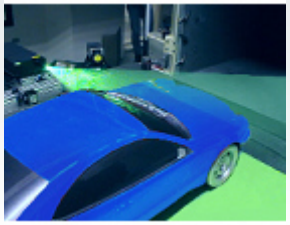
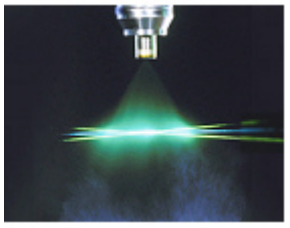
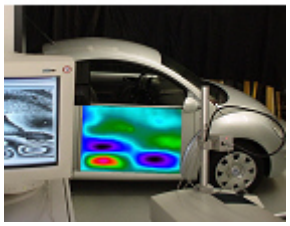
Advanced Optical Measurement Technologies for NDE

Partners for progress

Wind turbine related applications

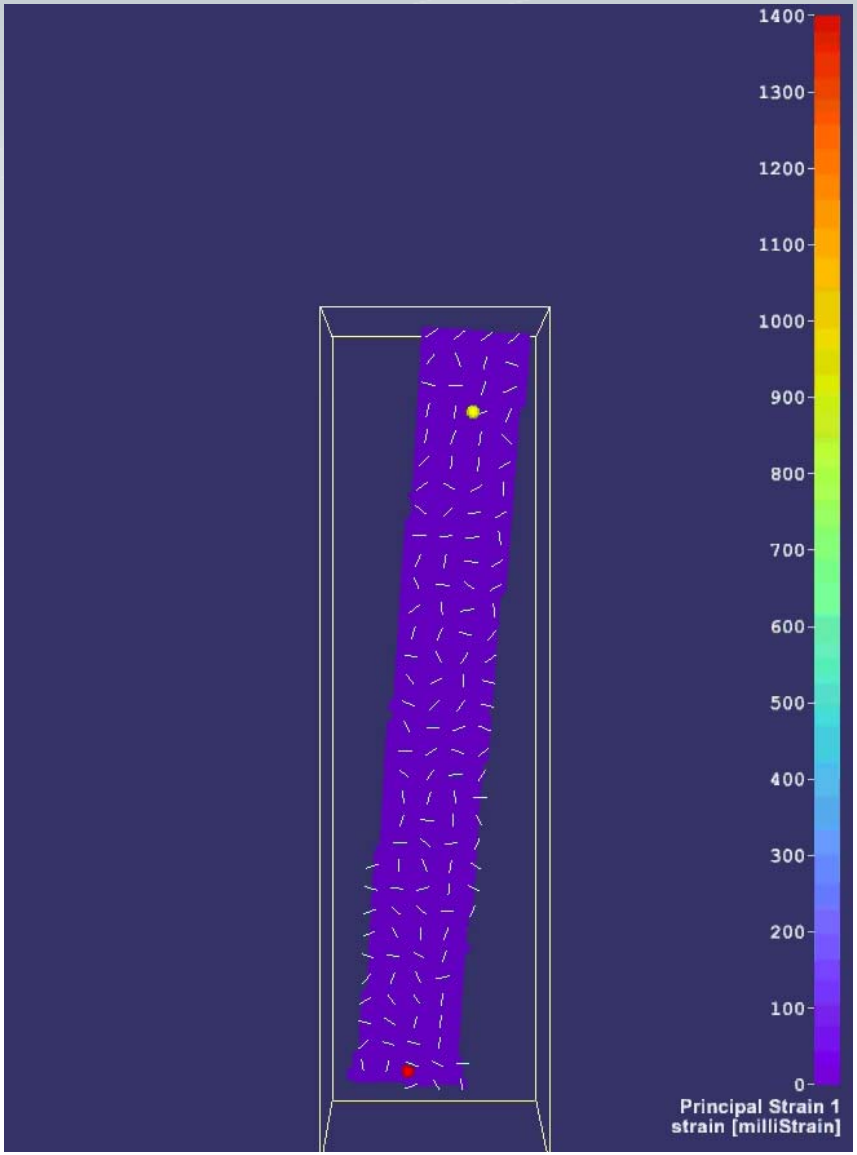
- Full field flow around an airfoil
- Measurement of
  - turbulence intensity, wake deficit, dissipation
- Fluid-structure interaction
- Flow induced vibration
- Flow separation
- Stress and strain field on turbine blades under static and dynamic loading
- Validation of finite element algorithms
- Detection of defects “waving/ wrapping “in composite materials



DANTEC DYNAMICS

Partners for progress



Partners for progress

Product portfolio

- Flow visualization
- Hot wire anemometers
- Laser Doppler anemometers
- PIV Systems
- DIC
- ESPI
- Shearographic inspection systems
- PLIF

General Statement

The wider use of composite materials in Aerospace requires fast, reliable and very accurate measurement technologies. These technologies must be easy to handle, flexible in application and able to cope with future requirements.

These complex needs can be covered by optical measurement technologies such as Shearography and Digital Image Correlation

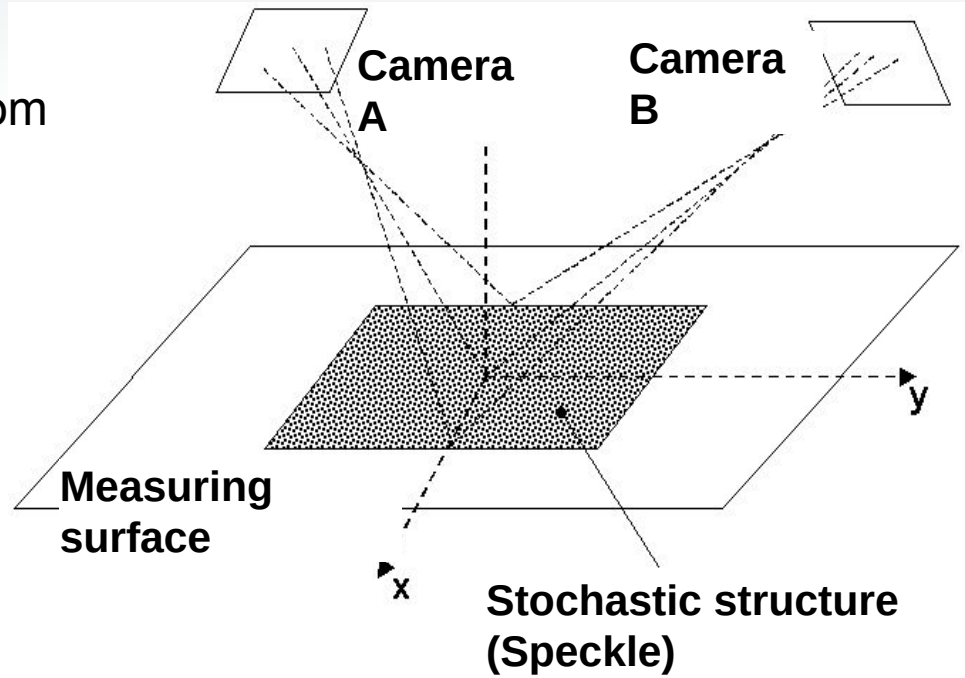
DIC System

- Digital Image Correlation
- 3D displacement and contour information
- Stress and strain field
- Shape
- Full-field measurement
- Non-contact measurement
- Modular

High-Speed measurements possible with HS cameras

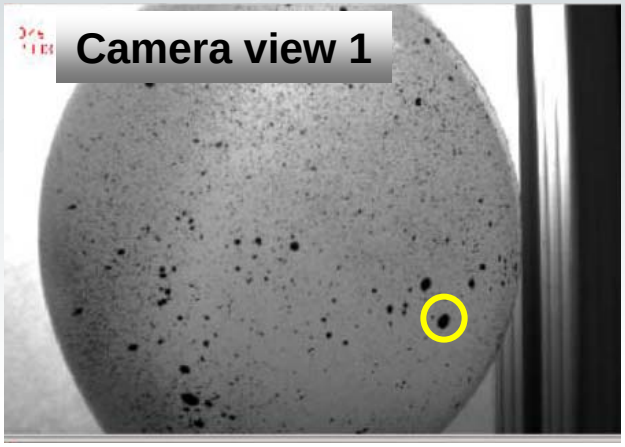
How Does it Work?

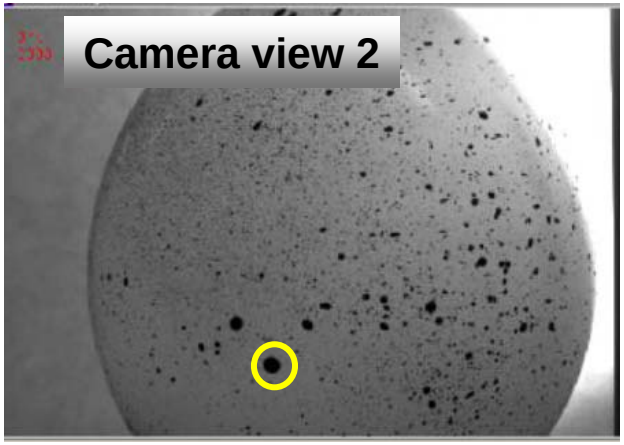
- Stereoscopic camera system
- Surface preparation with stochastic (speckle) pattern
- With known optical parameters the surface contour is reconstructed from two camera images

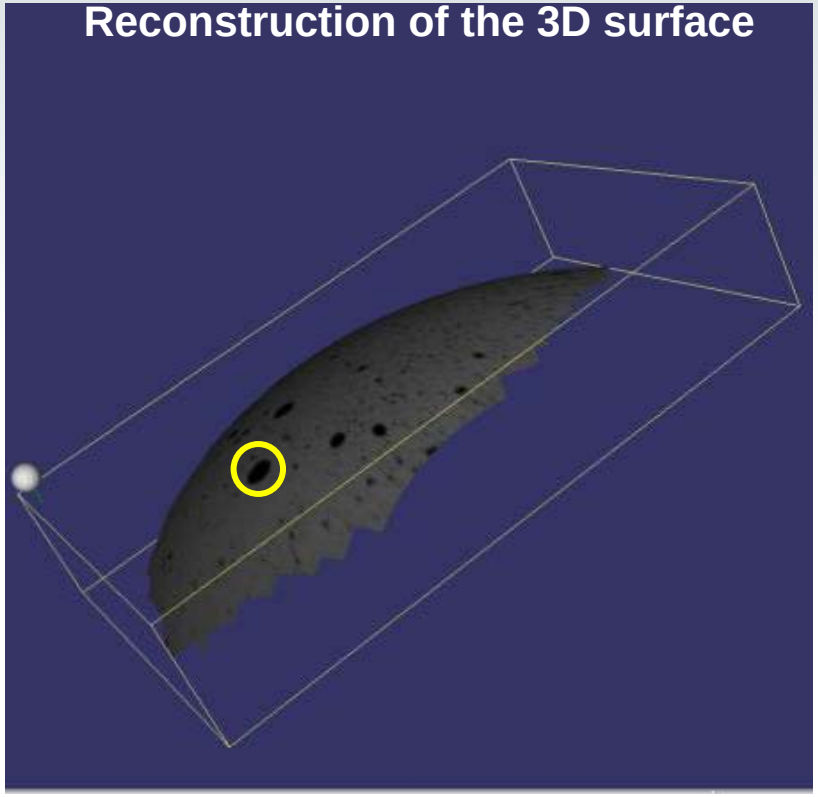


DANTEC DYNAMICS
Partners for progress

1st Step: Recognition of the Shape

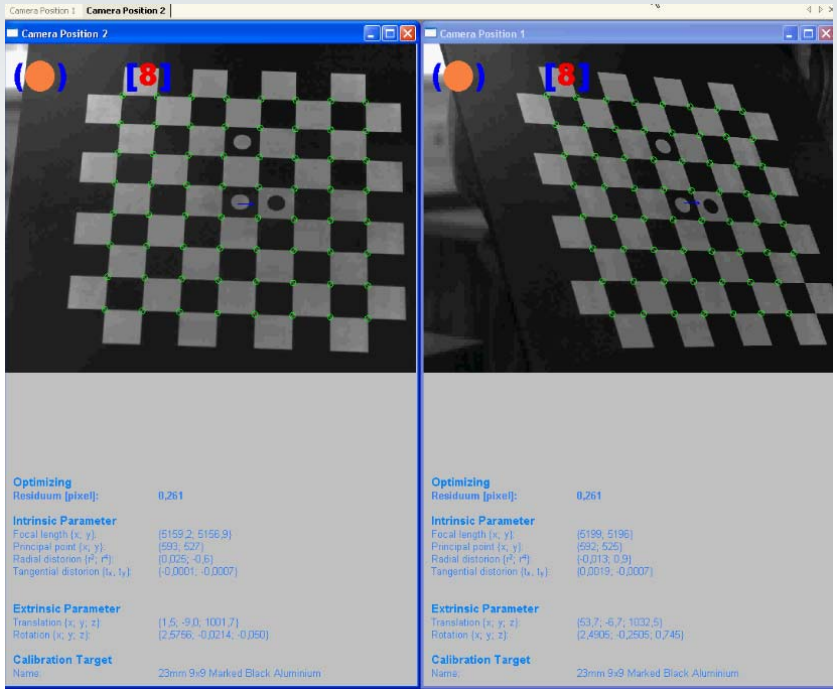






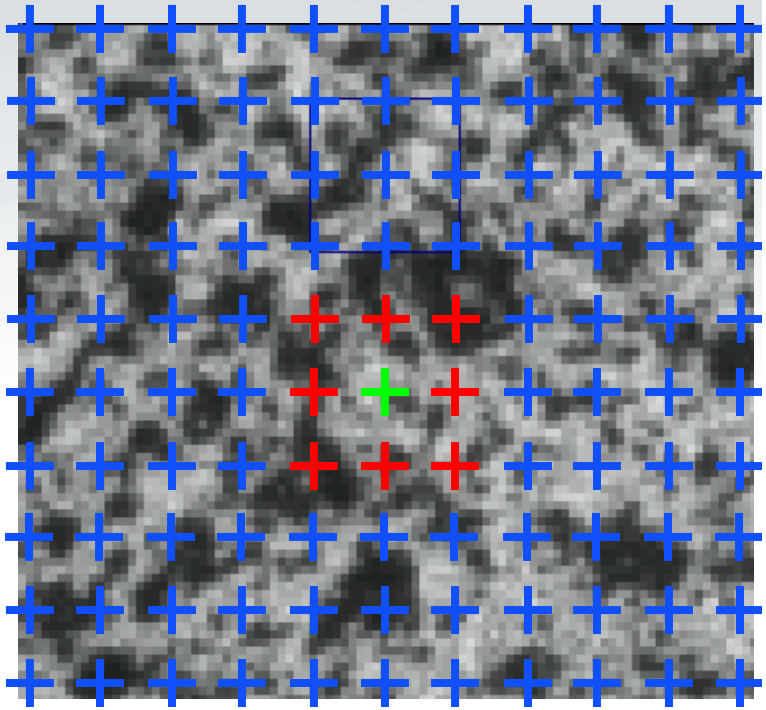
Calibration

- Semi-automatic calibration procedure integrated in the software
  - -Real-time detection of the calibration markers
  - -Direct online feedback of quality
  - -Calculation of optical parameters

