Les journées COFREND 2026

Lyon - May 2026 — CMPhy / ImViA

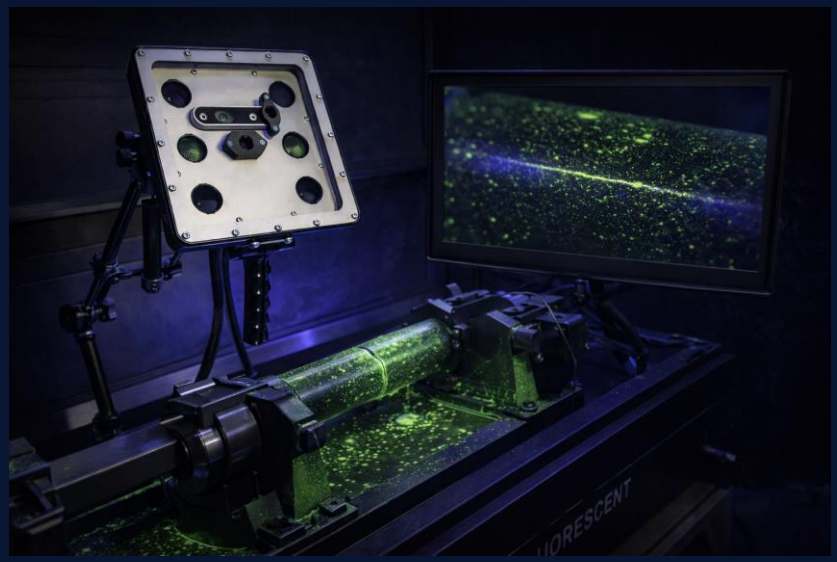
Arnaud PELLETIER – CEO CMPHY

# PARADES

## Intelligent vision system for Magnetic Particle & Penetrant Testing

*Instrument qualification, Artificial Intelligence and 3D Dimensional Measurement*

*Detect, measure, archive — automatically*



Target applications **Aerospace • Hydropower • Energy • Railway**

# The situation

Magnetic particle and penetrant testing: proven methods, but persistent operator constraints

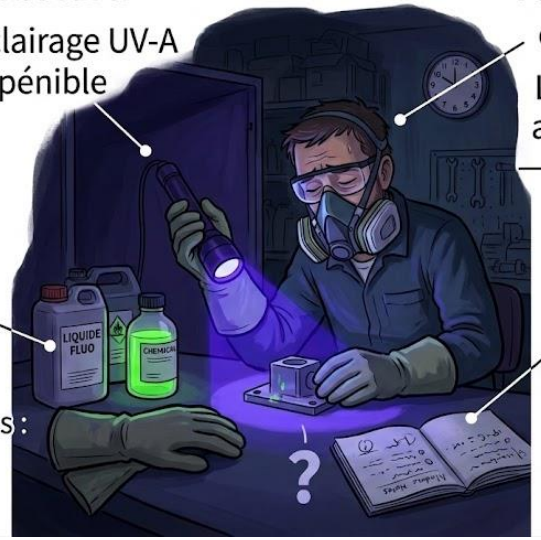
## The constraints of manual visual inspection

**Environnement obscurci**

Inspection sous éclairage UV-A en cabine fermée, pénible et fatigante.

**Exposition aux produits chimiques**

Liqueurs fluore-fluorescentes, produits magnétiques : risque sanitaire.




**Fatigue visuelle et charge cognitive**

La vigilance baisse au fil de la journée — risque de défauts manqués.

**Subjectivité du jugement**

Variabilité opérateur, difficulté de reproductibilité d'un contrôle à l'autre.

## Industrial challenges

**Traçabilité numérique**

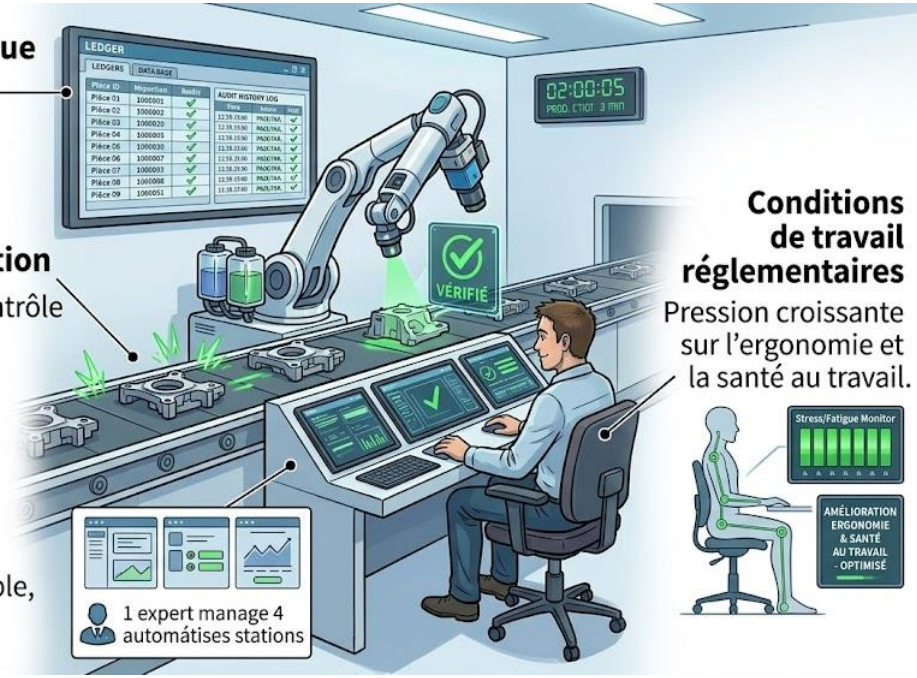
Exigences accrues d'historisation et d'audit qualité.

**Cadence de production**

Besoin d'intégrer le contrôle dans la ligne sans goulot d'étranglement.

**Pénurie de contrôleurs certifiés**

Démographie défavorable, formation longue, recrutement difficile.




**Conditions de travail réglementaires**

Pression croissante sur l'ergonomie et la santé au travail.

