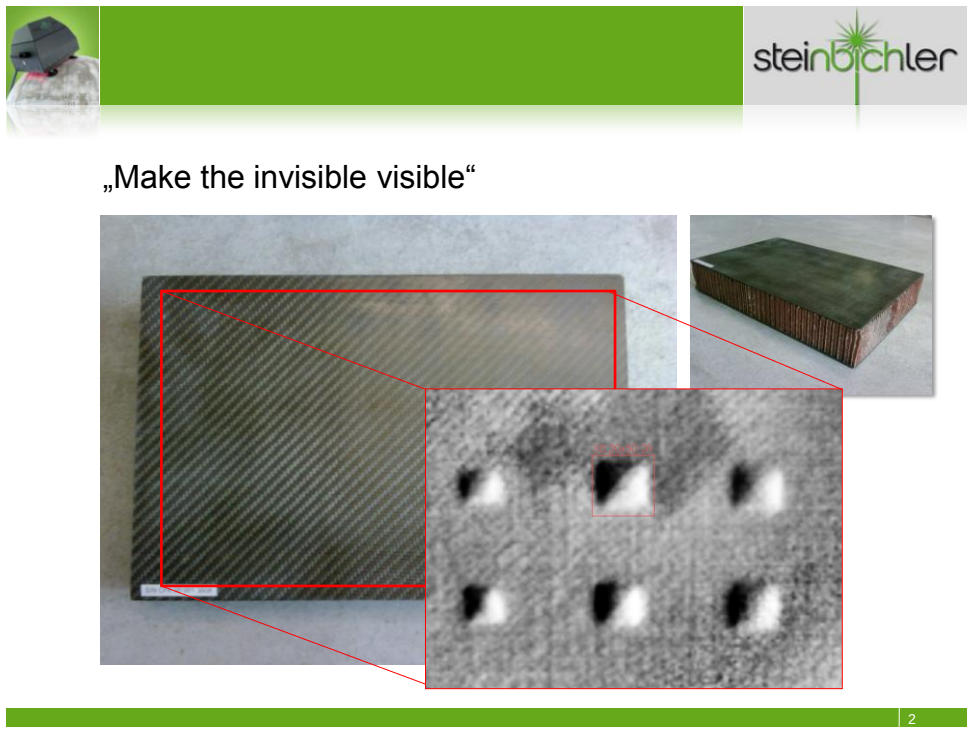


Content of Presentation

- Product lines
- Shearography principle
- Materials to be inspected
- Defects to be found typically
- Applications
- Systems
- References
- Summary

Products for Aerospace Applications

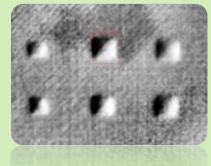
3D Scanners:

- Geometry (COMET & T-SCAN):
  - Compare (CAD data)
  - Measure
    - Distance
    - Radius

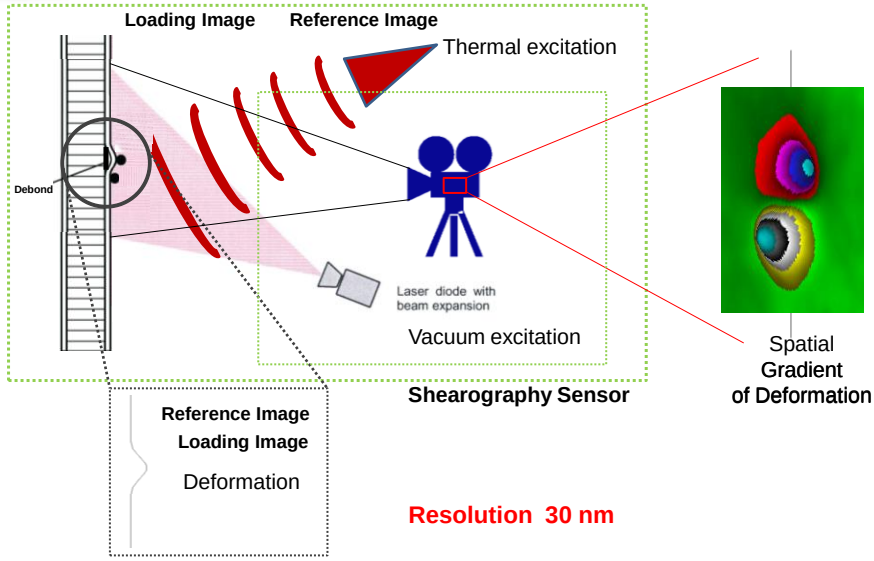
- Shearography NDT (ISIS)

