

FANTOM Project Overview

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InfraTec



- Introduction - Motivations
- Basic Principles
- FANTOM idea
- Implementation
 - Main project figures
 - Consortium
 - Workpackages
 - Results
 - Current-future works
- Conclusion

- FANTOM addresses
 - Inspection activities
 - During Development Phase of Aircraft
- In particular :

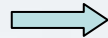
**Elements thermo-mechanical
behaviour assessment**

Structural testing

Defect detection

Elements thermo-mechanical behaviour assessment

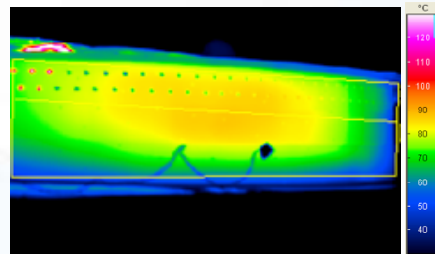
- Deformation
- Dilatation
- Coeff. Thermal Expansion
-



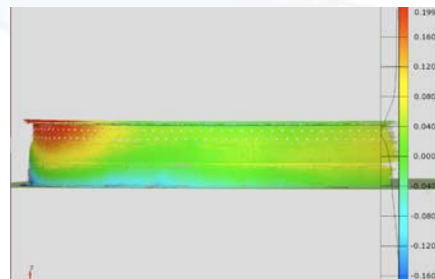
Structural testing

- Need of simultaneous measurement of*
- Temperature
 - Shape change

Defect detection

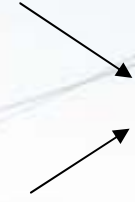


Temperature Measurement



Displacement Field Measurement

Comparison with Finite Element Analysis



Elements thermo-mechanical behaviour assessment

- Fatigue test
- Static loads
- Ultimate loads
-



Strain measurement by local strain gauges

Structural testing



Thermography for stress analysis

⇒ Observe start of damage

Displacement measurement by displacement transducers or non contact 3D optical systems



Elements thermo-mechanical behaviour assessment

Detection of defect :

- Element undergoes stimulation
 - thermal
 - static
 - dynamic
- Observation of local behaviour

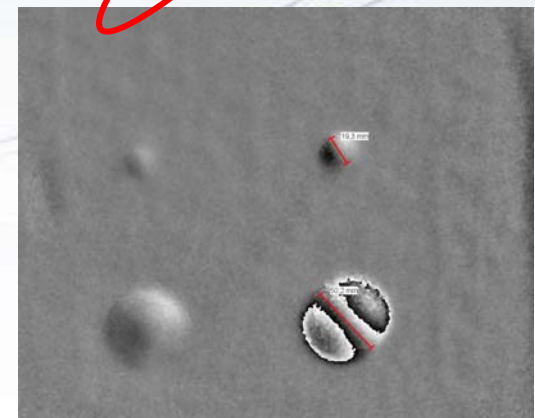
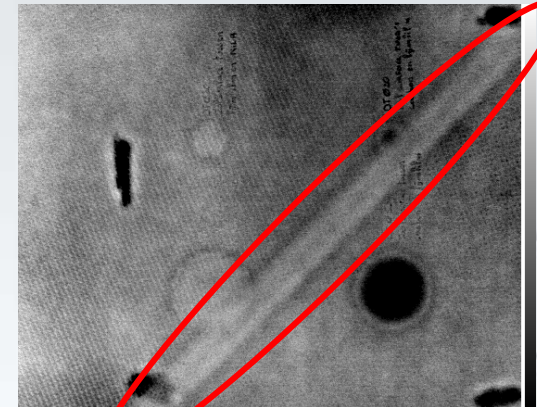