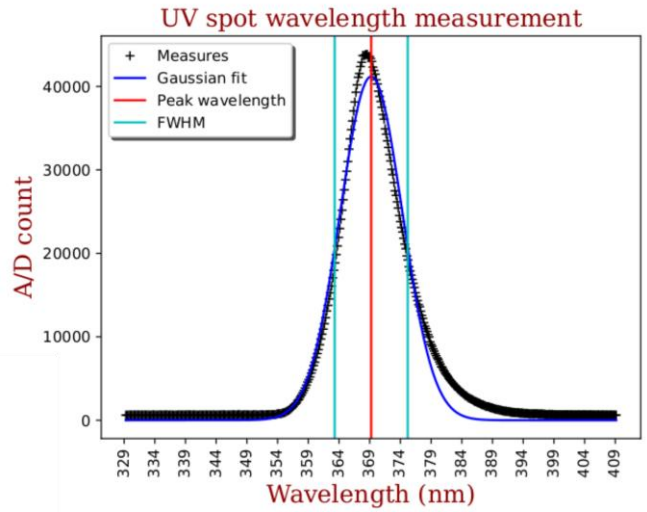
***Automation assisted by vision and AI addresses all these challenges simultaneously***

# PARADES at a glance

An integrated hardware + software platform dedicated to MT and PT inspections

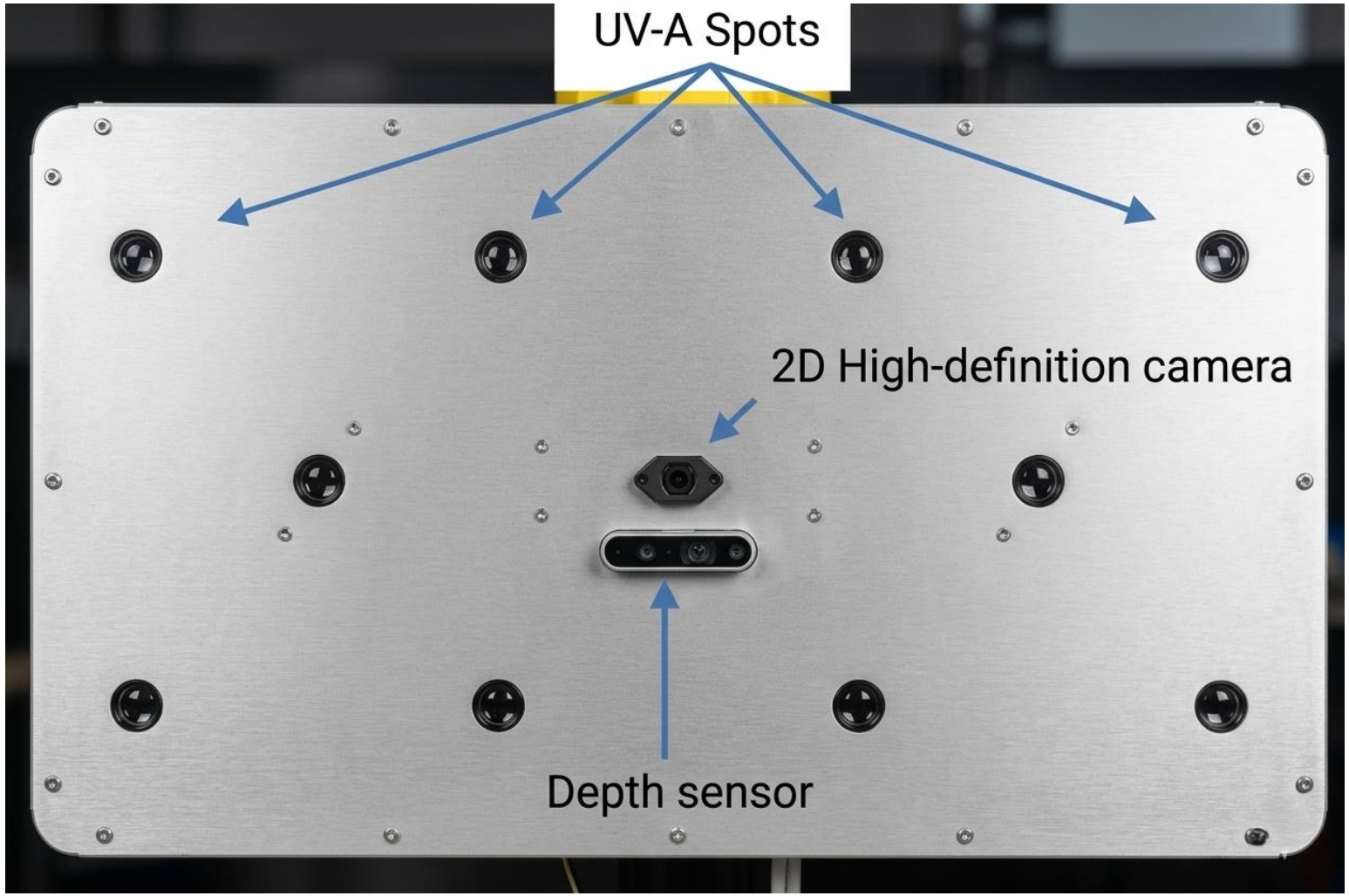
**PARADES** is an industrial solution that combines

- qualified UV-A lighting meeting the strict aerospace standard ASTM E3022




- a high-definition camera > 100 Mpx,
- an integrated 3D sensor
- an embedded computer running artificial intelligence models locally.

➔ All within rugged, industrial equipment, temperature-regulated to operate 24/7



# PARADES at a glance

An integrated hardware + software platform dedicated to MT and PT inspections

DETECT

## Automatic AI detection

Faster R-CNN network trained on an industrial dataset, qualified performance..

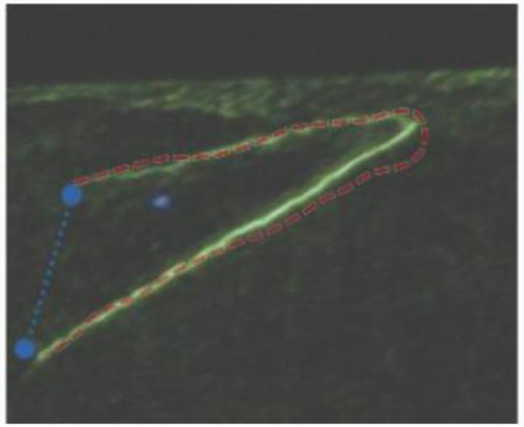
250 training images and 50 test images

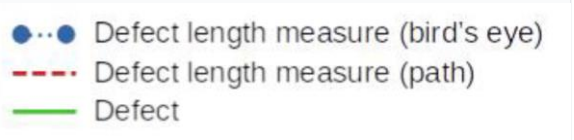
The diversity of parts is deliberately broad: forged, cast, machined and welded parts, with indications of the crack, shrinkage cavity, forging defect, or in-service mechanical-stress-induced defect type.