NEW NDT METHOD

- **NEW approach to NDT: Shearography (ST) method**
- **Enables Non-contact inspection**
- **Delivers Full-field results**
  - **1.4 Million datapoints**
- **Very Fast method**
  - **Image was obtained in 10s**
- **Included into international inspection standards:**
  - **NAS 410/ EN4179 (ST)** training & certification standard
  - **ASNT SNT-TC-1A** (Visual and optical testing procedure)
  - **ASTM E 2581-07** (Standard practice of Shearography for composites & aerospace applications)



Technical Basics – Shearographic Principle



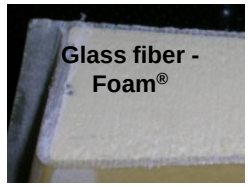
Resolution 30 nm

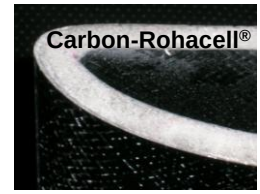
Fields of Application





Materials To Be Inspected





Defects To Be Found Typically

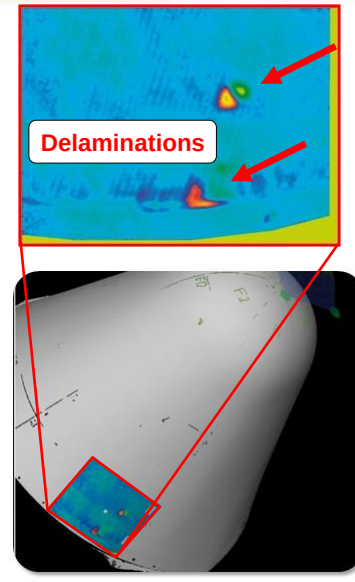
- Debondings
- Delaminations
- Cracks
- Impacts, Dents, BVID‘s
- Tooldrop impacts
- Failed repair areas
- Wrinkles, Waves
- Inclusions:
  - Air, Water, Foil
  - Foreign Material (FOD)

C-130 Hercules

C-130 Hercules

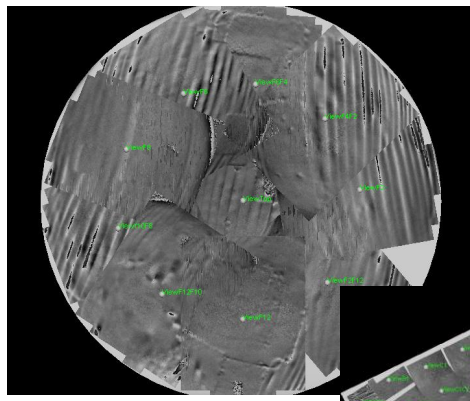
- Inspeciton of CFRP/ GRP nose
- Detection of delaminations
- Matching results with 3D-CAD data

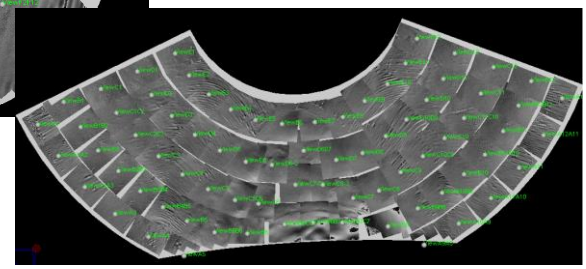
C-130 Hercules



- Detection of two laminate debonds
- Merging and matching of results with imported 3D CAD data

