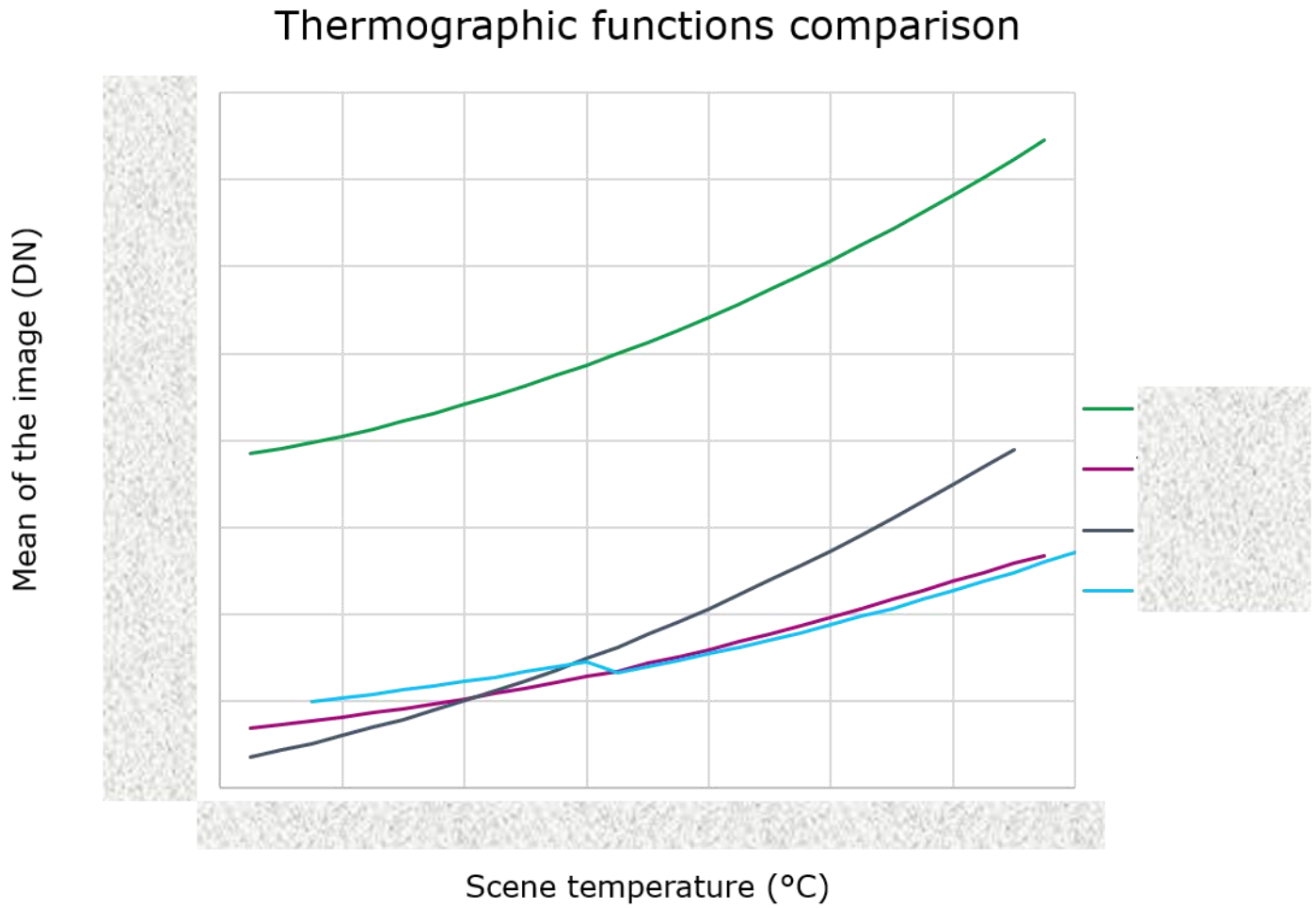




Source : PISÉO

THERMOGRAPHIC FUNCTION AT 25°C





Source : PISÉO

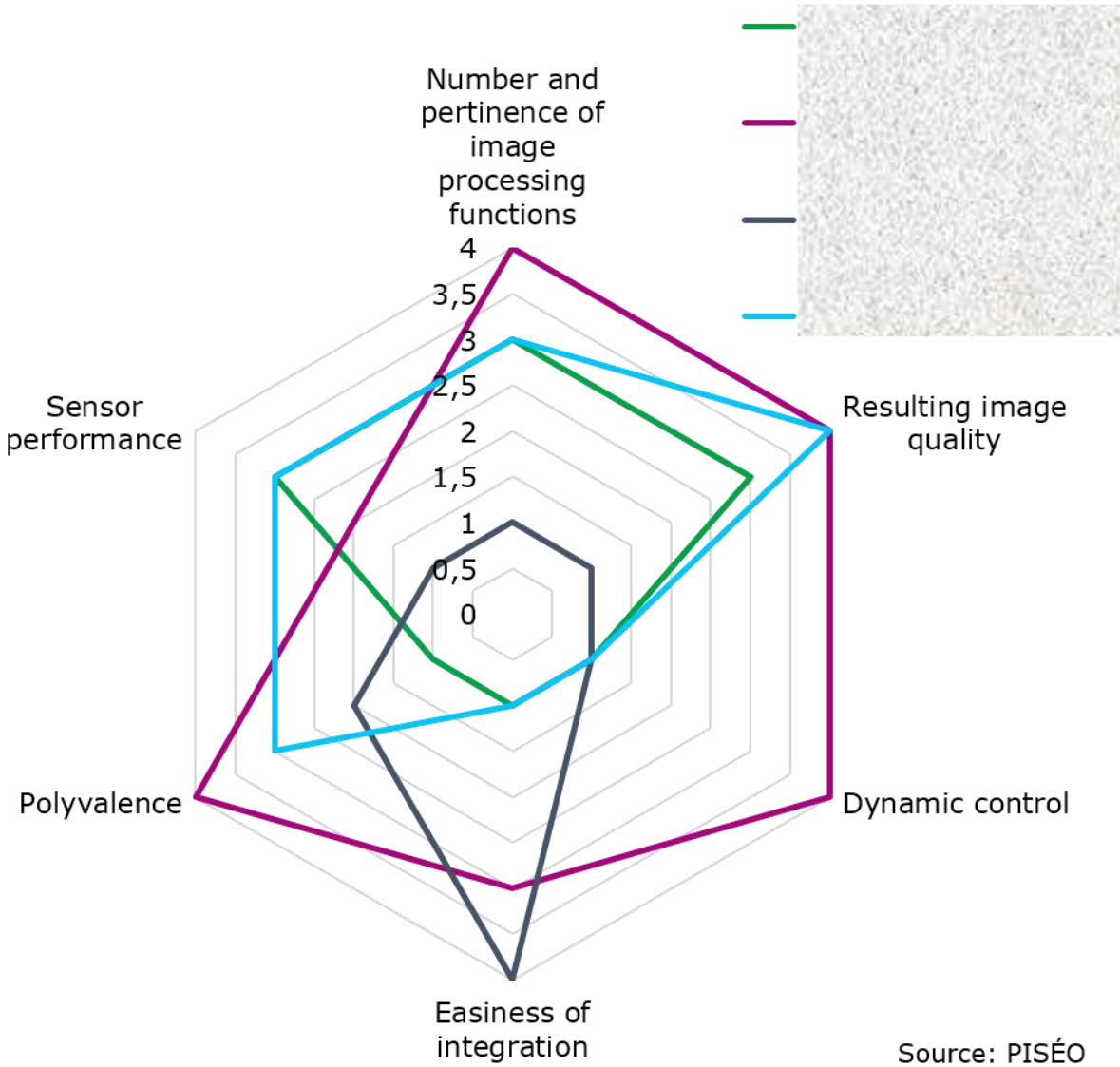
COMPARISON TABLE

CHARACTERISTICS		InfiRay T3S	FLIR BOSON 640	Seek Thermal S309SP	InfiRay Micro III 384T
Sensor characteristics	Pixel resolution				
	Pixel pitch				
	Frame rate				
Sensor performance at 25°C ambient temperature	Signal output resolution				
	NETD (claimed)				
	NETD (measured)				
	Resp				
	Scene dynamic				
	# of bad pixels				
	Operability				
	RFPN				
	RFPN impact on read temperature				
Temperature sensing	Functionality available				
	Accuracy (claimed)				
	Accuracy (measured)				
Correction algorithms and image processing	Non-uniformity and signal quality correction				
	Deviance on uniform image				
	Image processing				
	SDK				
	Calibration				