MEASURE

## 3D dimensional measurement

Length in mm on complex surfaces, independent of the part/camera distance.



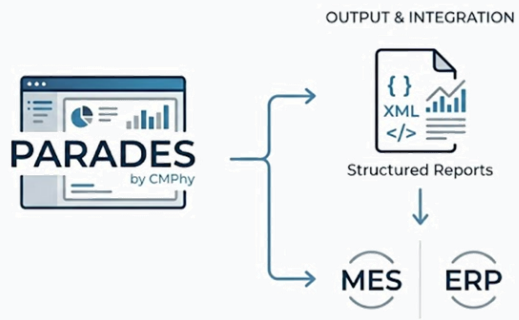



ARCHIVE

## Native traceability

Acquisitions and reports archived in a structured format (MES/ERP compatible).





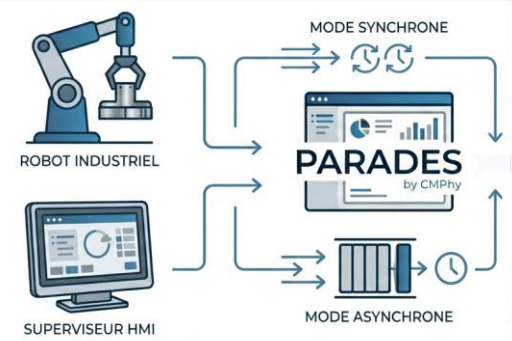

INTEGRATE

## API control

In-line integration via robot or supervisor,

**Synchronous mode** ➔ The robot sends an image to PARADES and **stops** until it has received the inspection result.

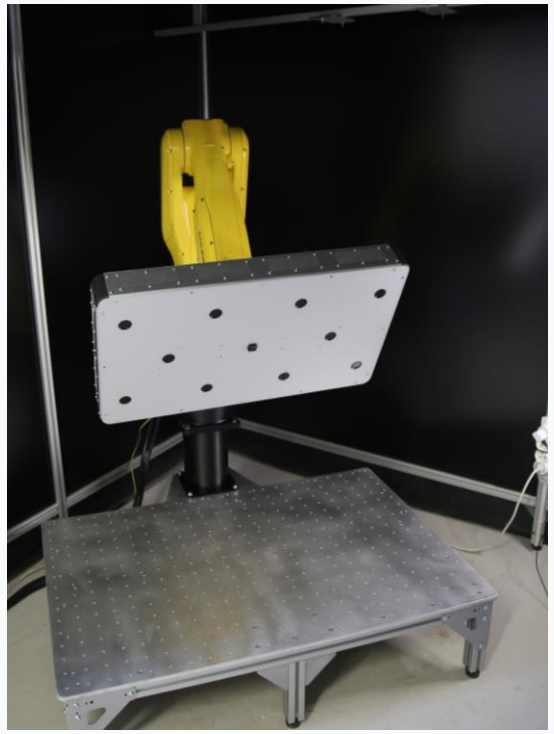
**Or asynchronous.** The robot sends the image into a queue (a "buffer") and **continues its work**



# Two formats, one shared technological core

Maxi for production lines, Mini for spot checks and field inspections

## PARADES Maxi



**Fully integrated vision head**

Power supply, computer, 365 nm UV lighting and cameras in a single enclosure.

**Large inspection area**

600 × 400 mm in a single view, up to 800 × 1200 mm in 4 captures.

**Robot automation via API**

Ideal for integration into an NDT production line: bench, rotating-field machine

➔ ***Specifically designed to inspect large surfaces quickly or a batch of parts positioned on a pallet***

*Series parts, large flat surfaces*

## PARADES Mini

**Remote vision head**

Head with 365 nm UV lighting/cameras + separate electronics box for great maneuverability, with computer, screen and keyboard

**Compact format**

300 × 400 mm area — small and medium-sized parts / **IP54** = protection against **dust** + **water splashes**

**Spot checks and field inspections**

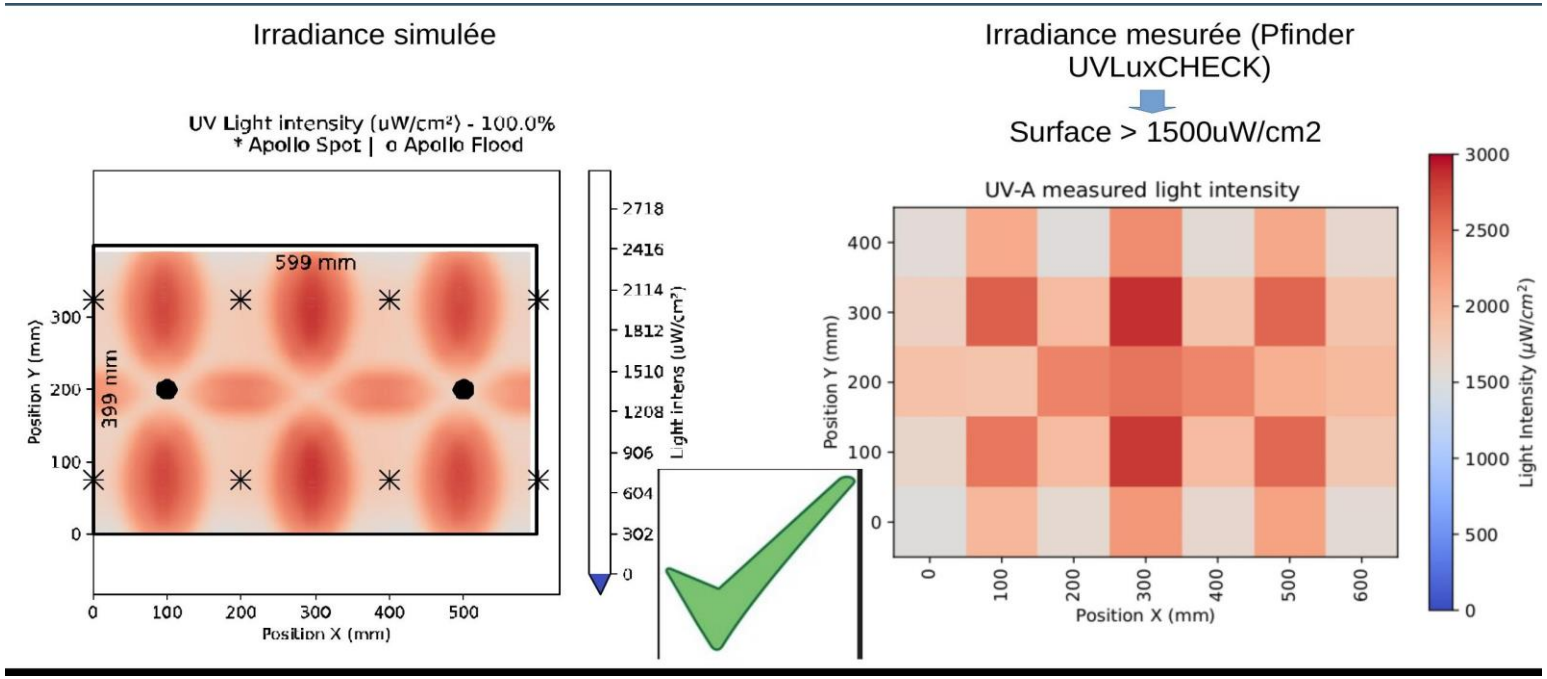
Suited to interventions in restricted-access areas.