Structural testing

Thermography :
Local Temperature change

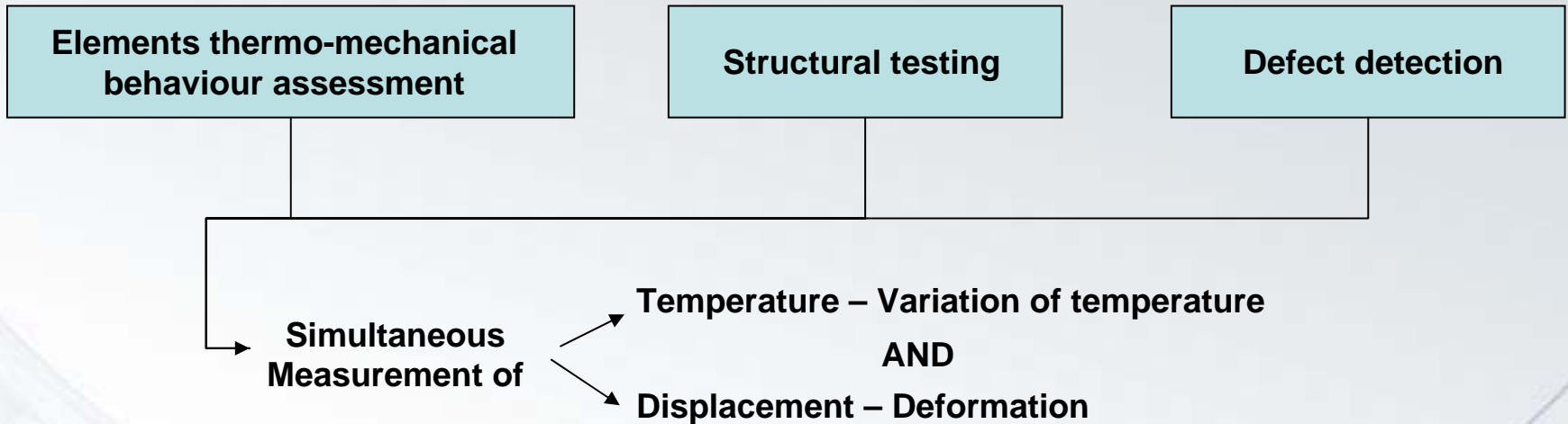
Holography/Shearography :
Local deformation

Defect detection



Techniques are complementary

- Features appear or not
- Features can prevent defect identification



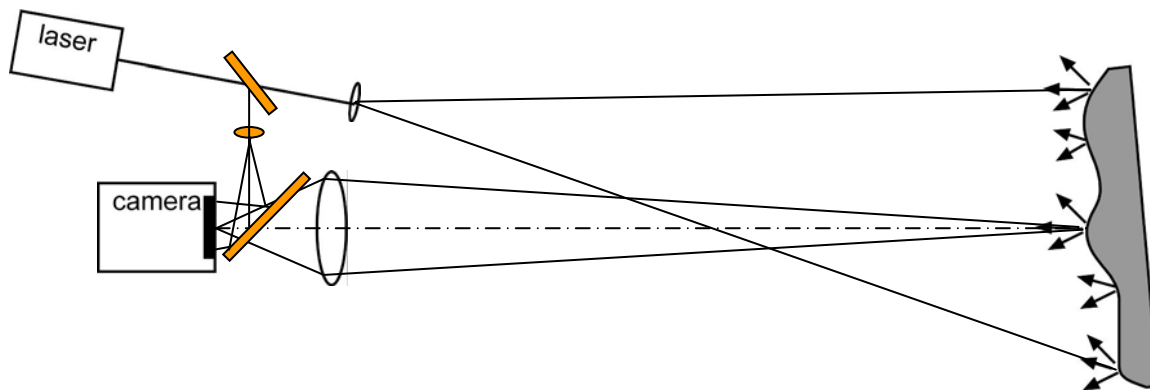
FANTOM : Full-Field Advanced Non-Destructive Technique for Online Thermo-Mechanical Measurement on Aeronautical Structures

- ✓ Combined Holography-Thermography
- ✓ Single Full-Field Sensor
- ✓ Simultaneous capture of Temperature-Displacement
- ✓ Each image element carries both information

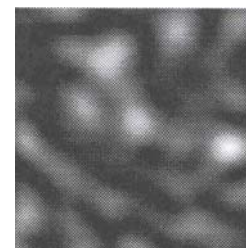
HOW ?

Holography in Long Wave InfraRed (LWIR) range

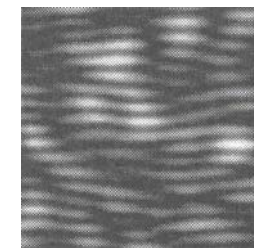
- Holography / Electronic Speckle Pattern Interferometry



Zoom of recorded intensity pattern



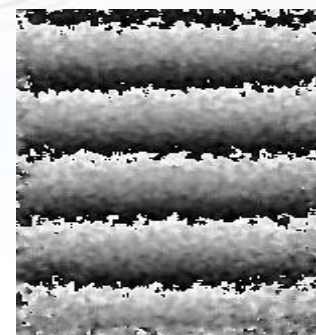
Zoom of local interference pattern $I(x,y)$



$$\text{Time } t_1: I_1(x, y) = I_{average,1}(x, y) + C_1(x, y) \cos[\psi(x, y)]$$