COMPARISON ASSESSMENT

Analysis

- The **FLIR BOSON 640** can be considered
- The **InfiRay Micro III 384T** is based on
- The **Seek Thermal S309P** sensor and image processing performance
- The **InfiRay T3S** provides



Source: PISÉO

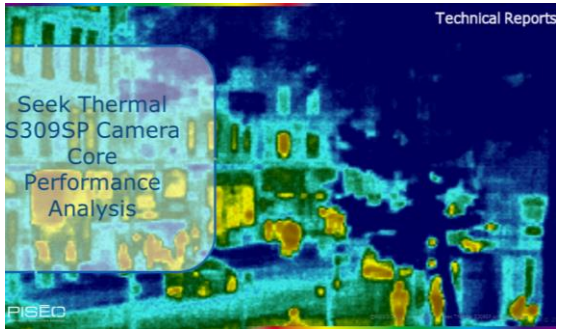
YOLE GROUP OF COMPANIES RELATED PRODUCTS

iRAY T3S Thermal Camera Performance Analysis

FLIR Boson Thermal Camera Performance Analysis

Thermal Imaging and Sensing 2021

Seek Thermal S309SP Camera Core Performance Analysis



InfiRay Micro III Camera Core Performance Analysis

PISÉO, INDEPENDENT INNOVATION CENTER

TOGETHER LET'S LIGHT THE FUTURE OF PHOTONICS

OUR JOB:

Supporting your product and photonic system innovations and optimizations

- DEDICATED EXPERT TEAM
- ELECTRO-OPTICAL ISO 17025 ACCREDITED LAB
- POWERFUL DESIGN AND SIMULATION MEANS : ZEMAX, LIGHTTOOLS, SOLIDWORKS, RHINO3D, OWN TOOLS AND MODELS…
- SOLID INDUSTRIAL ECOSYSTEM: MECHANICS, ELECTRONICS, SOFTWARE, AI, ASSEMBLY, TESTS…

Source : PISÉO, Olivier Ramonteu

PISÉO, INDEPENDENT INNOVATION CENTER

LET'S BRING YOUR PROJECTS INTO THE LIGHT

OUR OFFERS:

- **PRODUCT INNOVATION AND OPTIMIZATION**

ELECTRO-OPTICAL CHARACTERIZATION
OPTICAL RISKS

CRITICAL ANALYSES OF SYSTEMS AND IMPROVEMENT

DESIGN, INDUSTRIALIZATION OF INNOVATIVE SYSTEMS

TECHNOLOGICAL MARKETS, REGULATION WATCH

TRAINING

- **PUBLICATION OF TECHNICAL REPORTS**

COMPONENTS

SYSTEMS

Source : PISÉO, Olivier Ramonteu

HEALTHCARE, ENVIRONMENT, LIGHTING, AUTOMOTIVE, AERONAUTICS, RAILWAYS, DEFENSE, TELECOM, PROCESSES…

PISÉO
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MARKETS AND PRODUCT TYPES

PISÉO, THE FACTS

- **10 years old**.
- **8 shareholders,** including Yole Développement, GIL-Syndicat du luminaire, Syndicat de l'éclairage, Serma Group, Cluster Lumière.
- Electro-optical characterization **laboratory ISO 17025 accredited** by COFRAC (scope available on www.cofrac.fr).
- **150+ customers** (Start-ups, SMEs, large groups) in France and abroad.
- **17 employees** highly qualified from industry.
- **5000+** tests carried out.
- **300+** customer projects carried out.
- Based in **Lyon**, France.

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