*Field inspection, hard-to-reach areas, portable, rugged, easy to handle*

# Qualified UV-A lighting

Compliance with the strictest aerospace requirements — ASTM E3022, ISO 3059

| 369 nm | 11 nm | > 1500 | 100% |
|---|---|---|---|
| **Spectral peak** | **FWHM** | **µW/cm²** | **Compliant area** |
| *Target 365–370 nm* | *< 20 nm required* | *Over 600 × 400 mm* | *Validated by measurement* |




*Spatial qualification by simulation and measurement*

## Qualification methodology

**1. Spectral characterization**
Calibrated Hamamatsu spectrometer (1 nm res.)

**2. Angular LED characterization**
Dedicated bench, Pfinder UVLuxCHECK radiometer

**3. Proprietary simulation**
Automatic optimization of LED placement

**4. Experimental validation**
Measurement on a 600 × 400 mm grid

➔ UV lighting simulation software integrated into the PARADES software

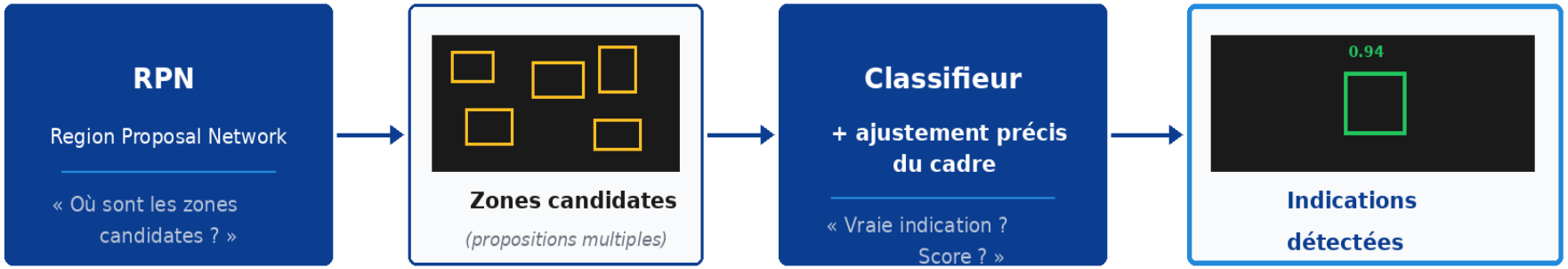
# Automatic detection by artificial intelligence

Faster R-CNN network specifically adapted to fine indications

## ÉTAGE 1 — EXTRACTION DE CARACTÉRISTIQUES


*utilise la même carte*

## ÉTAGE 2 — DÉTECTION & CLASSIFICATION




*L'architecture en deux étages — proposer largement, puis filtrer finement — est la clé de la performance sur les indications de très petite taille.*

## Why Faster R-CNN?

### The challenge

Detecting indications representing 1/10,000th of the image area, on 100+ Mpx.

### The choice

Two-stage architecture: propose broadly, then filter finely — the key to performance on very small indications

**Architectures ruled out:** YOLO (lacks finesse) and DETR (sensitive to residual lighting variations).

### Industrial learning

1) We start from the AI developed with a broad panel of parts and indication types

2) Data acquired with PARADES; the operator annotates the indications not spotted by the AI + multiplying images by rotation/symmetry ➔ the AI / neural network is specialized for a panel / type of part

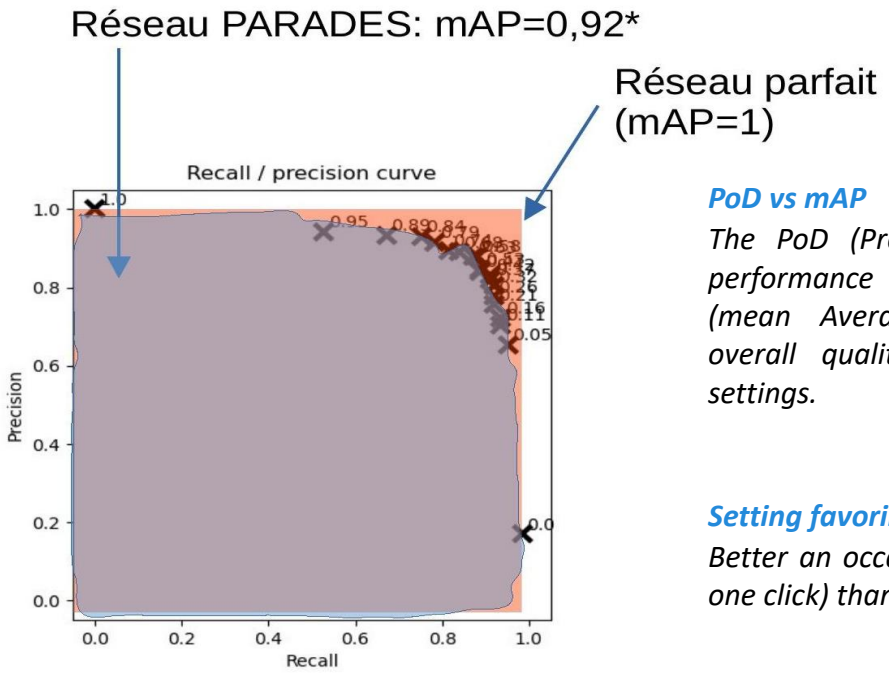
➔ **Neural network specialized and dedicated to a typology of parts and a panel of defects**

➔ **Specializing the AI like a more experienced inspector**

# Qualified performance

Evaluation on an independent test set — data never seen during training

| 91% | 0.42 | 0.92 | < 1 mm |
|---|---|---|---|
| **Probability of detection** | **False positives per image** | **mAP** | **3D measurement error (MAE)** |
| *Out of 100 defects present, 91 are detected* | *≈ 1 false alarm every 2–3 images* | *Out of 1.00 — close to ideal performance* | *On 20 / 30 / 50 / 60 mm standards* |




***PoD vs mAP***

*The PoD (Probability of Detection) is the performance at a given setting The mAP (mean Average Precision) measures the overall quality of the model, across all settings.*

***Setting favoring sensitivity***

*Better an occasional false alarm (removed in one click) than a missed defect.*

## Assistive mode

**The final decision always rests with the COFREND-certified inspector.**

A false alarm is removed in one click — with no impact on inspection quality.