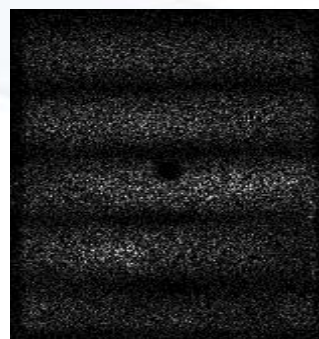
$$\text{Time } t_2: I_2(x, y) = I_{average,2}(x, y) + C_2(x, y) \cos[\psi(x, y) + \Delta\phi(x, y)]$$

Displacement Map



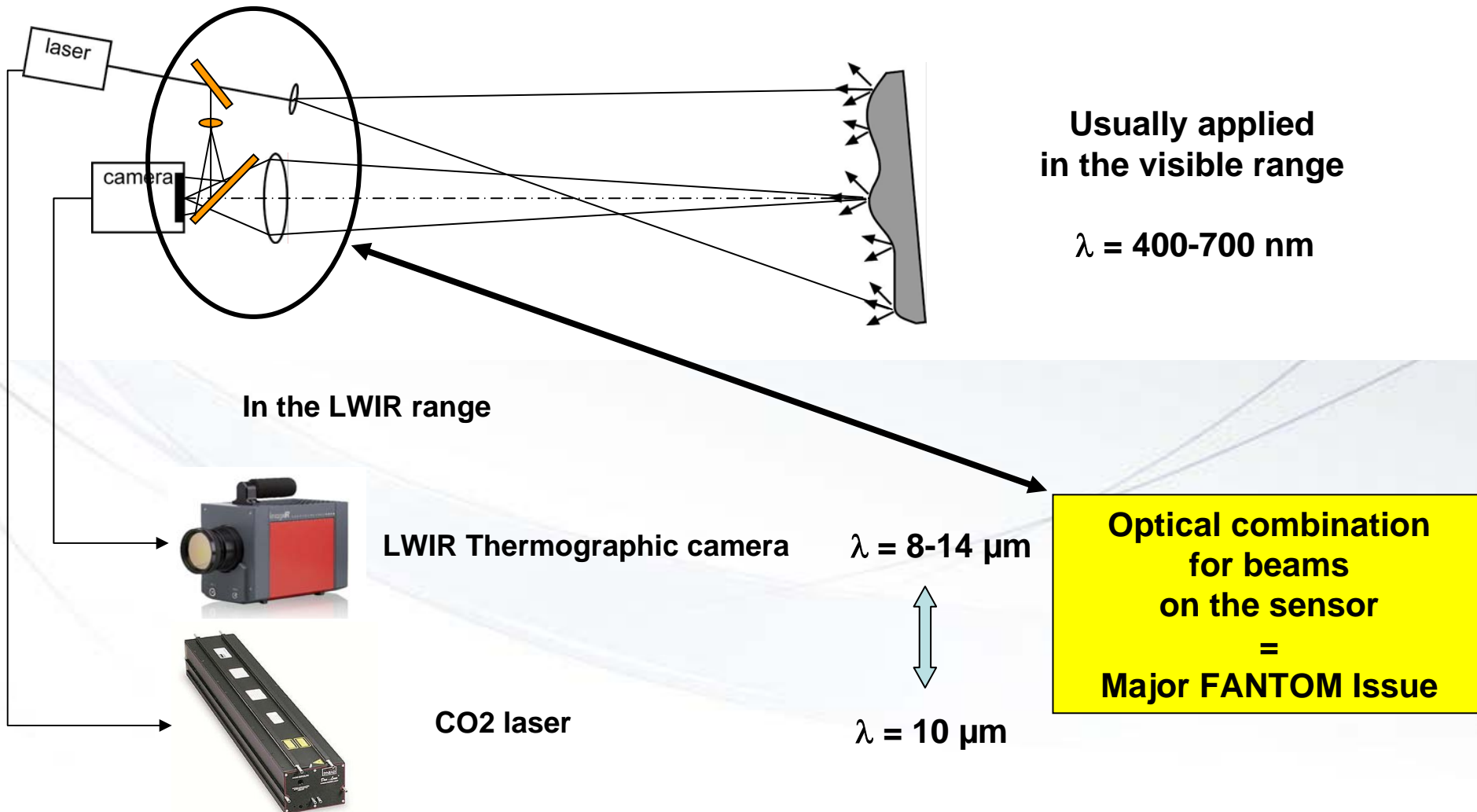
$\lambda/2$
 λ
 laser wavelength

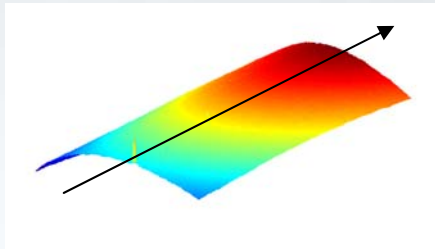
$$|I_1 - I_2|(x, y) \div \sin\left[\frac{\Delta\phi(x, y)}{2}\right]$$