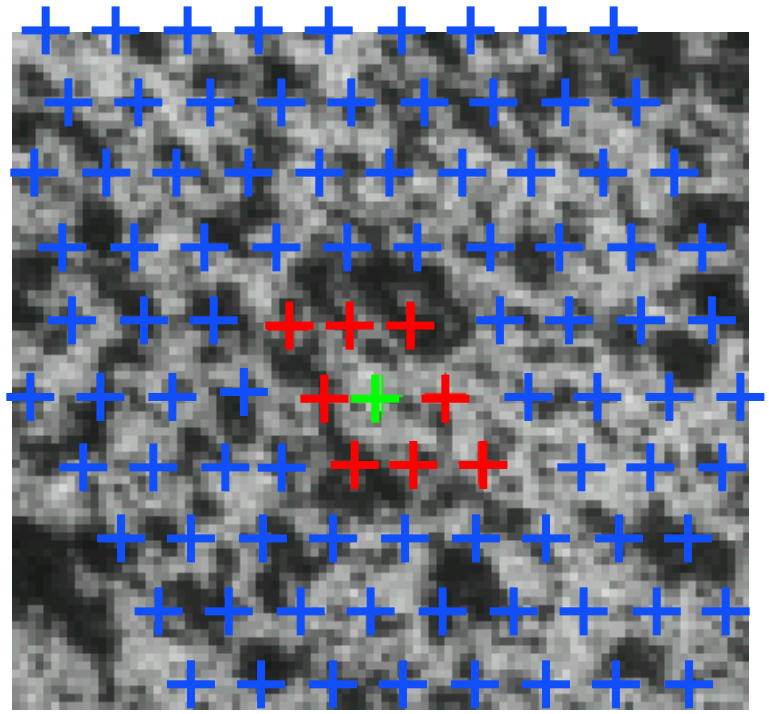


Partners for progress

2nd Step: Recognition of Displacement



Reference image



Deformed image

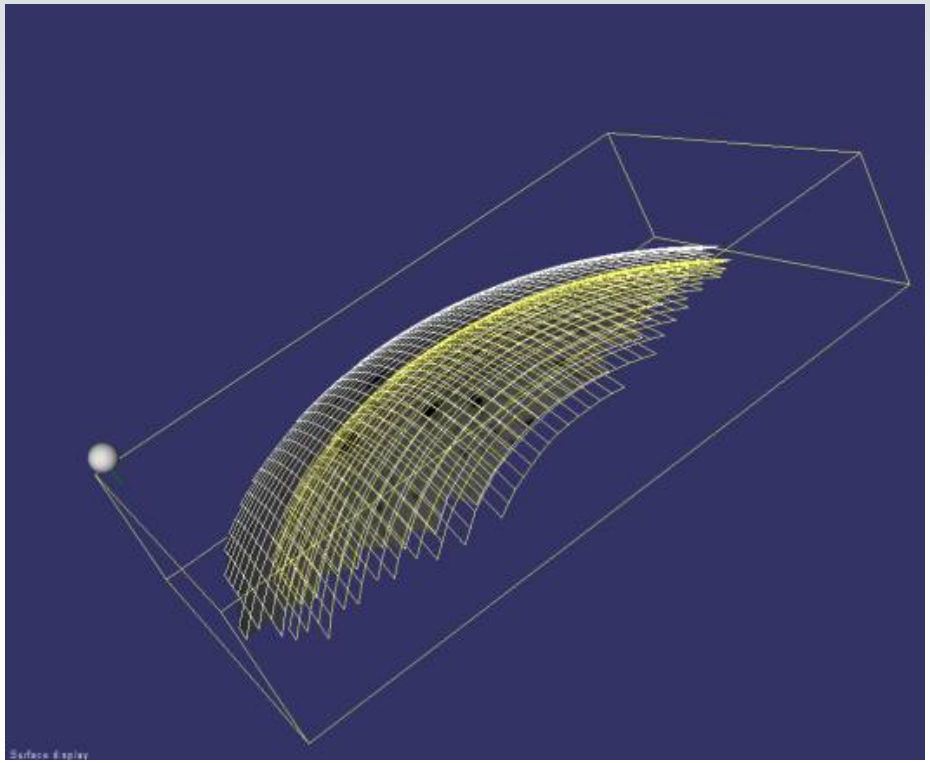
Partners for progress

Result: Contour and 3D-Displacement

- Resolution is dependent on the field of view (FoV)
- Resolution up to 10^{-5} the field of view

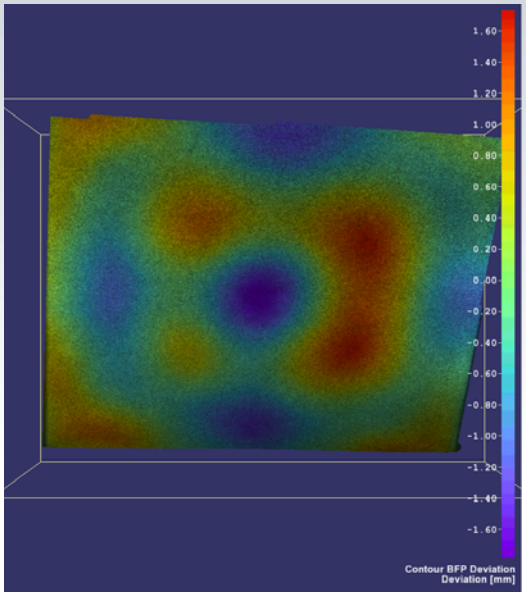
e.g. FoV 100mm,

Resolution 1µm



Visualisation

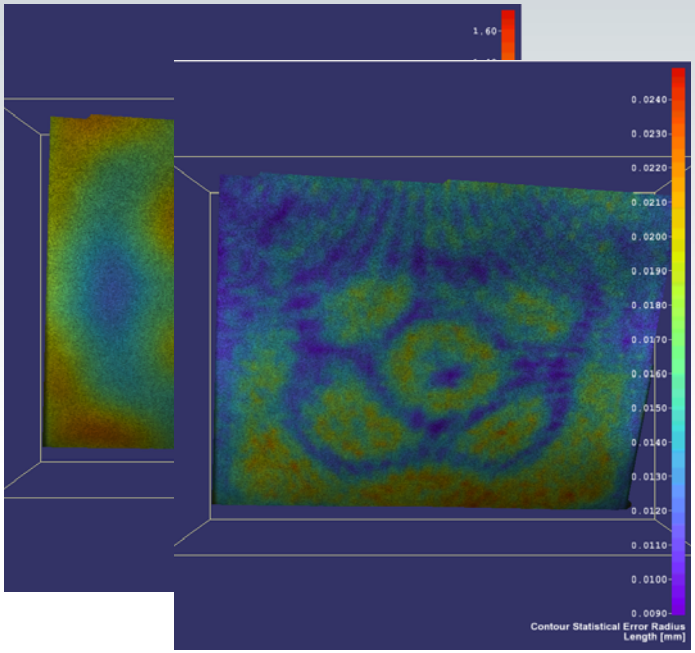
- Results are 3-dimensional
  - Results can be mapped on the object
    - -Pattern (live image)
    - -Contour
      - Distance to plane



DANTEC DYNAMICS
Partners for progress

Visualisation

- Results are 3-dimensional
  - Results can be mapped on the object
    - -Pattern (live image)
    - -Contour
      - Distance to plane
      - Error radius



Partners for progress

Visualisation

- Results are 3-dimensional
  - Results can be mapped on the object

    -Pattern (live image)