A missed defect, on the other hand, would be far more penalizing. The setting deliberately favors sensitivity.

# 3D dimensional measurement

Real length in millimeters, independent of the part geometry

**1**

## 2D operator trace

The inspector traces the indication on the acquired image, in a few clicks.

**2**

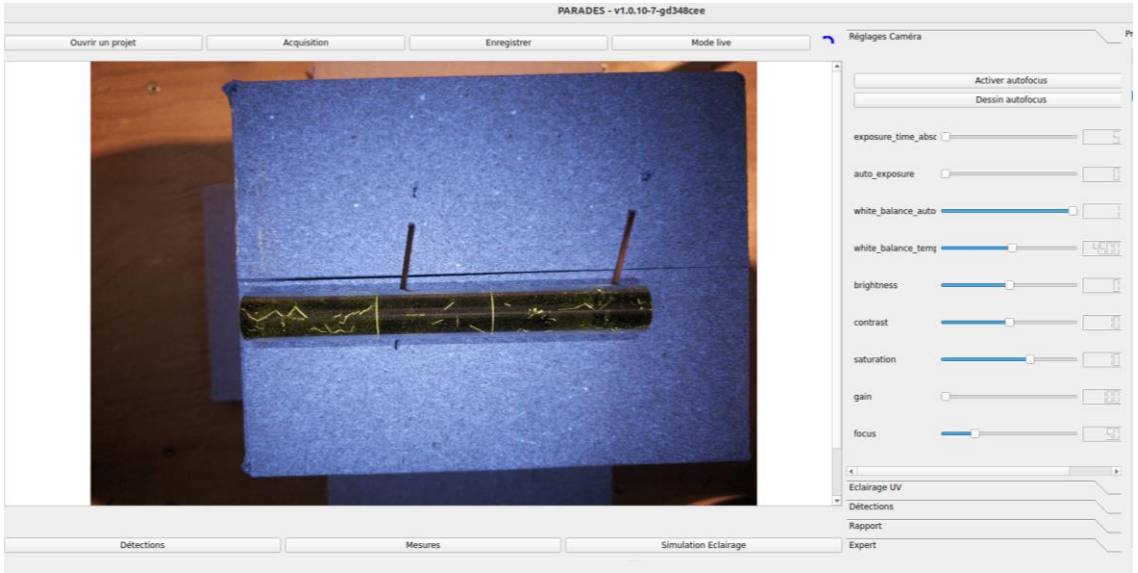
## 3D reconstruction

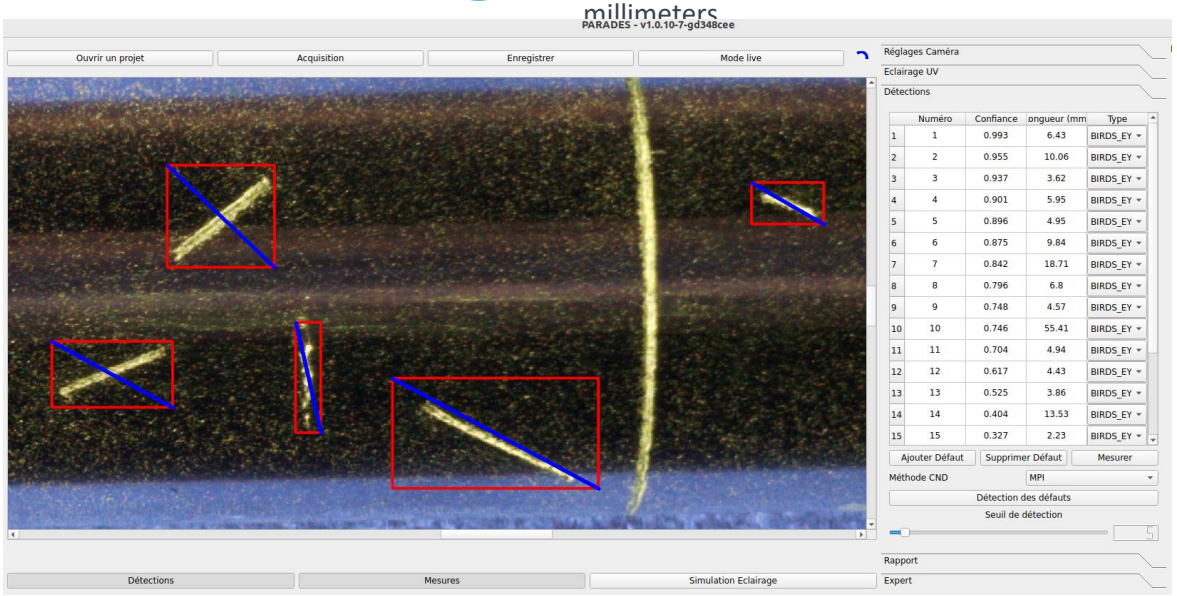
Each point of the trace is repositioned in real space using the depth sensor.