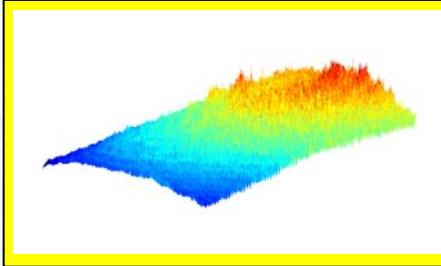
$\Delta\phi(x, y)$

- Holography / Electronic Speckle Pattern Interferometry

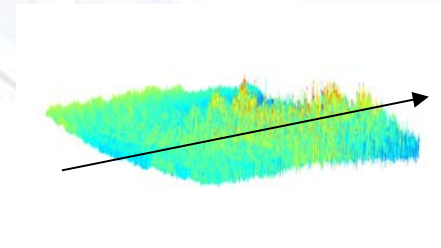




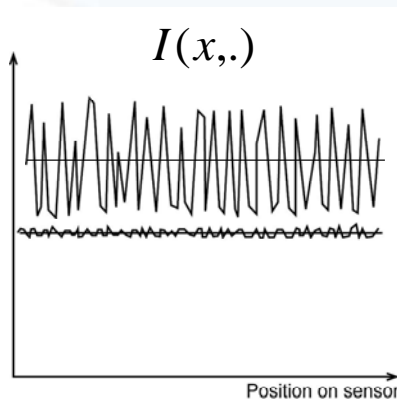
$$I(x, y) = I_{\text{thermal}}(x, y)$$



$$I(x, y) = I_{\text{thermal}}(x, y) + I_{\text{average}}(x, y) + C(x, y) \cos[\psi(x, y)]$$



$$I(x, y) = I_{\text{average}}(x, y) + C(x, y) \cos[\psi(x, y)]$$



→ Hologram













→ Thermal background

**Decoupling both
=
Major FANTOM Issue**

FP7 – Call 1 Transport (Aeronautics)

- **THEME AAT.2007.4.1.1.**
- **Aircraft Development Cost - Design Systems and Tools**

- **Duration : 36 months**
- **Start : Dec 1, 2008**
- **End : Nov 30, 2011**
- **EC grant : 1.7 M€**

Partner	Country	Profile
Centre Spatial de Liège Université de Liège 		Coordinator – University Research Centre Development/application of non destructive testing techniques
Institut für Technische Optik Universität Stuttgart 		University Research Centre Specialist of Holography
InfraTec GmbH 		SME – Development of Thermography system and applications
Centro de Tecnologias Aeronauticas 		Research Centre Specialist of Non Destructive Testing – Structural Tests
Optrion S.A. 		SME – Development of Holography system and applications
Innov Support 		SME – Servicing partner

WP1	Specifications	
WP2	Conceptual design	
WP3	Developments	
WP4	Samples	
WP5	Prototype building	
WP6	Industrial validation	
WP7	Dissem-Exploitation	
WP8	Management	

WP1 :

- ✓ Establish State of Art of Technique/Components
- ✓ Establish End Users Requirements
- ✓ Cross both
- ✓ Establish Specifications

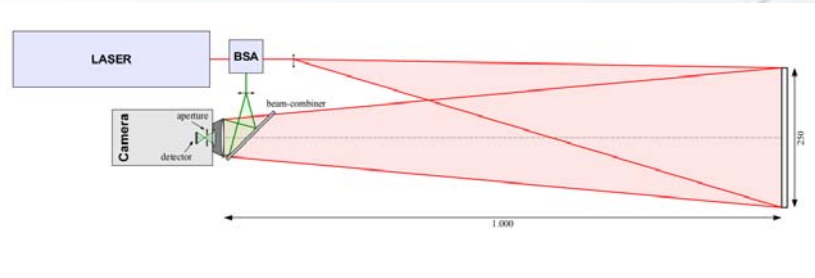
With help of
Club of End-Users :