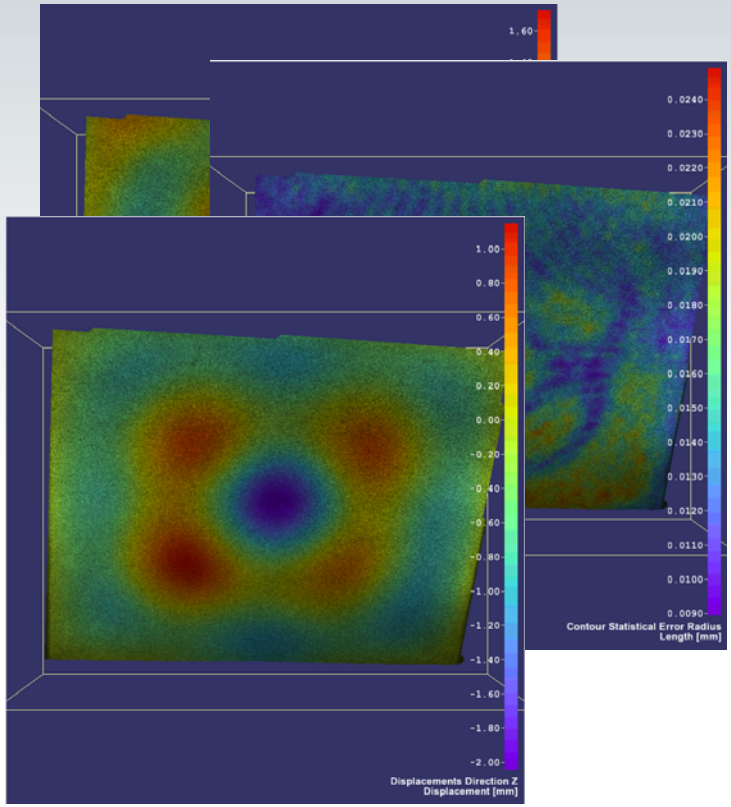
    -Contour

    Distance to plane

    Error radius

    -Displacement

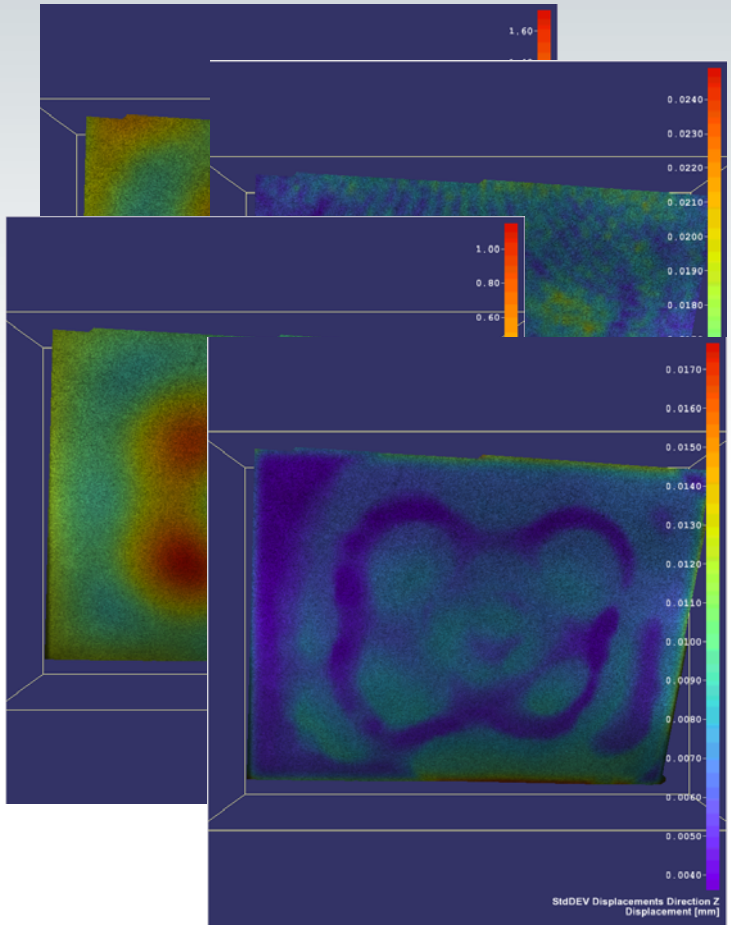
    X-, Y-, Z-displacement



DANTEC DYNAMICS
Partners for progress

Visualisation

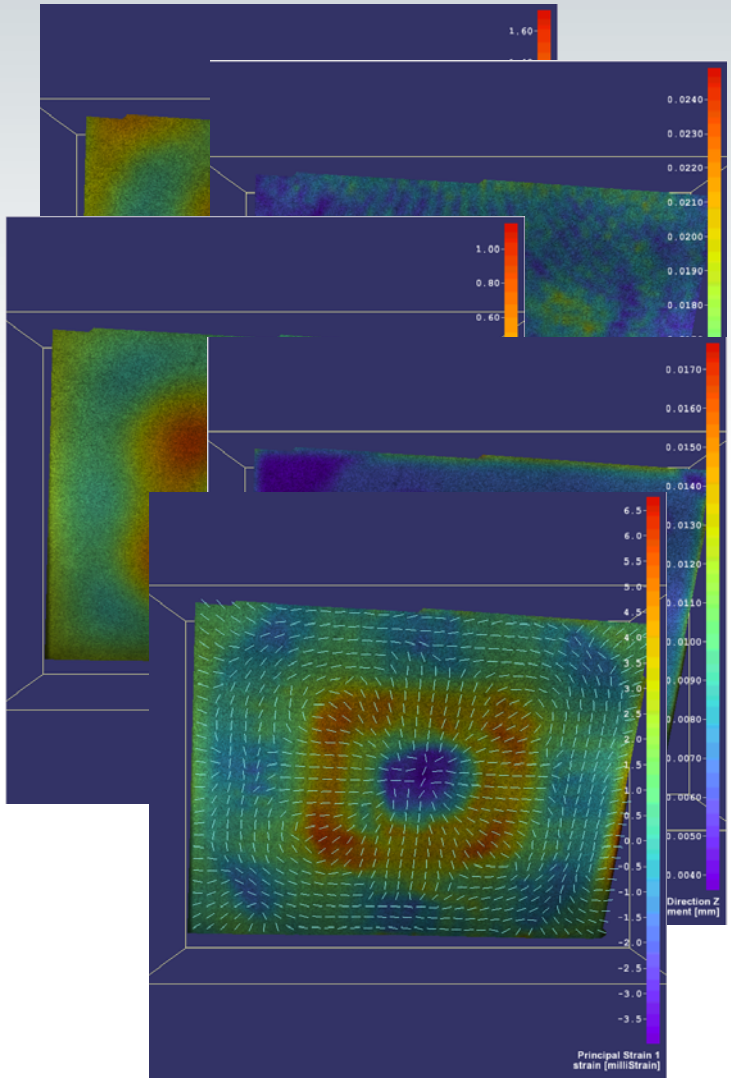
- Results are 3-dimensional
  - Results can be mapped on the object
    - -Pattern (live image)
    - -Contour
      - Distance to plane
      - Error radius
    - -Displacement
      - X-, Y-, Z-displacement
      - Std. deviations



DANTEC DYNAMICS
Partners for progress

Visualisation

- Results are 3-dimensional
  - Results can be mapped on the object
    - -Pattern (live image)
    - -Contour
      - Distance to plane
      - Error radius
    - -Displacement
      - X-, Y-, Z-displacement
      - Std. deviations
    - -Strain
      - Different strain components
      - Std. deviations



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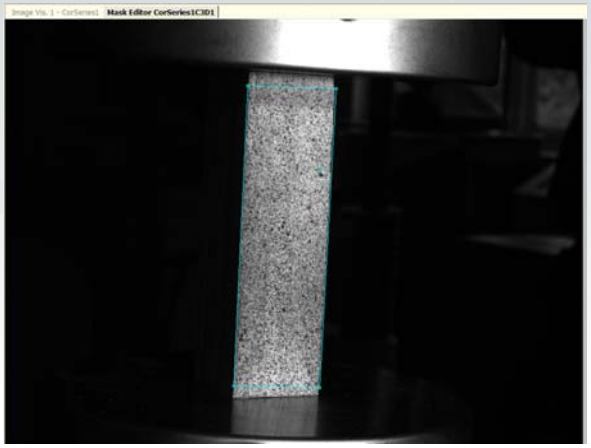
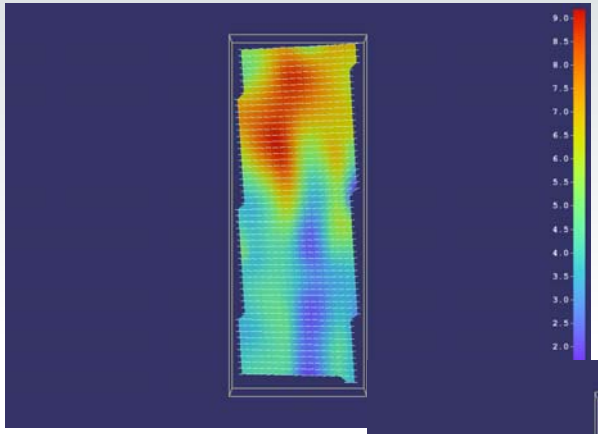
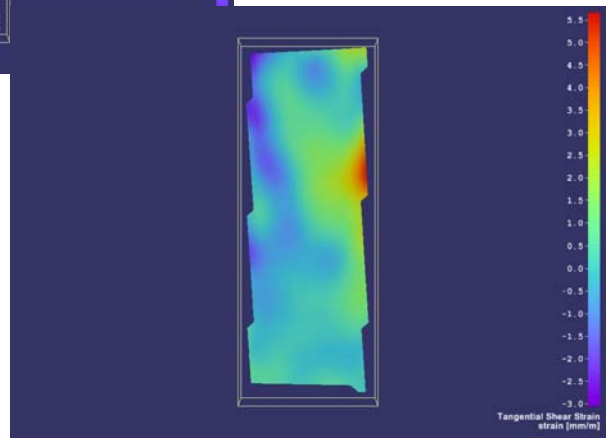
Partners for progress

Measurements on Wood







-Loaded under compression

-Tangential X strain

-Shear strain

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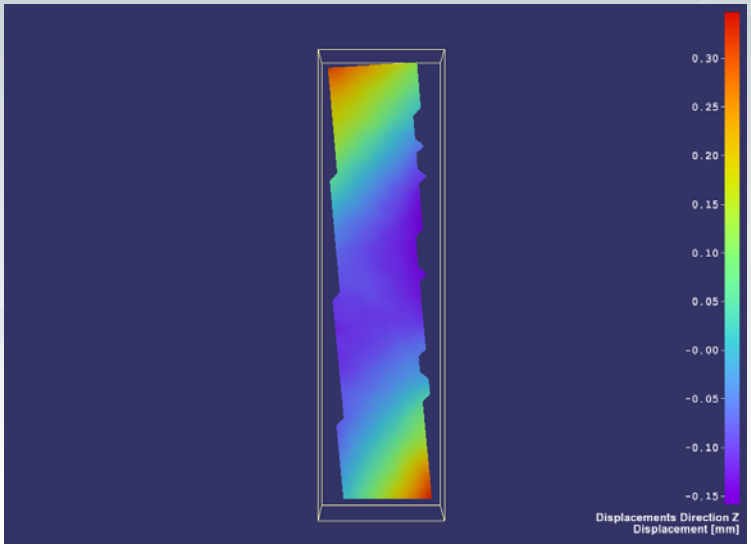
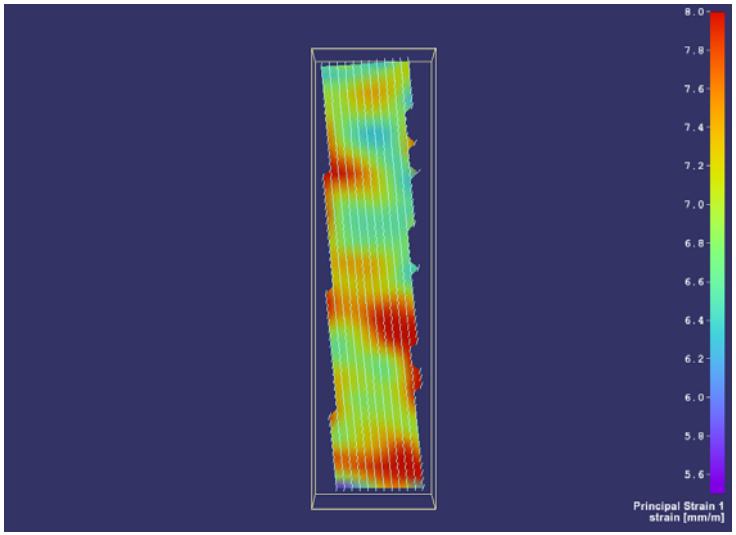
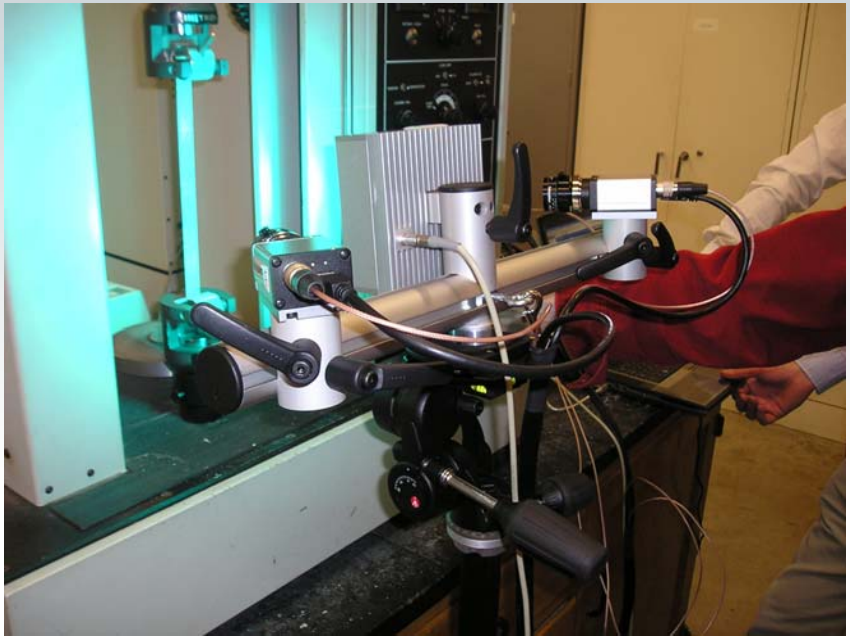
Partners for progress

Measurements on Paper



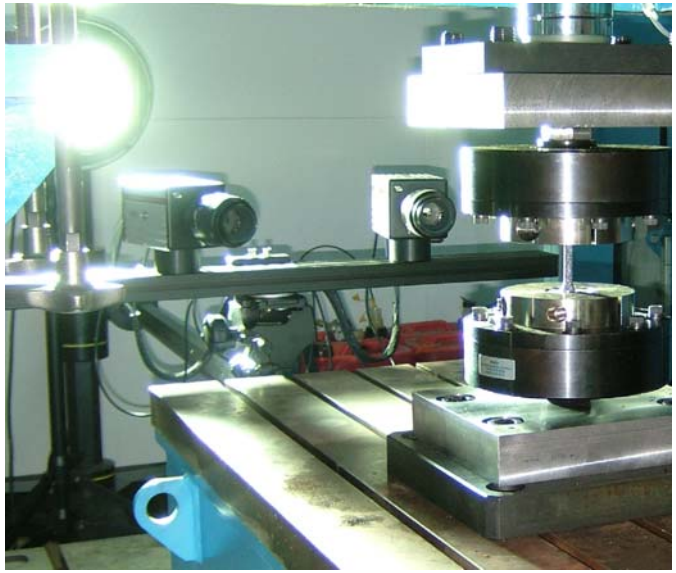


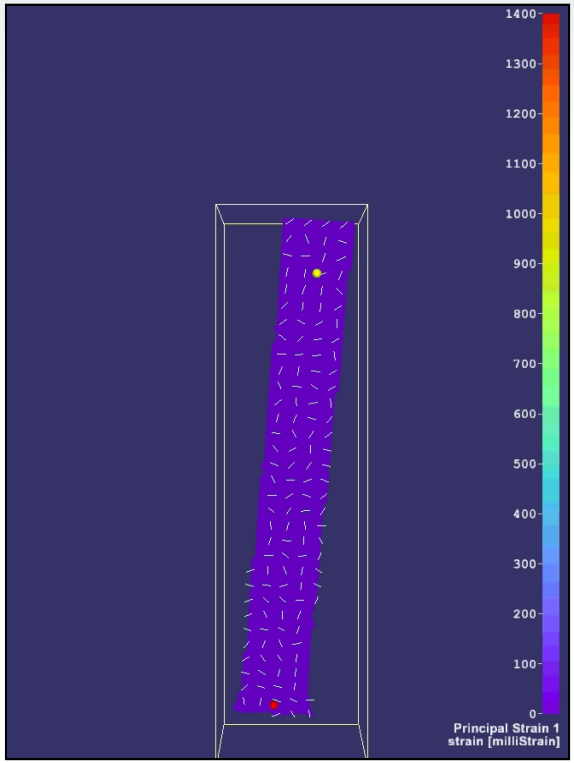


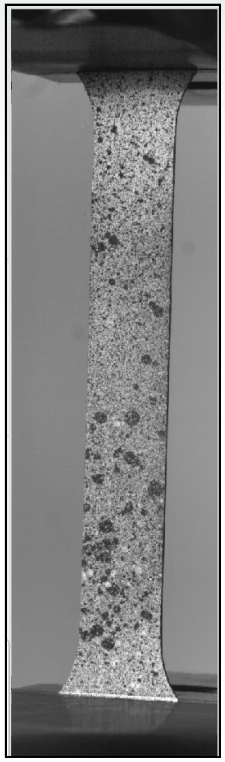
- *Out-of-plane displacement*
- ***Principal Strain 1***