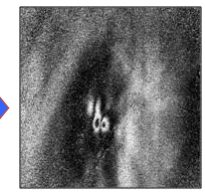
C-130 Hercules



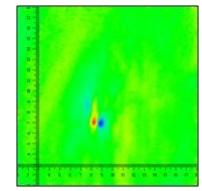


- 100% documentation
- Complete stitching of results

NDT on Tornado



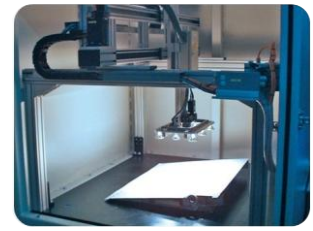
real-time image



test result

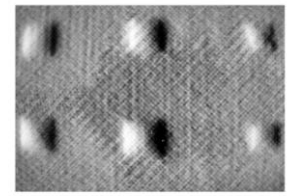
- Shearography inspection on Tornado hull
- Time saving full-field inspection method necessary in maintenance for detection of dents and impacts

Acoustic liner material



Full automatic testing by stationary unit

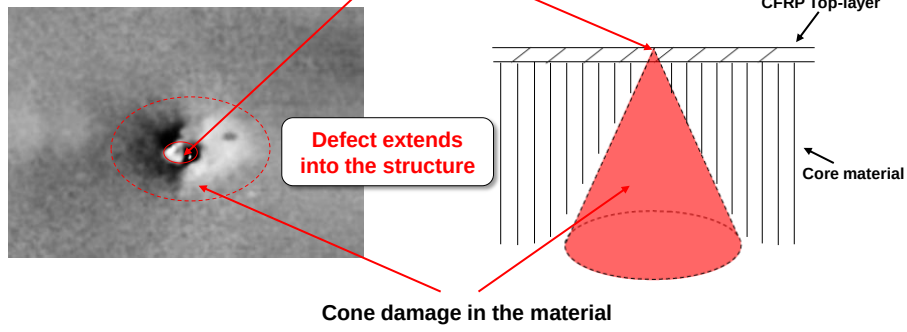
Acoustic liner material: Detection of laminate-honeycomb core defects



Barely visible impact damages

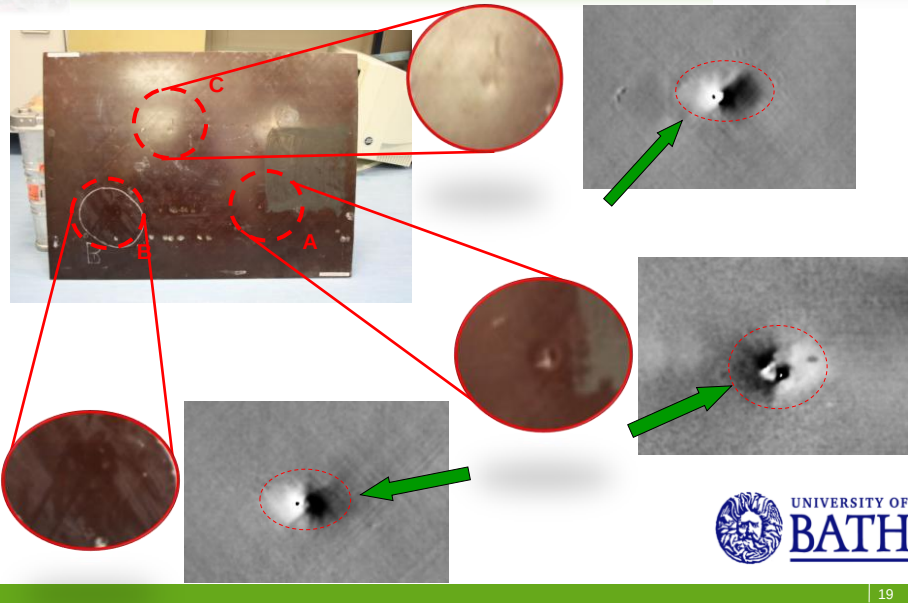
- **Barely visible impact damages on a stringer panel**
- **Inspection of impact**
- **Damage assessment of surrounding area**