WP1	Specifications	
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WP2 :

- ✓ Concept of set-up
- ✓ Choice of critical components :
 - Laser
 - Camera sensor/technology



Cooled 640x512

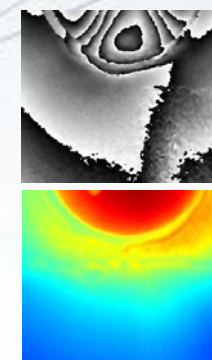
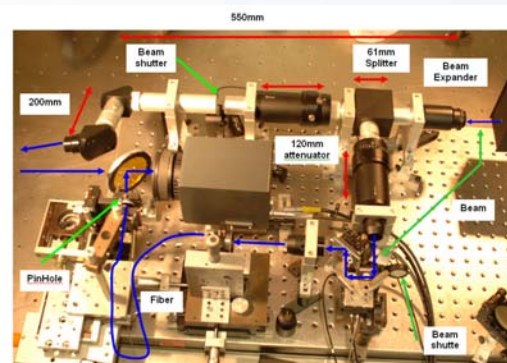
↔
Wavelength ?



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WP3 :

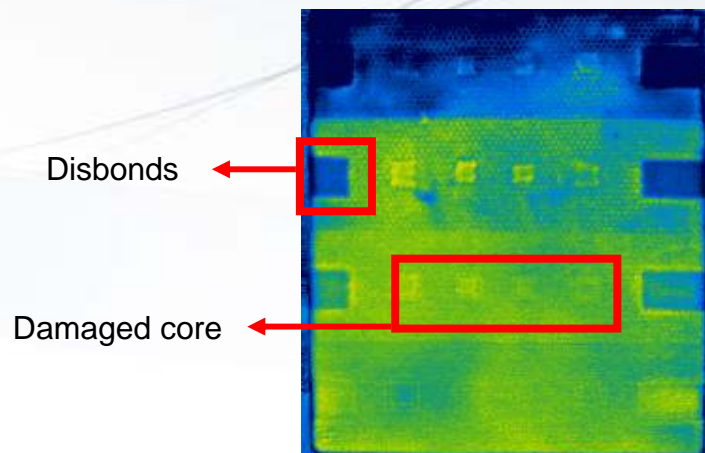
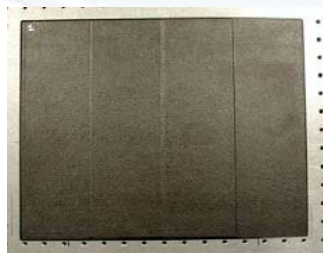
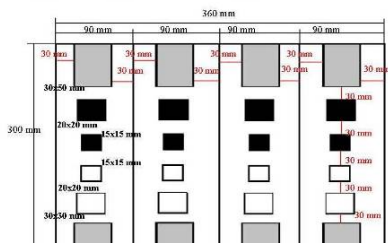
- ✓ Study of Techniques
- ✓ Developments of new High Resolution Camera
- ✓ Decoupling Thermal-Deformation signals



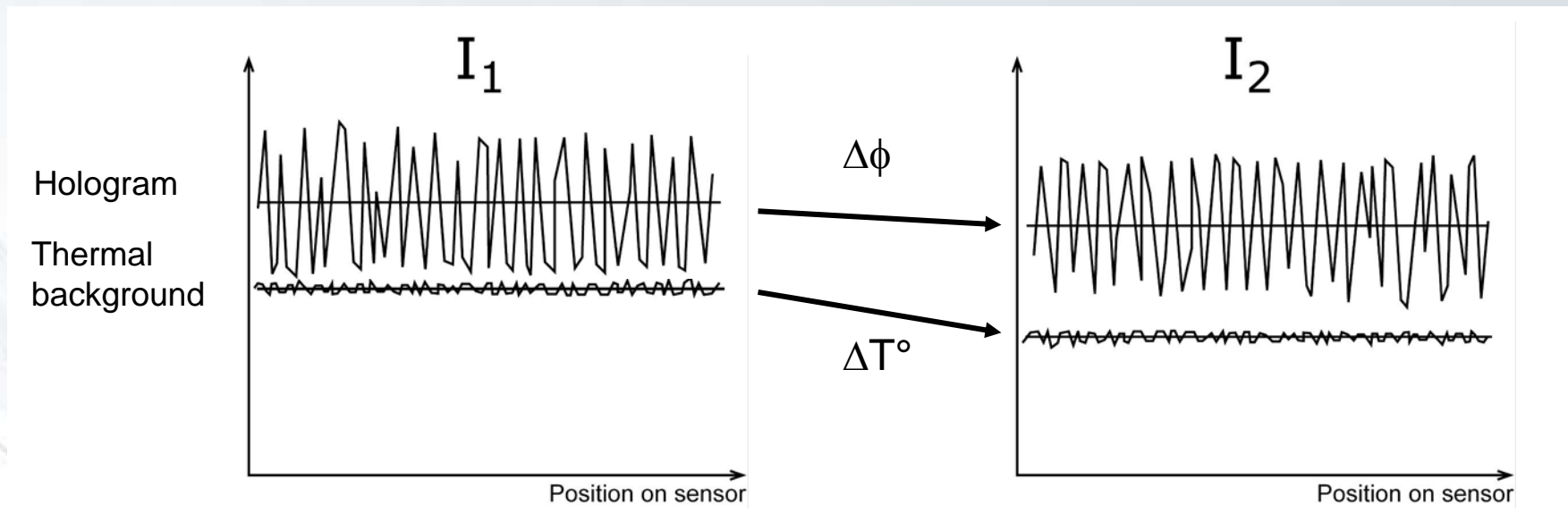
WP1	Specifications	
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WP4 :