Tensile Test

- Measurement of a standard Tensile Test sample using Q-450 System
  - -Object: Aluminum, 150 mm length
  - -Traverse speed: 50 mm/min
  - -Frame Rate: 10 Hz
  - -Evaluated: 10th image
  - -Test until failure



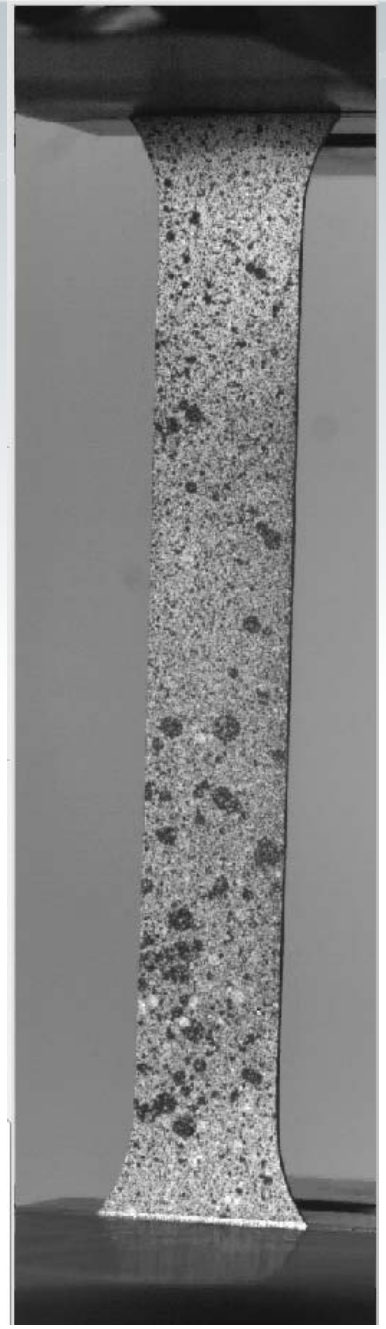




(Click right then left image above to play videos)