**3**

## Euclidean measurement

The length is computed in the real coordinate frame — not in the image — in millimeters




## Metrological qualification

| Standard | 20 mm | 30 mm | 50 mm | 60 mm | Overall error |
|---|---|---|---|---|---|
| **MAE** | < 1 mm | < 1 mm | < 1 mm | < 1 mm | < 1 mm |
| **Relative error** | 0 – 6% | 0 – 5% | 0 – 3% | 0 – 2% | ≤ 6% |

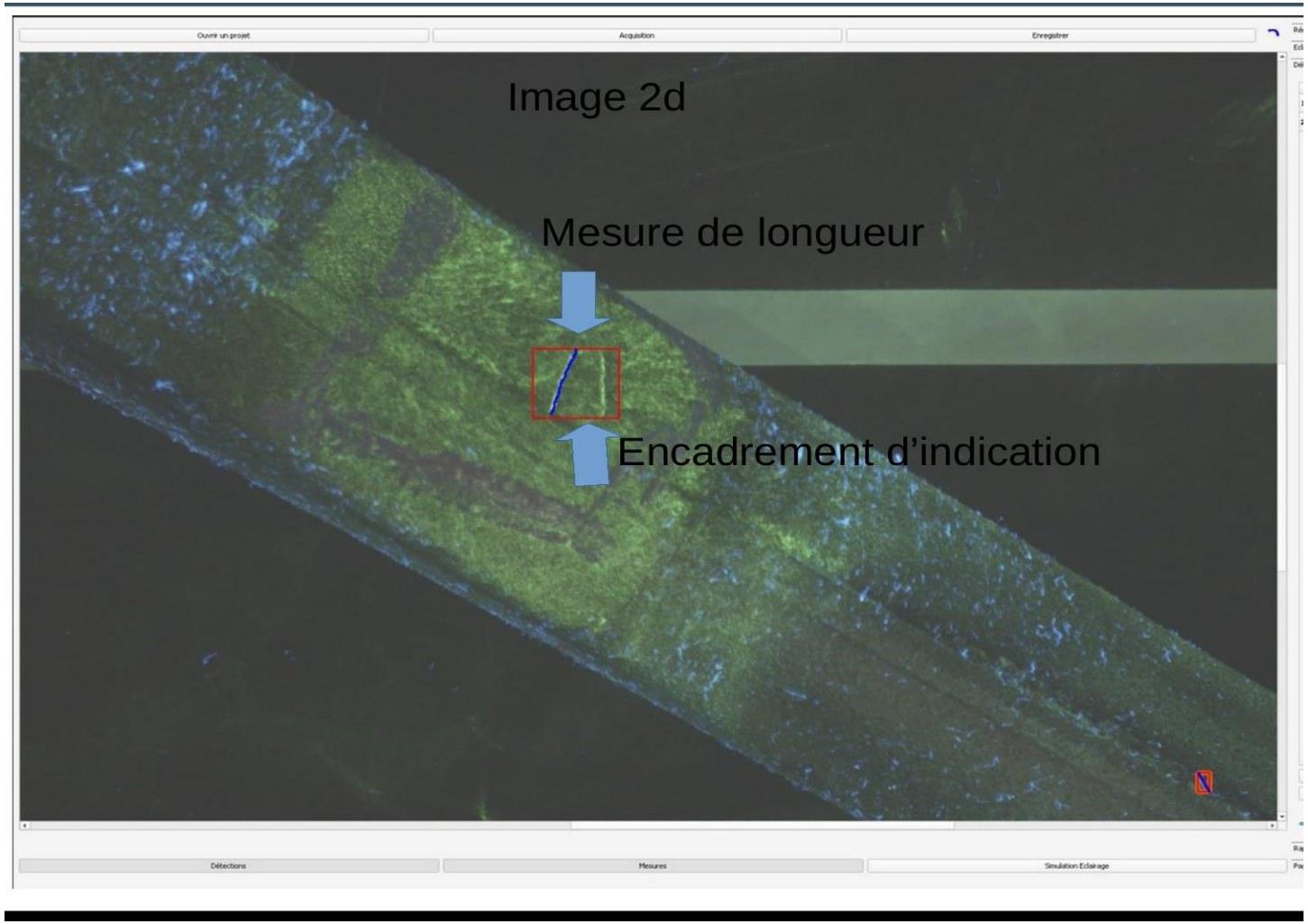
*Specifications met: targeted MAE < 1 mm on curved surfaces — compliant with industrial requirements*