- ✓ Building of samples
 - ✓ Various materials : CFRP, Kevlar, Glass fibers
 - ✓ Various defects
- ✓ Certification by other NDT techniques



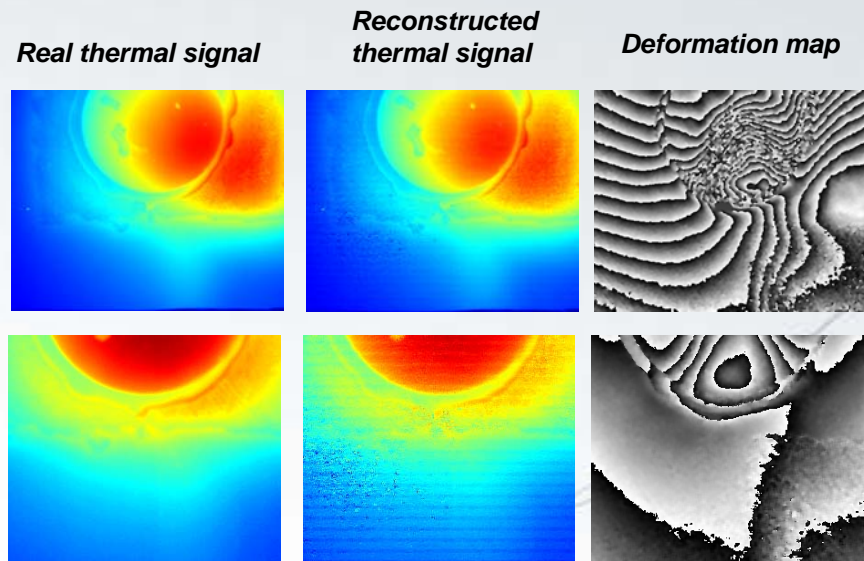
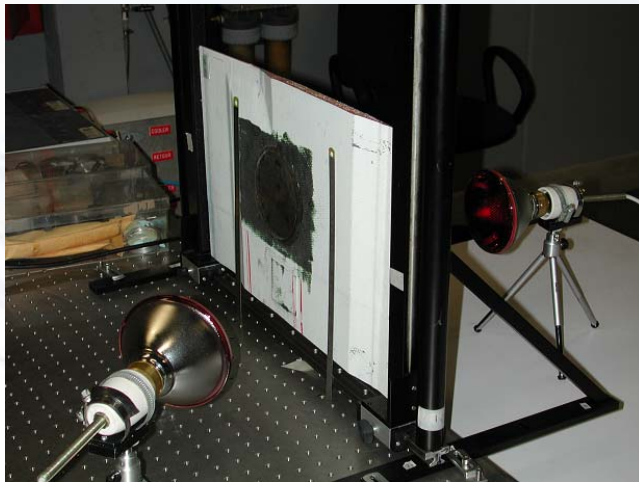
- Decoupling temperature and deformation