DANTEC DYNAMICS

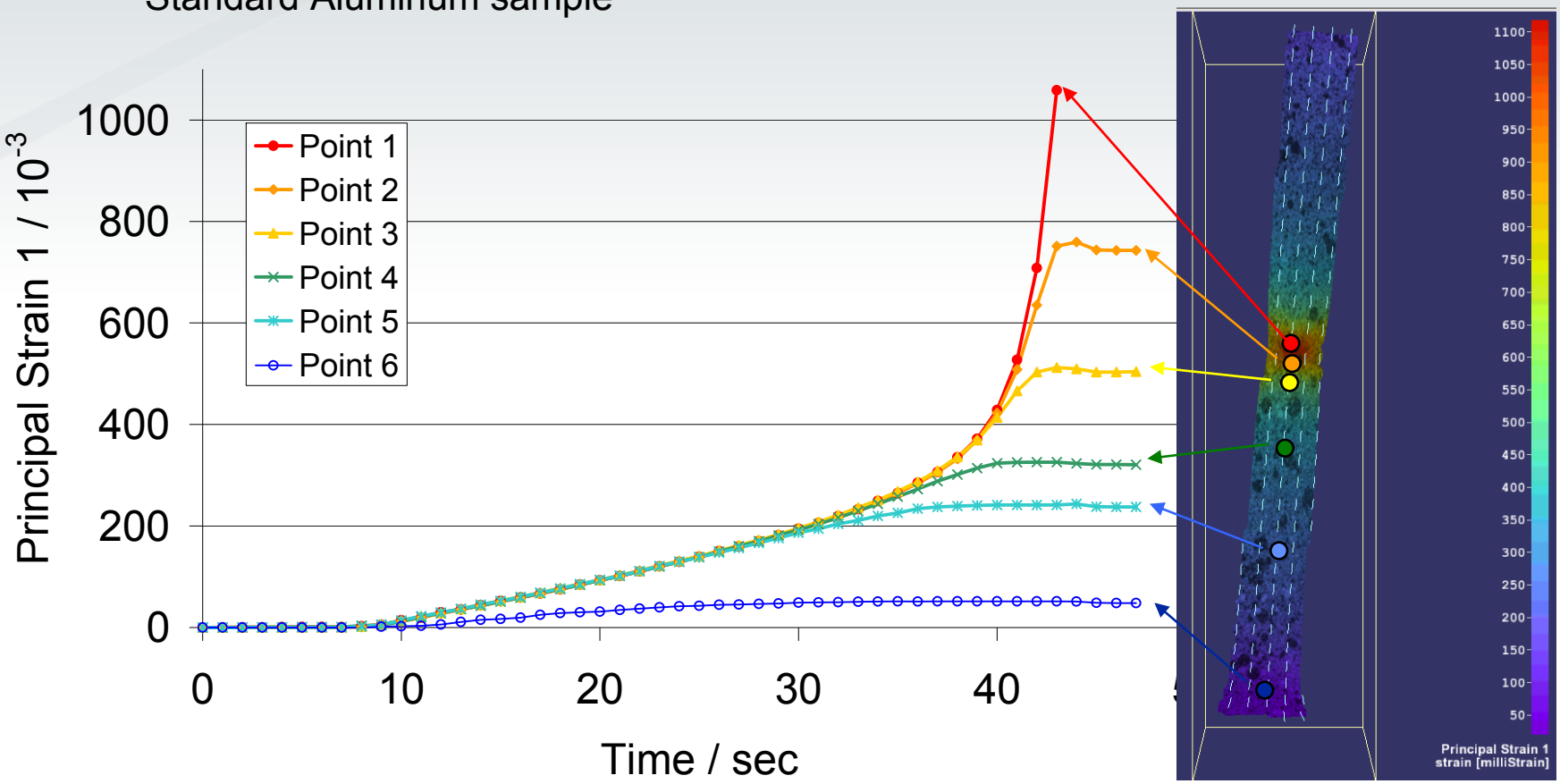
Partners for progress



Partners for progress

Tensile Test

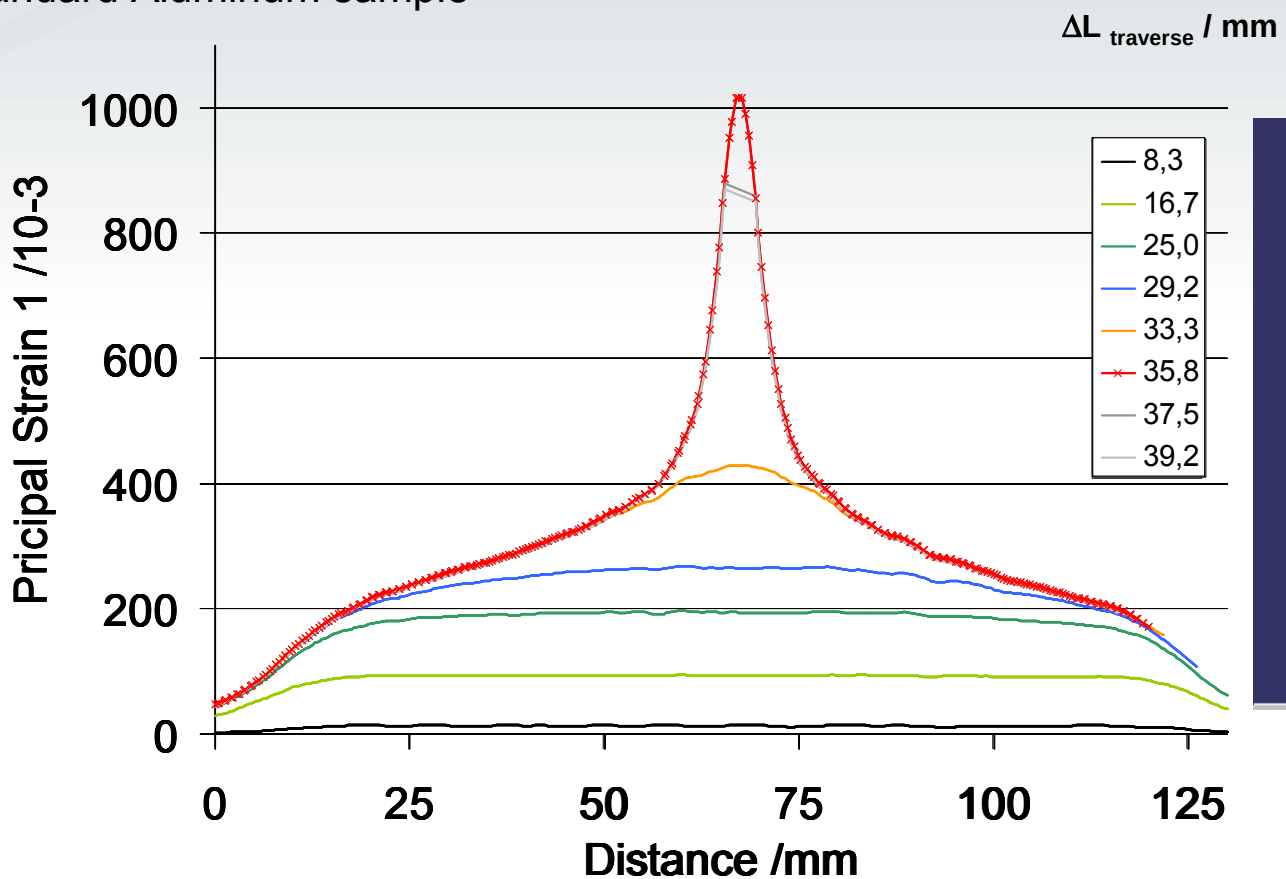
- Standard Aluminum sample

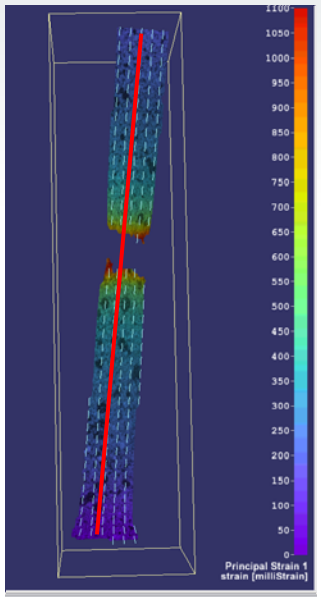


Partners for progress

Tensile Test

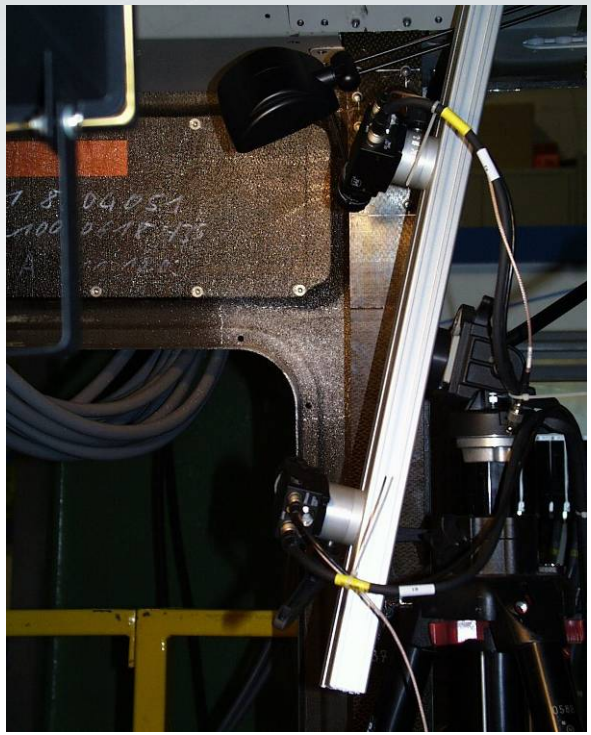
- Standard Aluminum sample





DANTEC DYNAMICS
Partners for progress

Strain Analysis of a CFRP-Corner

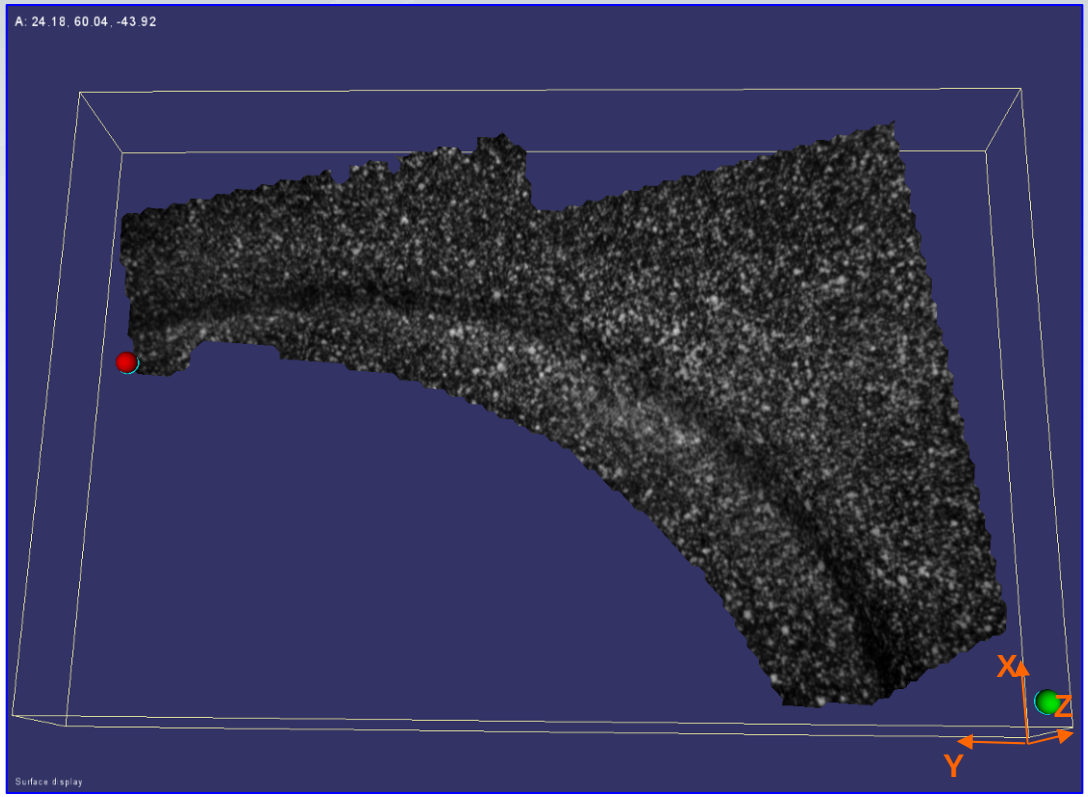


Q-400 System

Surface preparation

DANTEC DYNAMICS
Partners for progress

Strain Analysis of a CFRP-Corner



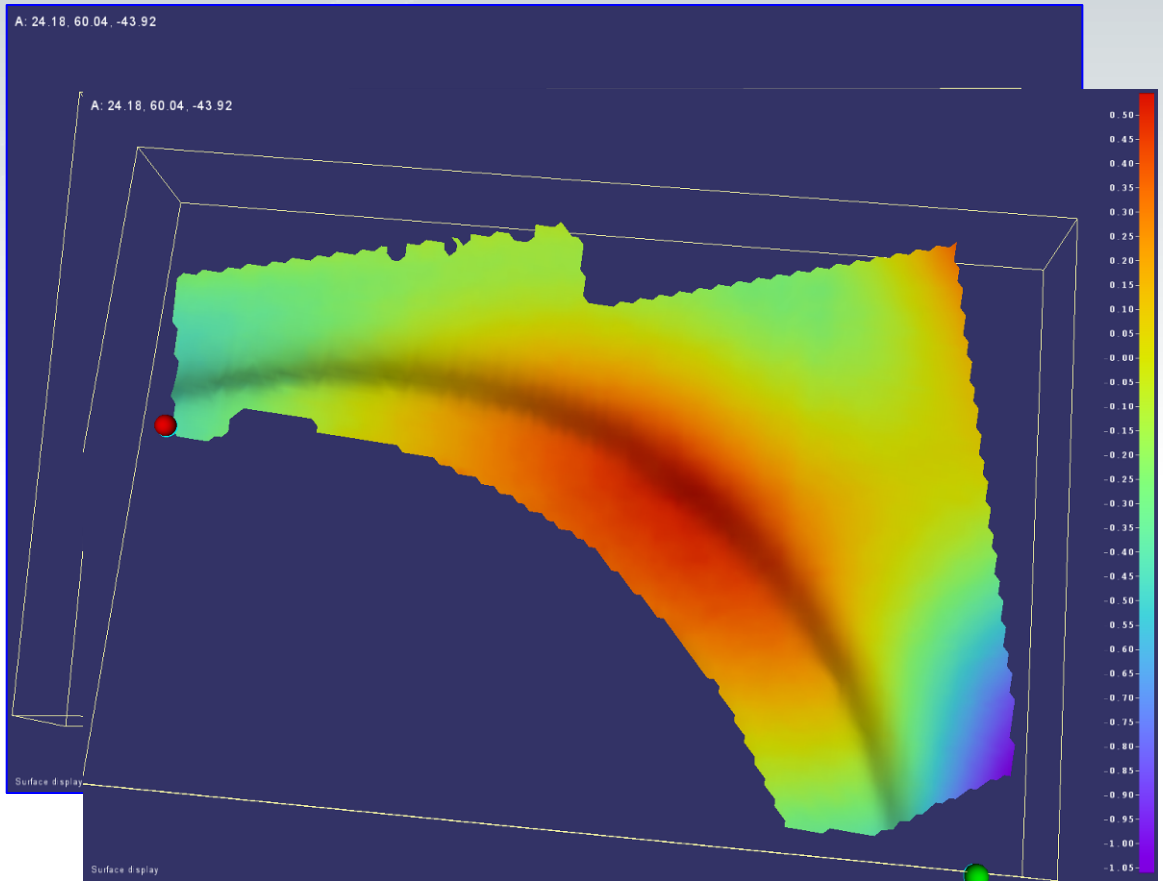
Calculated contour

Out-of-plane displacement

Principal strain

Partners for progress

Strain Analysis of a CFRP-Corner

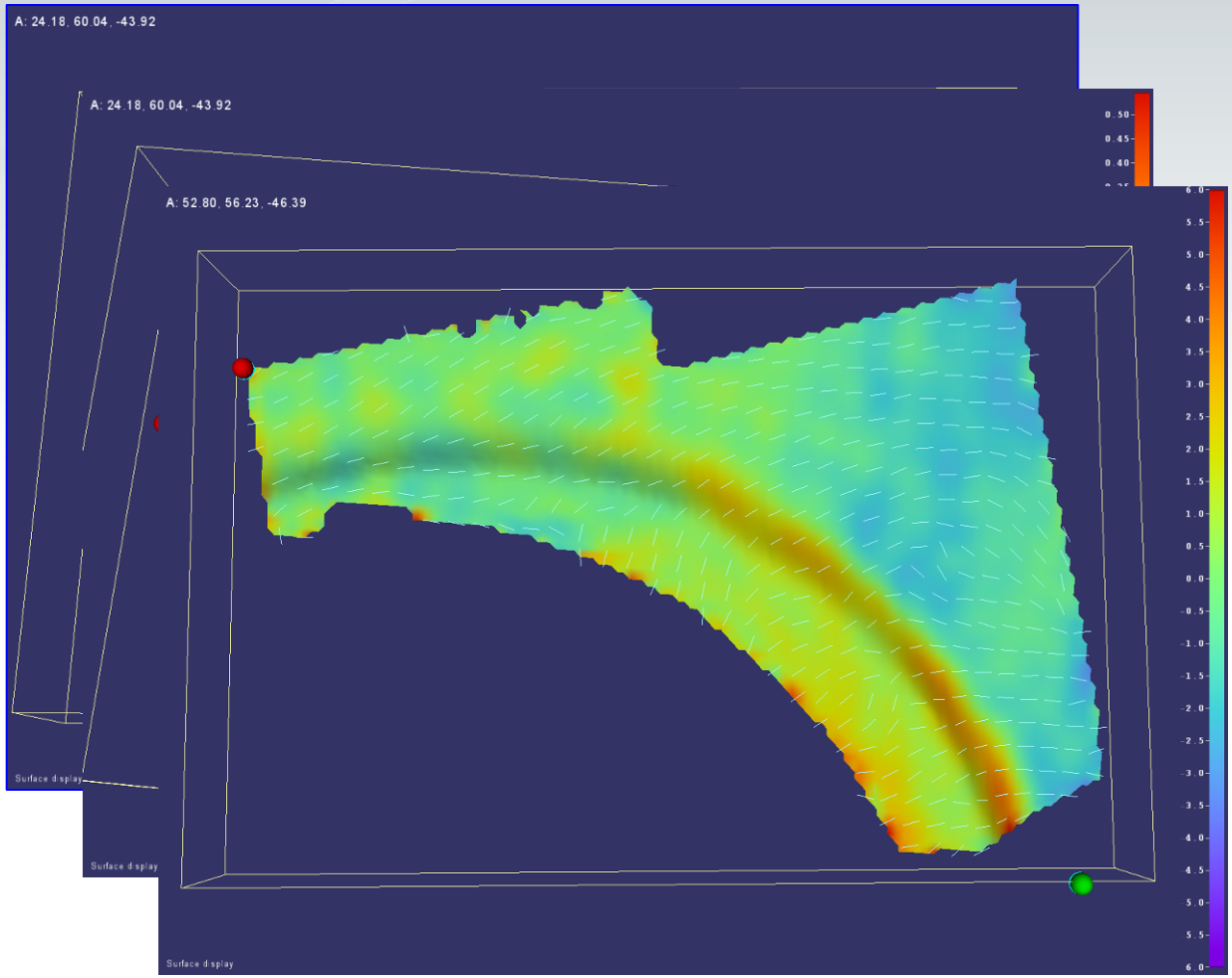


Out-of-plane displacement

Principal strain

Partners for progress

Strain Analysis of a CFRP-Corner

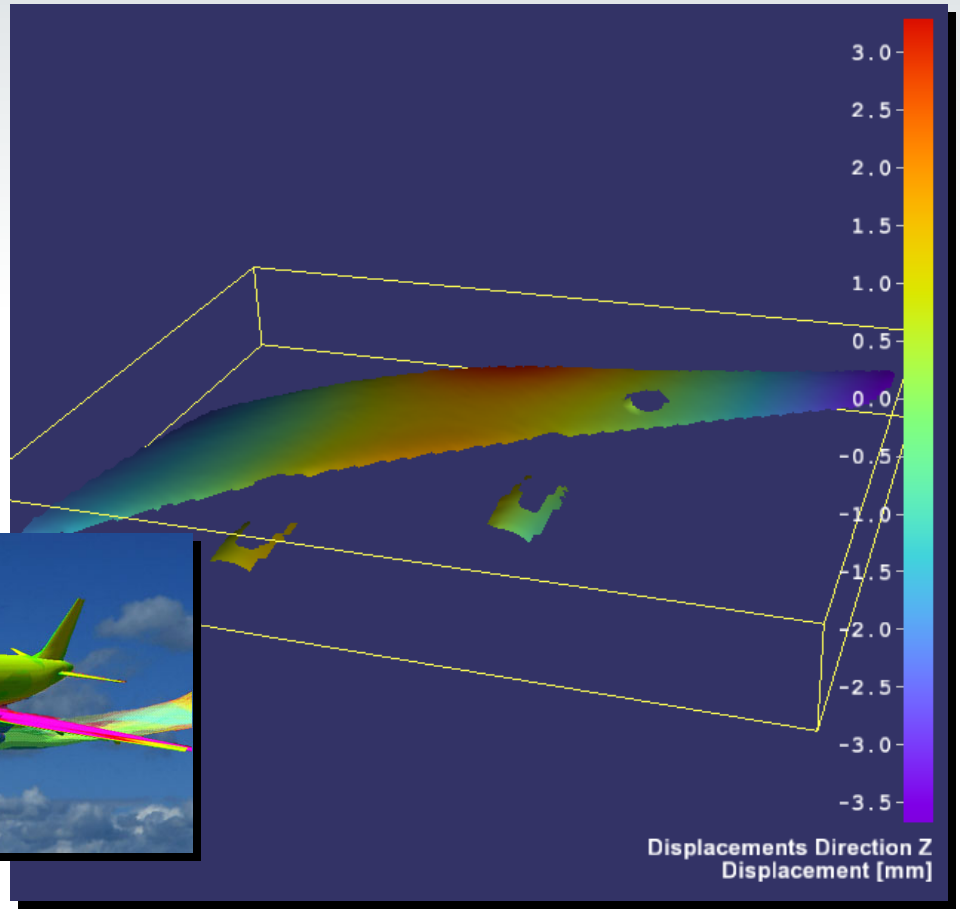


Principal strain

Partners for progress

Strain distribution on a windtunnel model

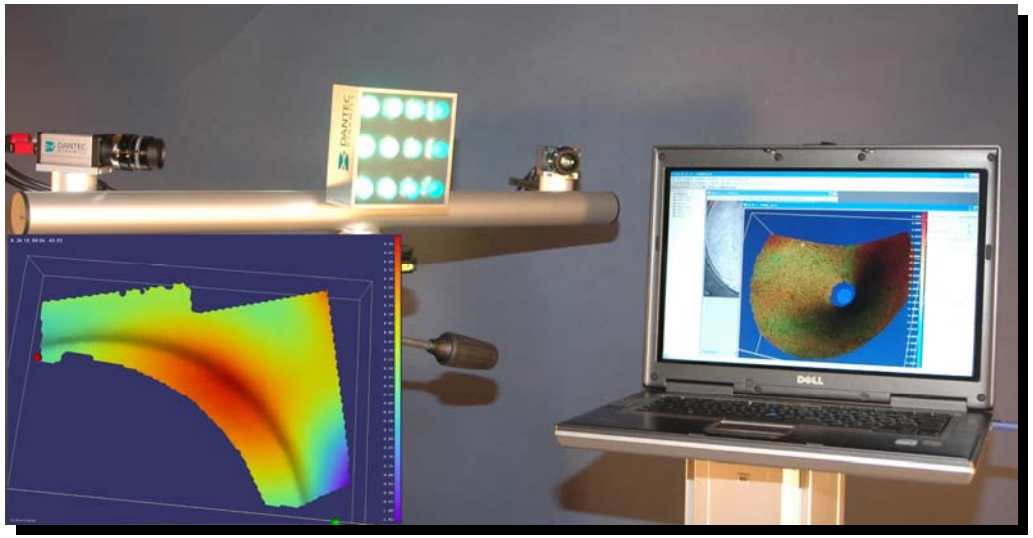
Model in Air: Courtesy of Airbus Bremen



Partners for progress

Summary of DIC

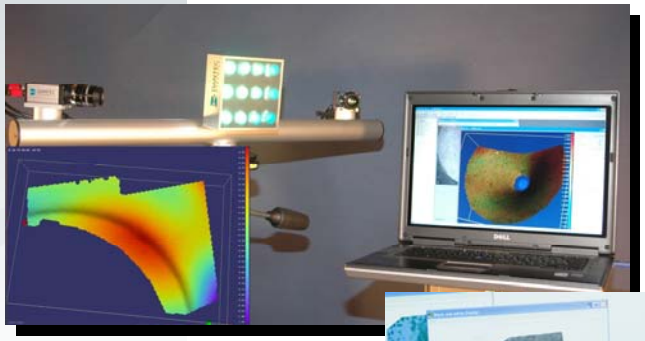
- Digital Image Correlation is a robust and flexible technique for full-field, non-contact 3D deformation and strain analysis
- Field of View and stand-off distance can be changed with lenses
- Results give contour, displacement and strain information
- Technique possible on almost any shape and material
- High-speed measurement possible (Q-450)
- Investigation of even complex deformations with high dynamic range