# CMPhy

MESURES PHYSIQUES

# Application software

The entire inspection chain in a single interface




*PARADES interface — acquired image, boxed indications, measurement*

## Software capabilities

### AI acquisition & detection

2D image + 3D map, automatic boxing of indications

### Interactive measurement

As-the-crow-flies mode or curvilinear trace, length in mm

### NDT project management

Tree structure by part, batch, operator, equipment

### Report generation

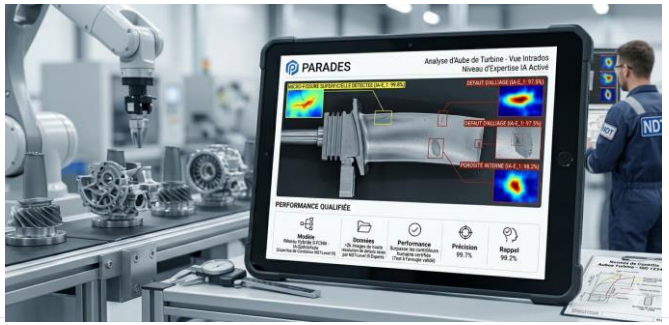
Structured format, MES / ERP compatible

### Synchronous & asynchronous modes

Acquisition in a confined area, remote analysis

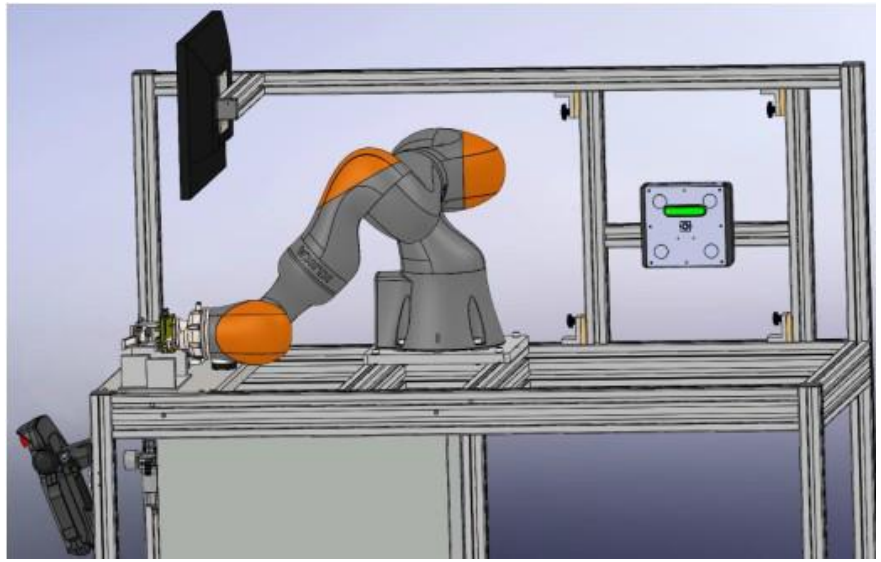
### Multi-platform & API

Linux, Windows, macOS — control by robot or supervisor

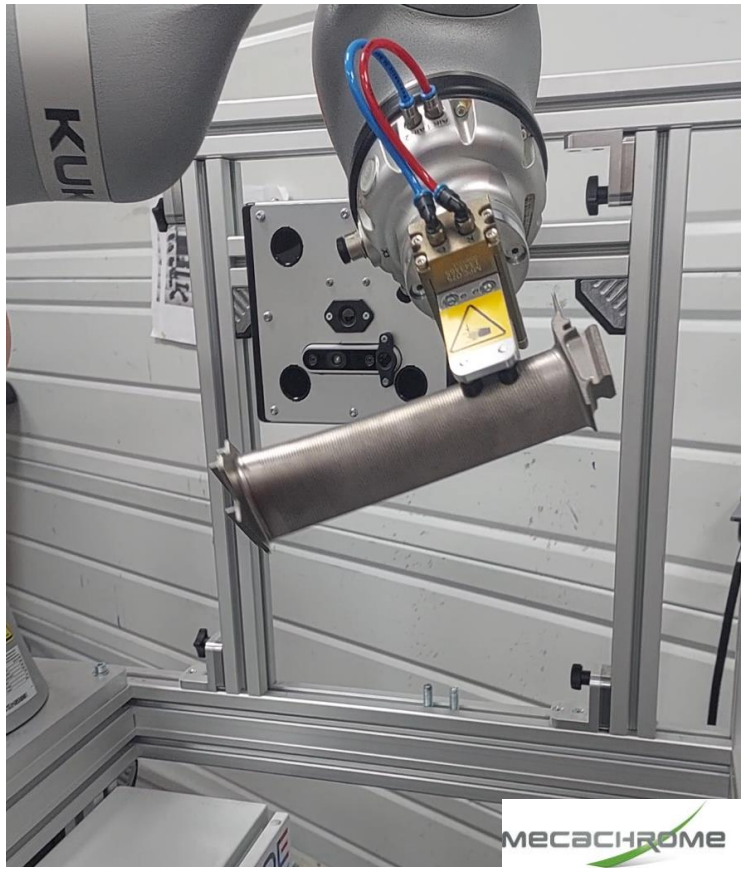


# Application case — Aerospace

Automated penetrant testing on engine turbine blades



*Parts moving in front of the system; the PARADES vision system is fixed*




➔ *High-quality-requirement parts, series production, aerospace certification*

Nadcap

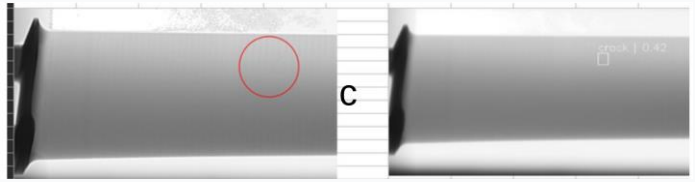
## Performance under real conditions

### Penetrant Testing

PoD: 79% — continuously improving

### Digital radiography

PoD: 90% • False positives: 0.27 / image




### Integration

Control by collaborative robot via API

### Industrial benefit

Automated cycle, native traceability, operator focused on borderline cases

*Engine turbine blades — integration on a robotized station*

# Application case — Hydropower

Magnetic particle testing on large parts, in an atypical environment

*Intervention beneath a turbine, in a humid and cramped environment*

## Dedicated adaptations

**IP54 rating** — protection against dust and water splashes

**Repeatable mechanical mount** — reproducible positioning in hard-to-reach areas

**“All-terrain” version** — system mounted on a 4×4 vehicle for on-site interventions

## Functional qualification

### Detection target

Indications 6 mm long • 1.5 mm deep

### Normative framework

Approach compliant with the European technical report **CEN/TR 14748**

*Recognized methodology to formally qualify an NDT method*

### Industrial benefit

Inspector in a comfortable area, objective and archived measurements

# Roadmap

PARADES is evolving towards an autonomous multi-method inspection platform

## AREA 1 — Multi-method NDT software platform

### Dedicated modules per method

Penetrant Testing (PT) — Magnetic Particle Testing (MT) — Digital Radiography (RT) — Visual Testing (VT)

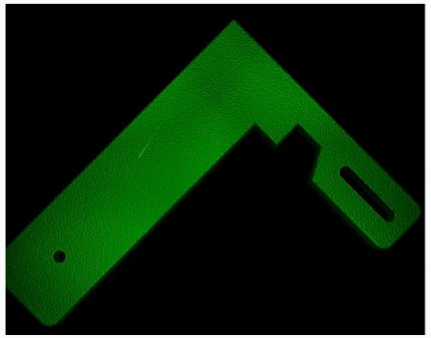
### Pre-trained AI model

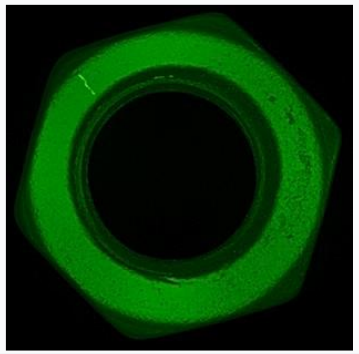
A “ready-to-use” foundation from commissioning, with a representative panel of parts.

### Specialization by the manufacturer

The user annotates their own images and triggers a re-training on their parts. The detector becomes increasingly effective with use, while remaining the property of the customer.

PARADES Simu: From a CAD model or a 3D scan of a part, it is possible to set the surface roughness and texture, insert artificial defects from a library, then simulate the UV-A lighting and the induced fluorescence





## AREA 2 — Autonomous robotization & next best view

### 6-axis robot

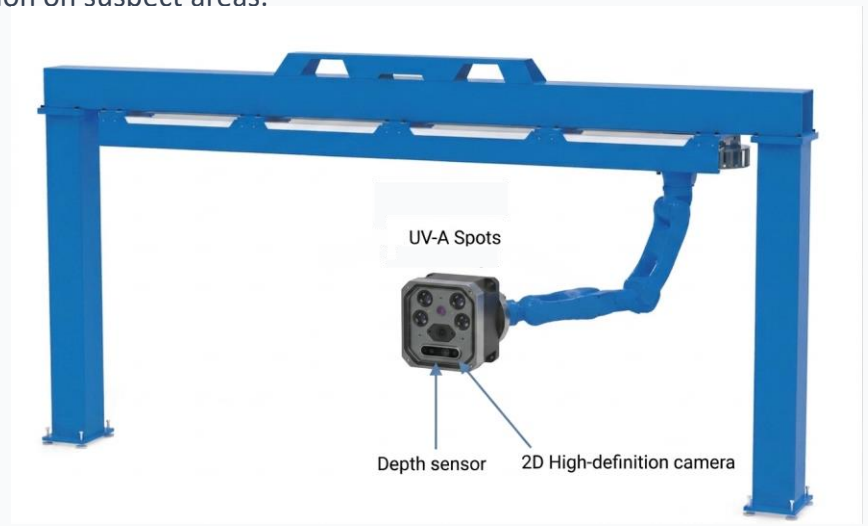
Extended mobility — access to complex geometries.