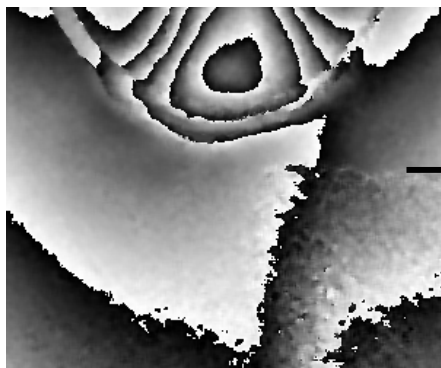
Isolate specklegrams from thermal background

- Separate acquisition of thermogram (laser OFF) and specklegram (laser ON)
 → Not perfectly simultaneous
- Use specific algorithms to recalculate thermogram from specklegram
 → Simultaneous

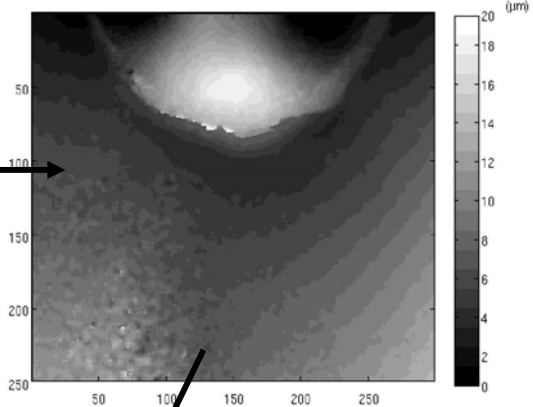
- Decoupling temperature and deformation



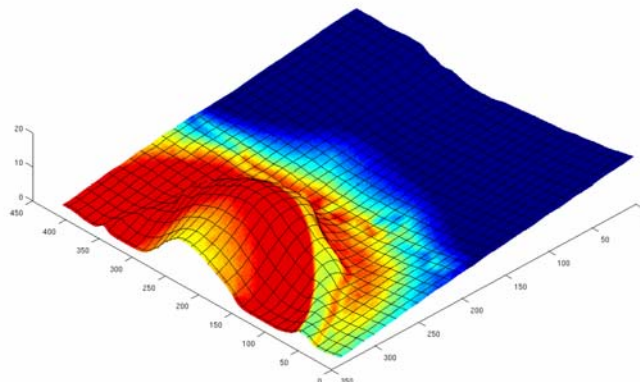
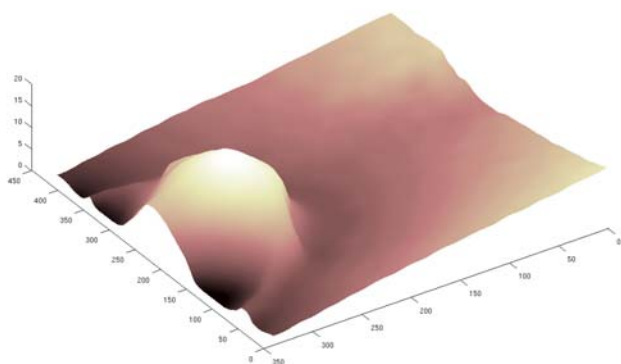
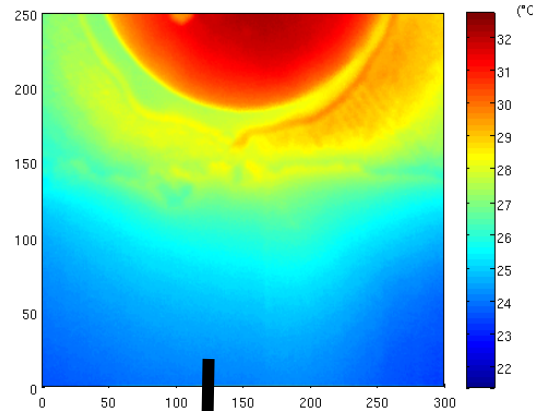
Phase variation (modulo 2π)