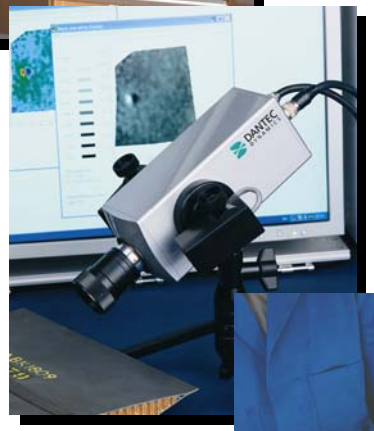
DANTEC DYNAMICS

Partners for progress

Available Equipment for NDE



Q-400/450 Digital Image Correlation

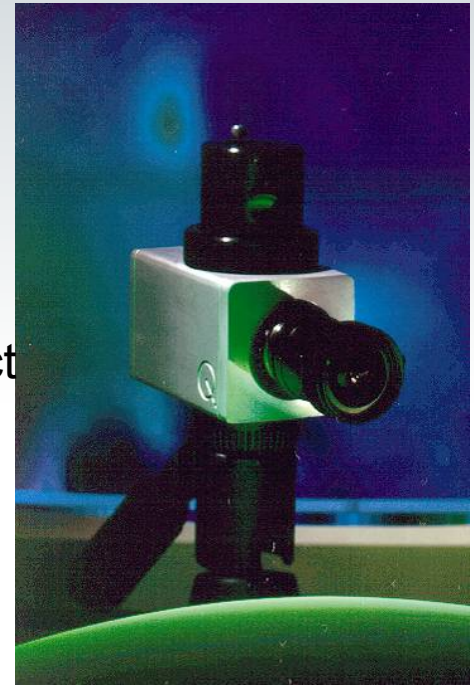


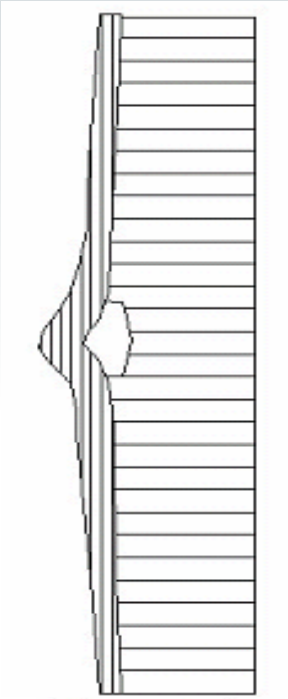
Q-800 Shearography Sensor

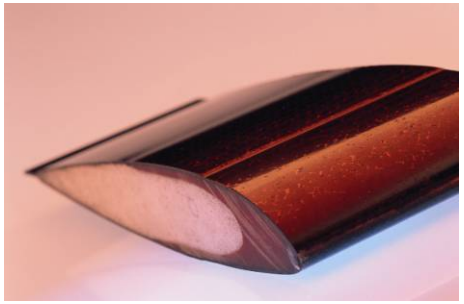
Q-810 Shearography System

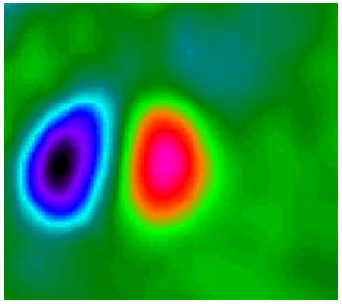
Non-Destructive Inspection With Shearography

- Technique to identify defects in almost any material
- Slightest surface excitation leads to surface deformations from the internal flaws
- The shearography system can detect these very small deformations
- Full-field, non-contact technique





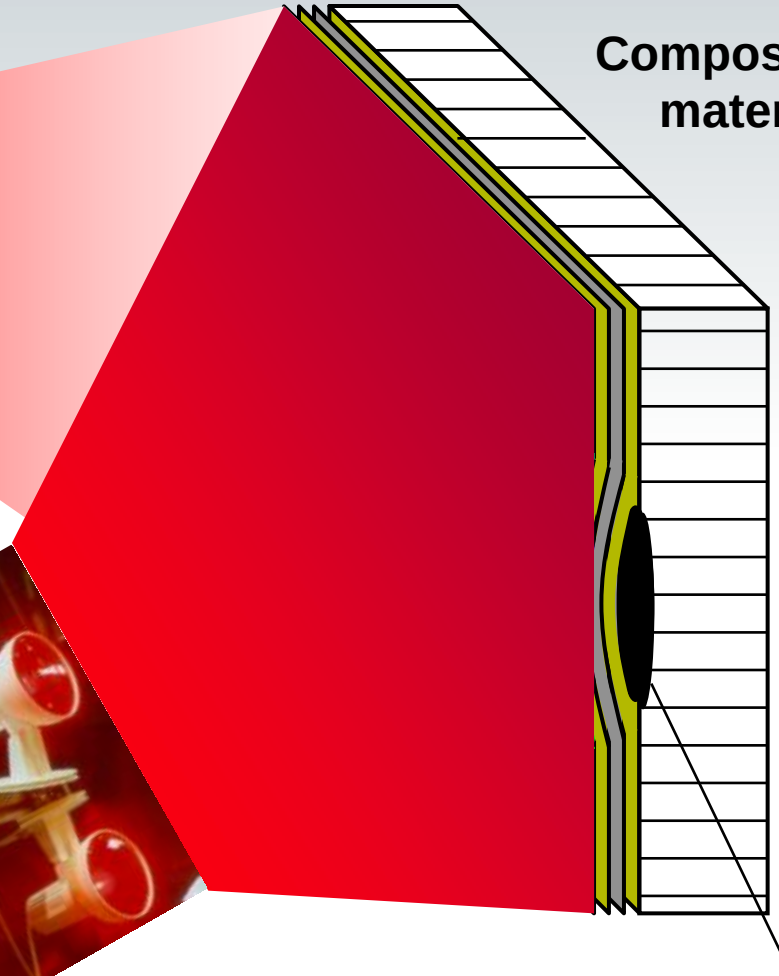




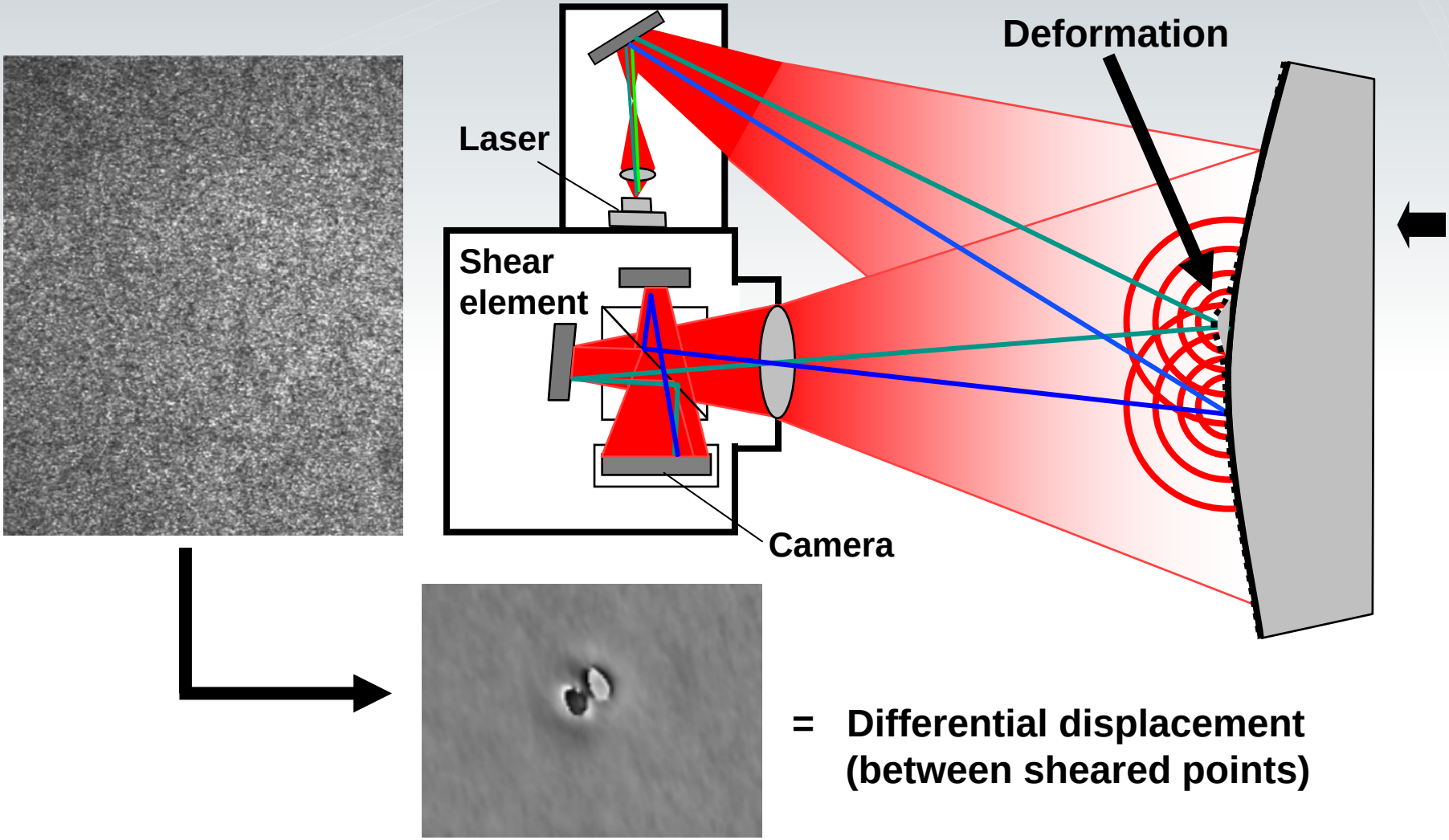
How does it work?

Shearography camera

Loading system (heat)



Principle of Shearographic Measurement



= Differential displacement
(between sheared points)

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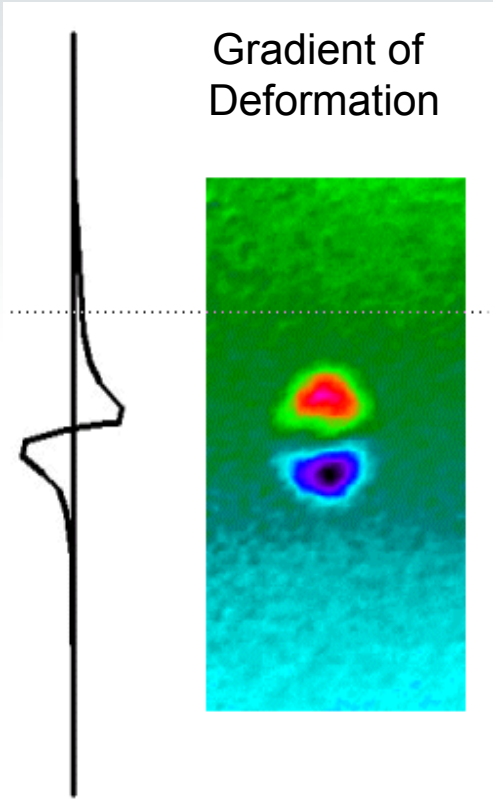
Partners for progress

Typical Result

- **Difference in deformation between two points on the object which are separated by the shear vector**