### Next best view strategy

From an unknown part, the system decides on its own the best capture views: lighting, distance, angle, accessibility.

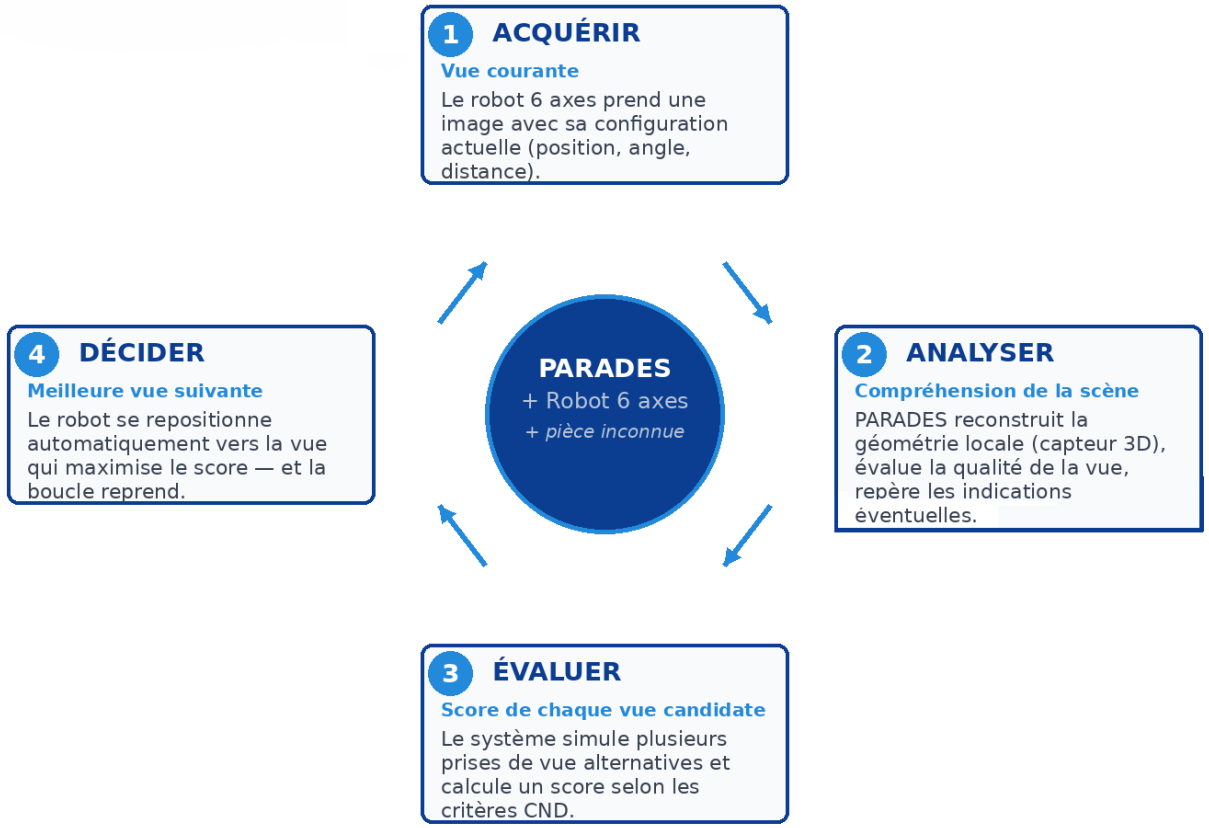
### Large parts

Up to 4–5 m on a rail or mobile base. Two-pass strategy: fast scanning, then fine local investigation on suspect areas.



# Next Best View — focus

The autonomous image-capture logic applied to MT and PT inspections




## Les critères évalués pour chaque vue candidate

*Exactement ceux qu'un contrôleur certifié appliquerait — encodés dans l'algorithme*

| INTENSITÉ UV-A | DISTANCE | ANGLE DE VUE | ACCESSIBILITÉ | RECOUVREMENT |
|---|---|---|---|---|
| **≥ 1500 µW/cm²** | **Plage utile** | **Quasi-normal** | **Trajectoire libre** | **Zones non vues** |
| Validée sur la zone visée (simulation 3D) | Caméra à la bonne distance — ni trop près, ni trop loin | Limite reflets et indications perdues en biais | Vérifie congés, zones d'ombre, collisions robot | Priorise surfaces non couvertes par la caméra |

## Why it matters

### Reproducing the inspector's know-how

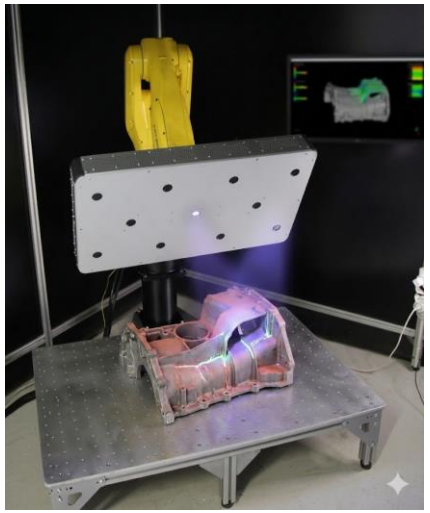
The quality criteria for an MT or PT capture are well known to certified inspectors. PARADES encodes them in its decision algorithm.

### Inspecting an unknown part

No prior programming needed: the system discovers the geometry in real time and adapts its trajectory.

### Guaranteed exhaustive inspection

The overlap criterion ensures no surface is missed — including complex areas (fillets, connections, undercuts).



# Why not test PARADES on your parts?

On-site demonstration, equipment loan, feasibility study on real parts, co-development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