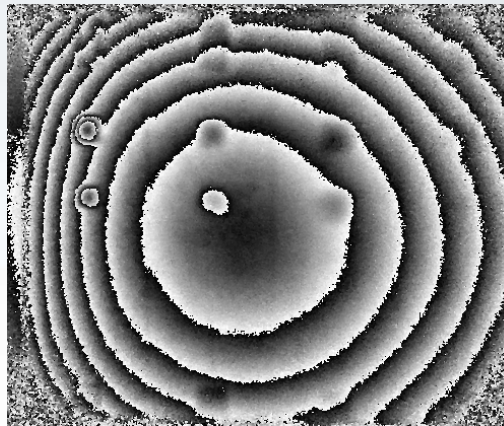
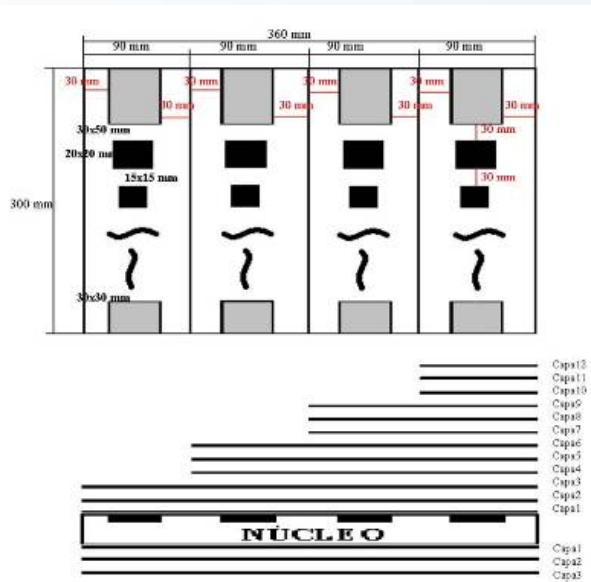
Deformation



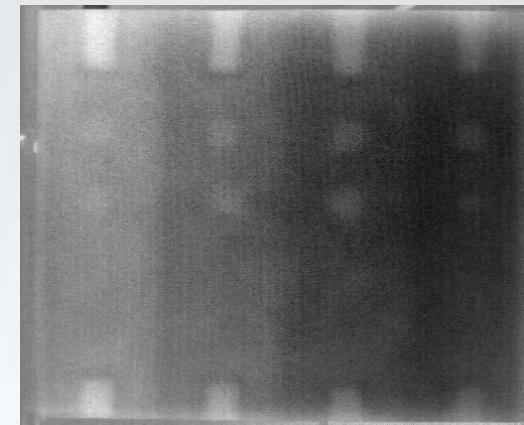
Temperature variation



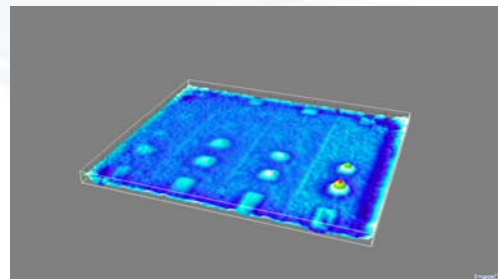
- Defect detection
 - CTA sample
 - Halogen Heating



Temperature Map



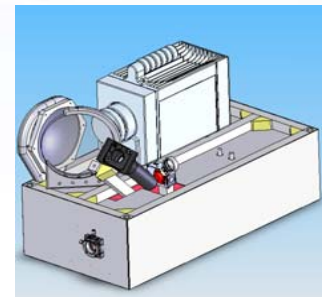
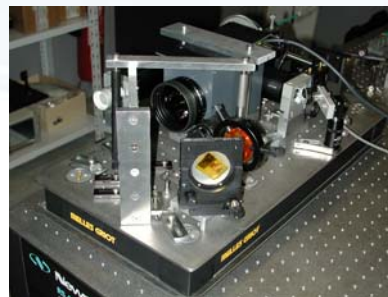
Deformation map



WP1	Specifications	
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WP5 :

- ✓ Concept of prototype
- ✓ Building of prototype
- ✓ Validation at CTA (NDT, Structural testing)



- Performances (2 options)

Uncooled - μ Bolometers



VarioCAM hr from JENOPTIK

- *640x480 pixels*
- *Frame rate : 50 Hz (rolling frame)*
- *NETD : <50 mK*
- *Displacement : 1 μ m to 100 μ m*

Cooled - MCT



ImageIR LWIR from INFRATEC

- *640x512 pixels*
- *Frame rate : 100 Hz (full resolution - snapshot)*
- *Integration : can be 1 μ s*
- *NETD : <25 mK*
- *Displacement : 1 μ m to 100 μ m*

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WP6 :

✓ Industrial validation at Airbus (Structural testing) – D41 - Toulouse



We have shown

- Combination Holography-Thermography in single sensor
- Simultaneity of both information feasible

Benefits for inspection capabilities in aircraft development

- Gain in inspection time
 - 1 system instead of 2 systems
- Better correlation between both information
 - No need of post-processing for images superposition
- Complementary techniques for defect detection in single sensor
- Could be used out of laboratory conditions

Thanks for Your Attention !

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Thanks to FANTOM collaborators



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