- **The difference in deformation corresponds to the gradient of deformation**

- **Shearography measure the gradient of deformation**



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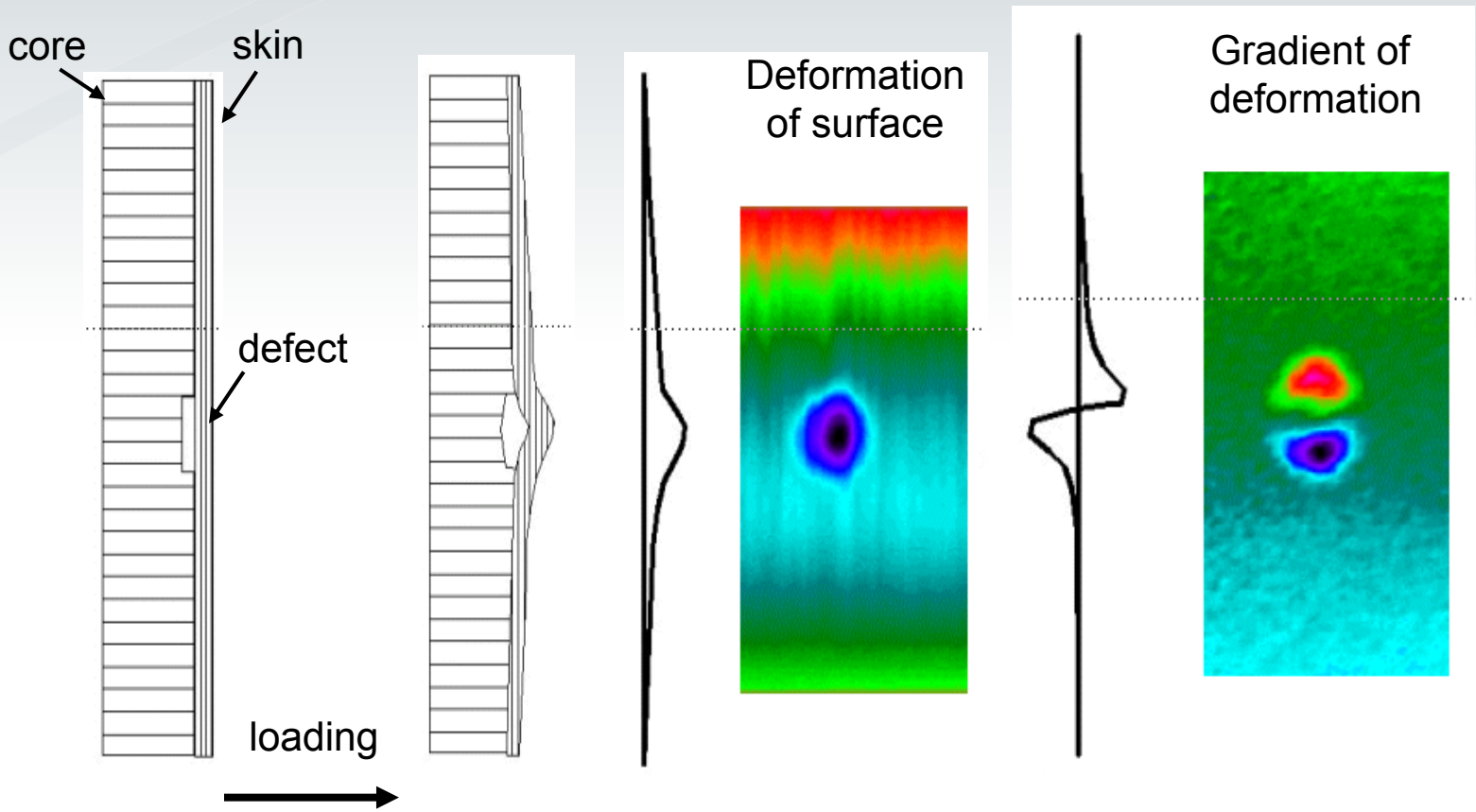
Partners for progress

Typical Result



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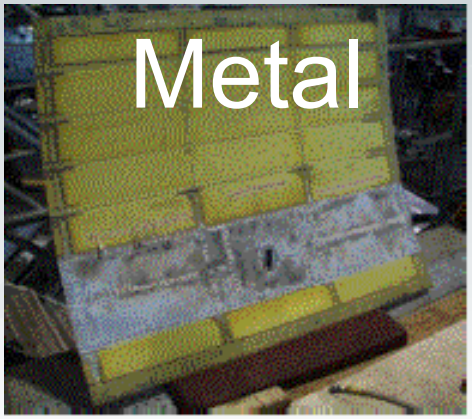
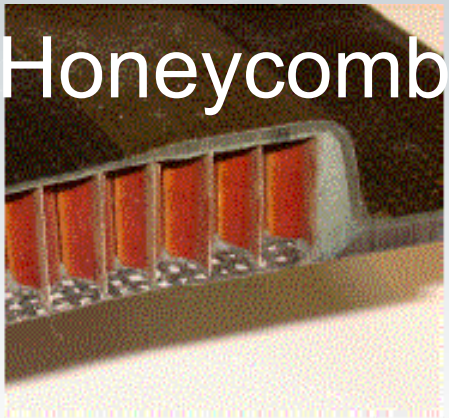
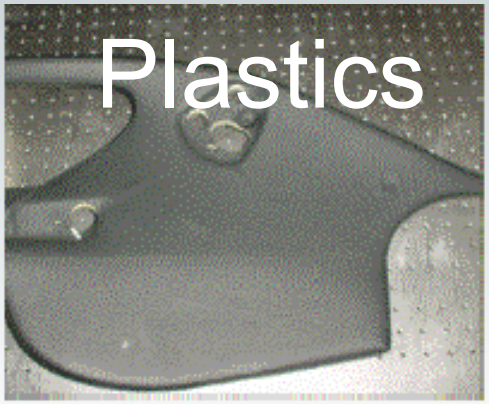
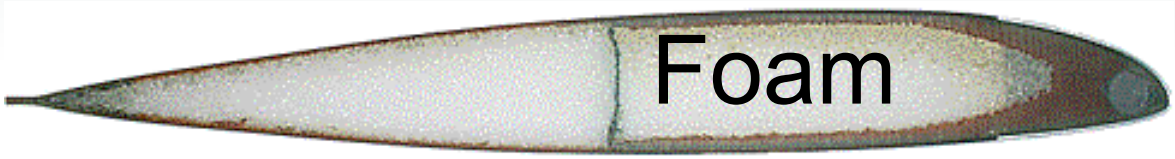
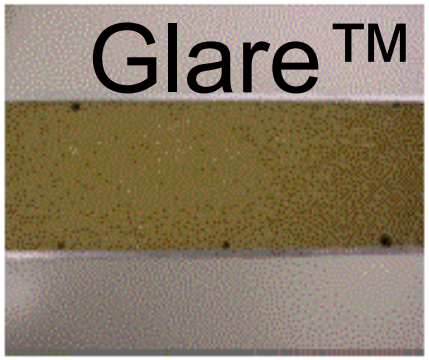
Shearography Inspection

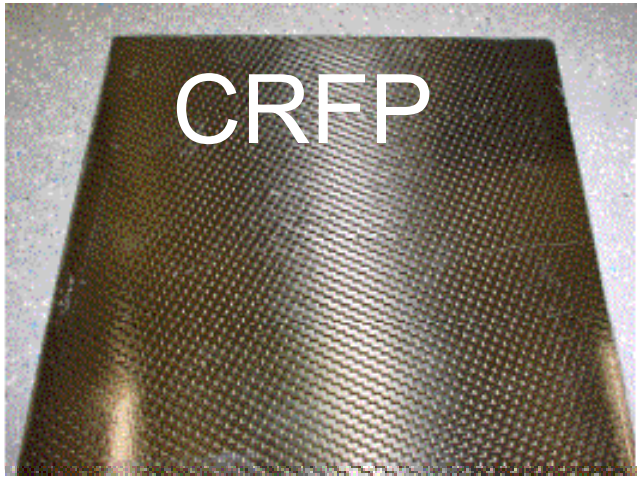












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Excitation Options for Shearography Inspection

- **Mechanical**
- **Vibration**
- **Thermal**
- **Vacuum**

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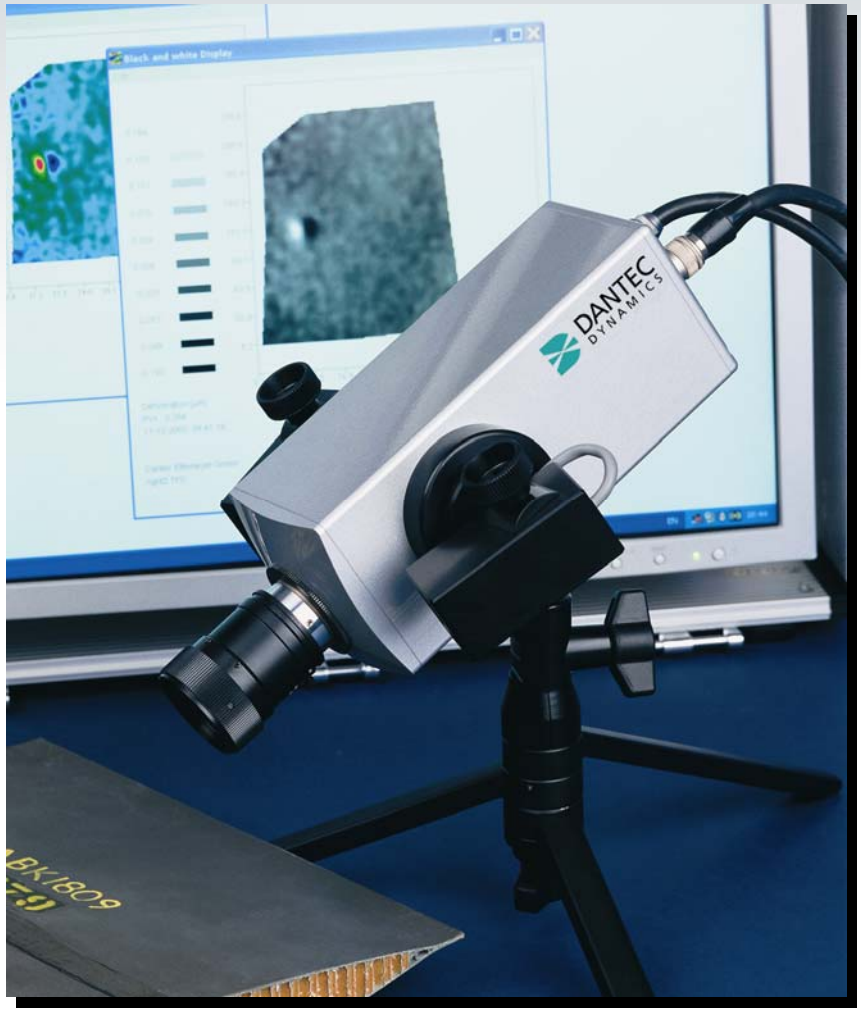
Detectable Defects with Shearography

- Delamination
- Debonding
- Separation of structural components
- Undulation/waving/wrinkling
- Kissing bonding
- Impact Damage (FOD)
- Structural anomaly
- Inter- laminar separations
- Crushed Core, differentiates between disbonds
- Internal corrosion
- Changes in section and core splices / bulkheads



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Fields of Application

- WInd Turbines
- Aerospace
- Automotive
- Space
- Boat Industry
- Green Energy
- Home Appliances
- Electronics
- Machinery

at the Development

Production and

In-Field Level

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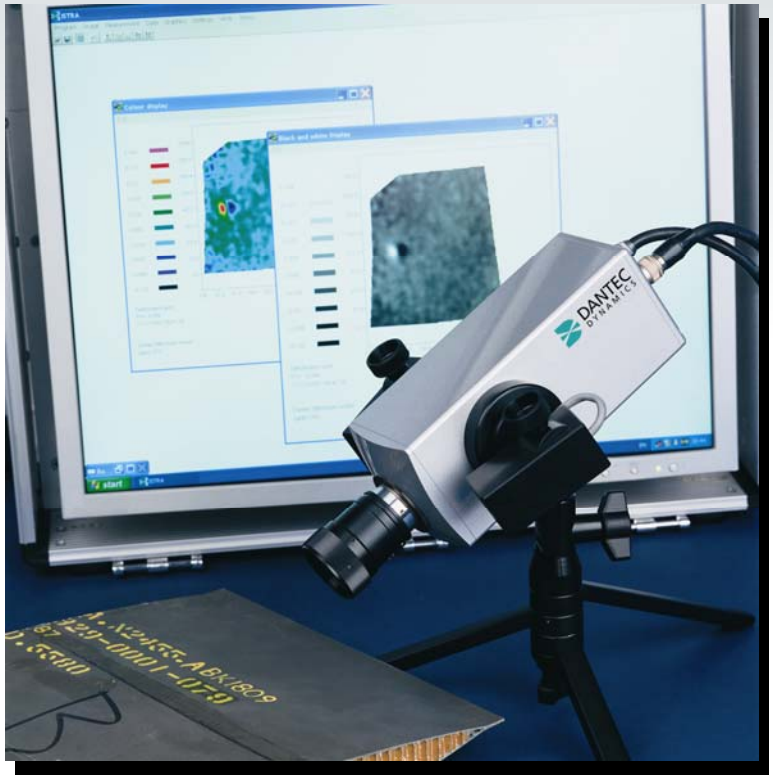
Standard Q-800 System

Q-800 Shearography Sensor for various applications in production or in-Field

- Variable field-of-view
- Lightweight
- Compact design
- Any excitation method



For most materials no surface preparation required

Q-810 Vacuum Hood System

Q-810 portable Shearography System for applications in production or in-Field Service

- Large area coverage
- Hood mounted touch-screen monitor
- Thermal and vacuum loading
- Lightweight
- Long cable connection >20m

Customised Stationary Systems

Various systems with different excitation methods

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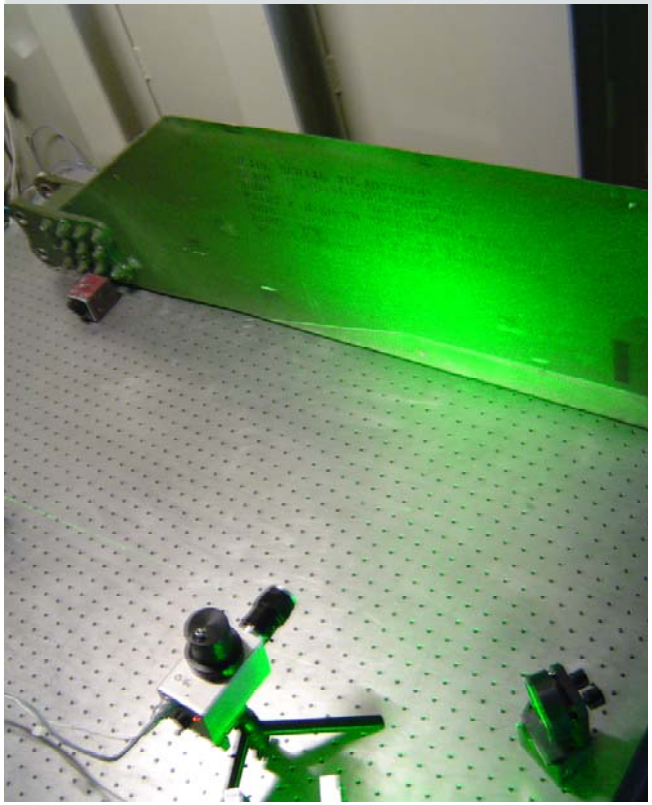
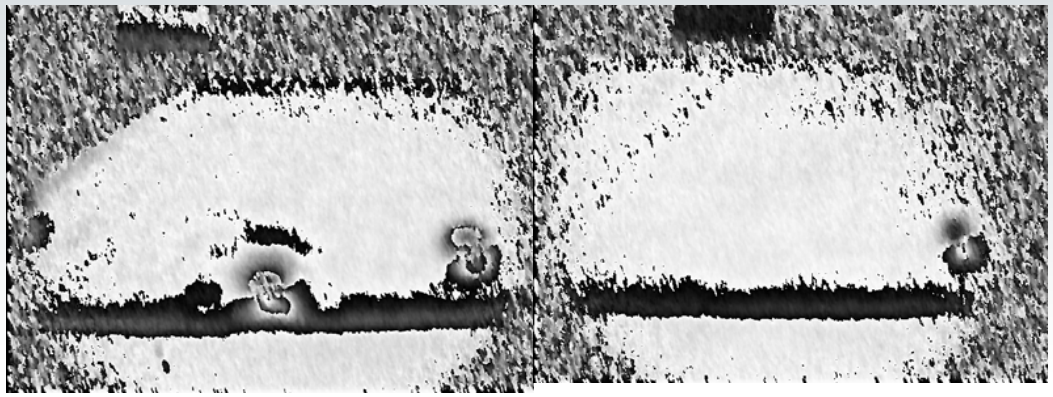
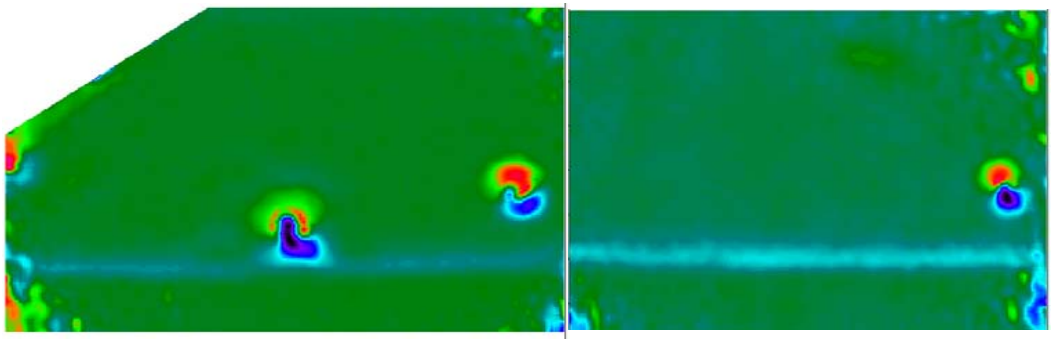
Inspection of Helicopter Main Rotor





Pressure difference: 2 – 10 mbar



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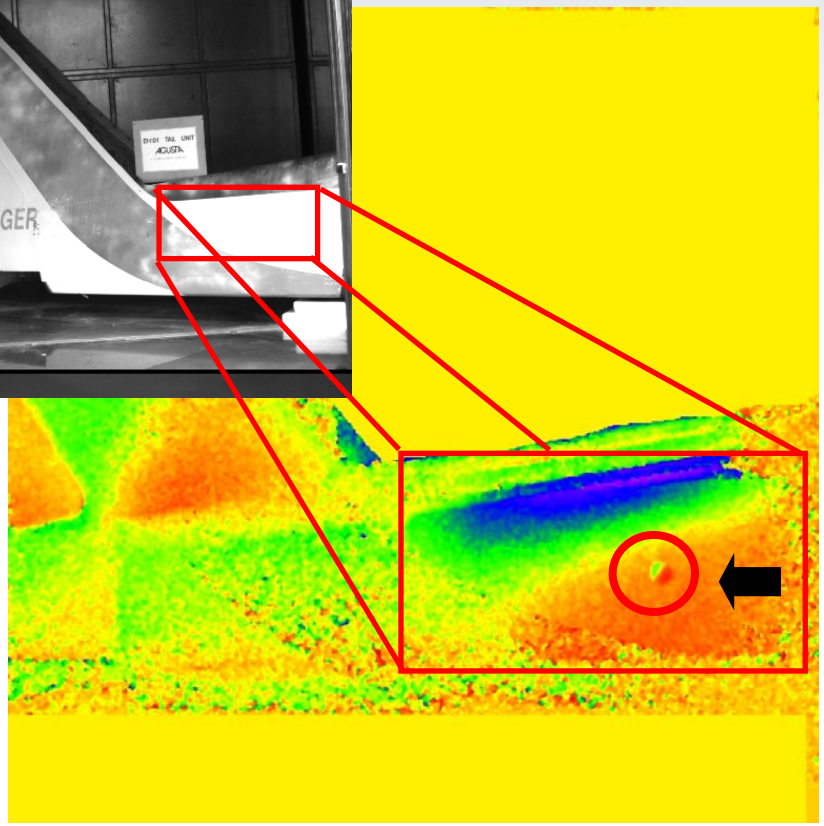
AGUSTA Helicopter EH-101 Testing



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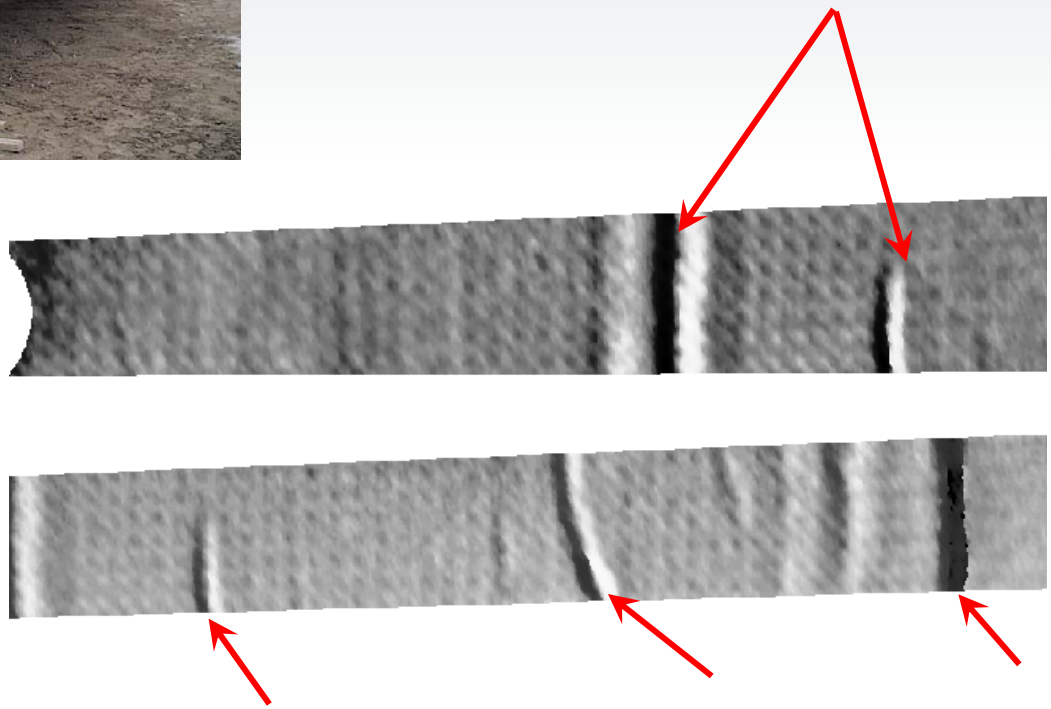
Wind Turbine Blade

Wrinkles/ Waving



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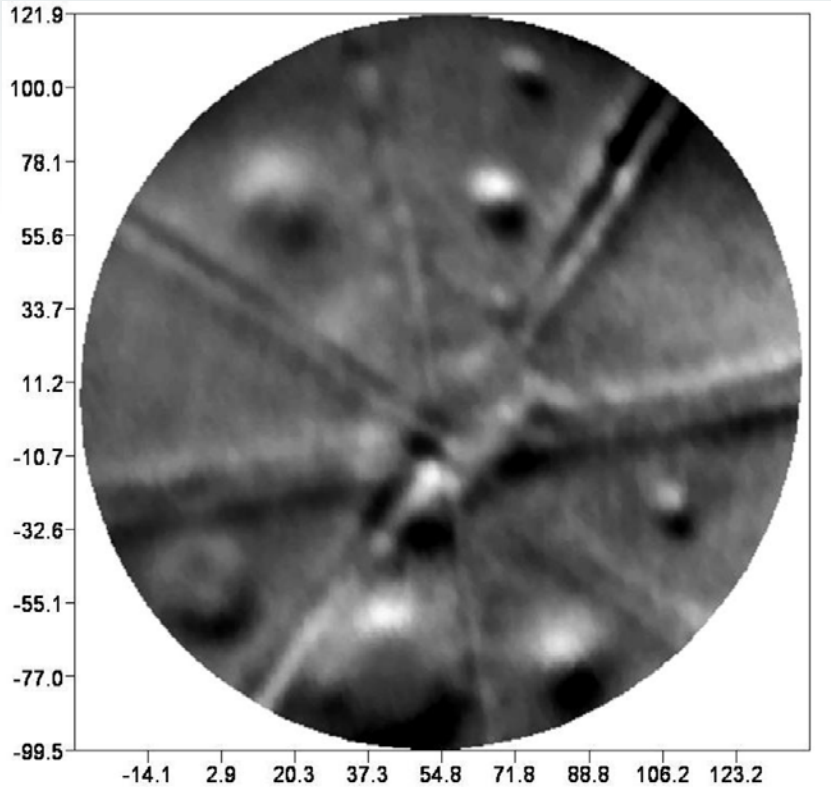
Radome Inspection

Inspection of Composite Material

- Various material mix
- Rubber coated
- large area inspection



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Realtime phase unwrapping

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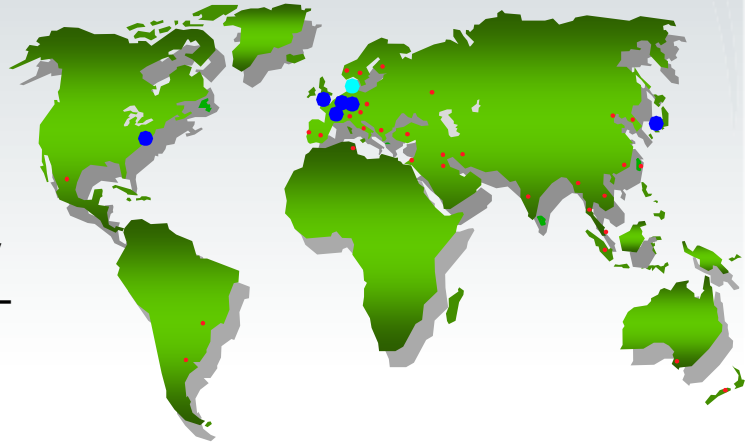
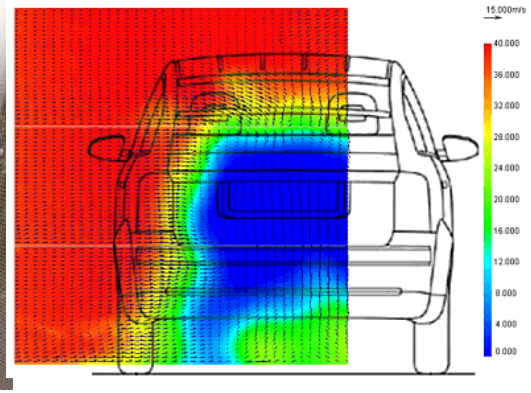
Summary of Shearography

- Very fast inspection
- Repeatable
- “Zero” False Calls
- Flexible
- Easy to use and understand
- Don‘t waste time on defect free areas
- Can detect waving/wrinkling, kissing bonds...

Conclusion

- Measurement techniques in fluid and solid mechanics help us to understand complex physical phenomena in a way that is impossible to replace: direct observation.
- Dantec systems are state-of-the-art and can improve your competitive advantage.
- We are looking for partners in the wind turbine industry who can capitalize on measurement capabilities and in-house expertise.
- Visit us on the web at www.DantecDynamics.com





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