Barely visible impact damages



Shearographic image **Theoretical approach**

Barely visible impact damages

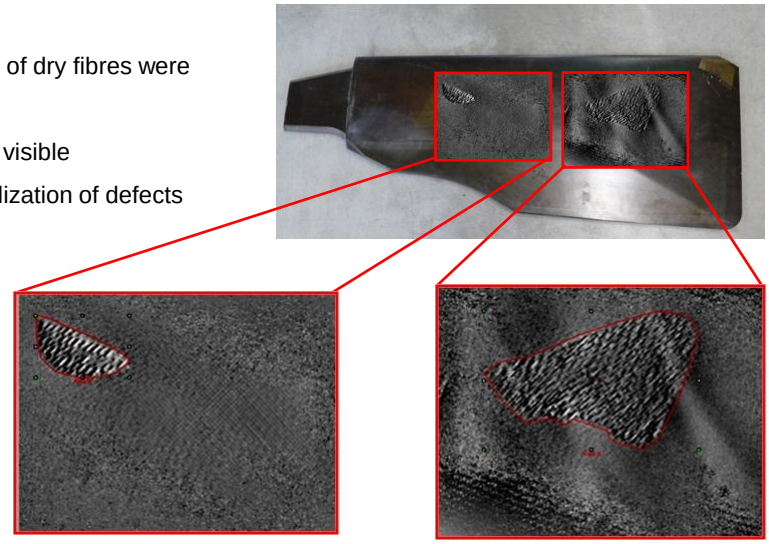


NDT on UAV Wing

- NDT on UAV wing
- Shearography enables fastest inspection procedure
- Defect detection with thermal excitation

NDT on Drone Wing

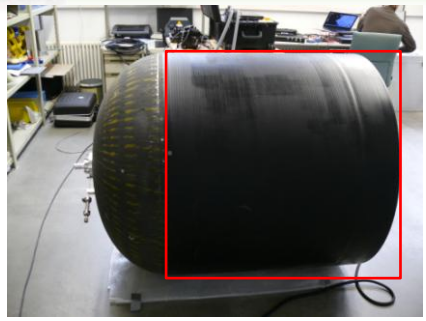
- Two fields of dry fibres were detected
- Flaws not visible
- Easy localization of defects

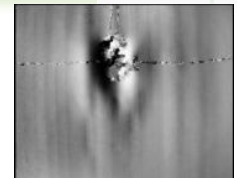


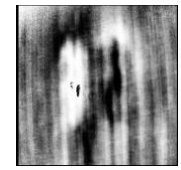
Nitrogen Satellite Tank

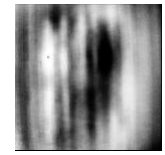
- Set-up: Optical Shearography NDT System (ISIS1100)
- Tank measurement on cylindrical and dome area
- Detection of artificial inserts
- Radome area stiffer than cylindrical area

Cylindircal area defects



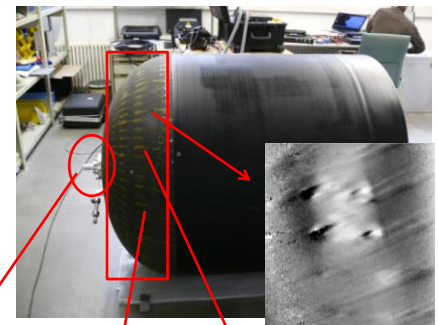




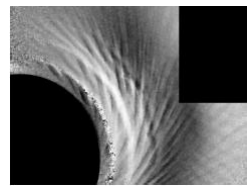


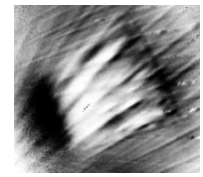
- Cylindrical area inspected
- All 4 defects found
- Defects of inserts in CFRP
- Thermal excitation of 4s

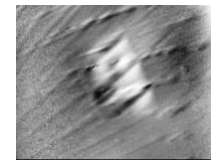
Radome area defects



- Thermal excitation 5s
- All 4 defects found

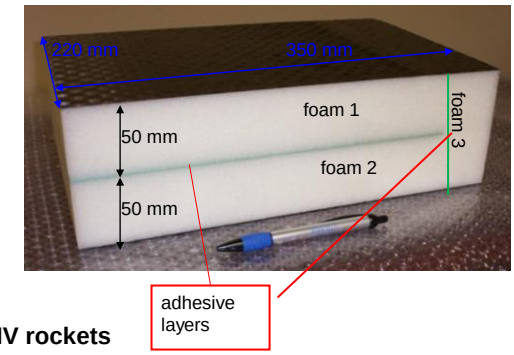






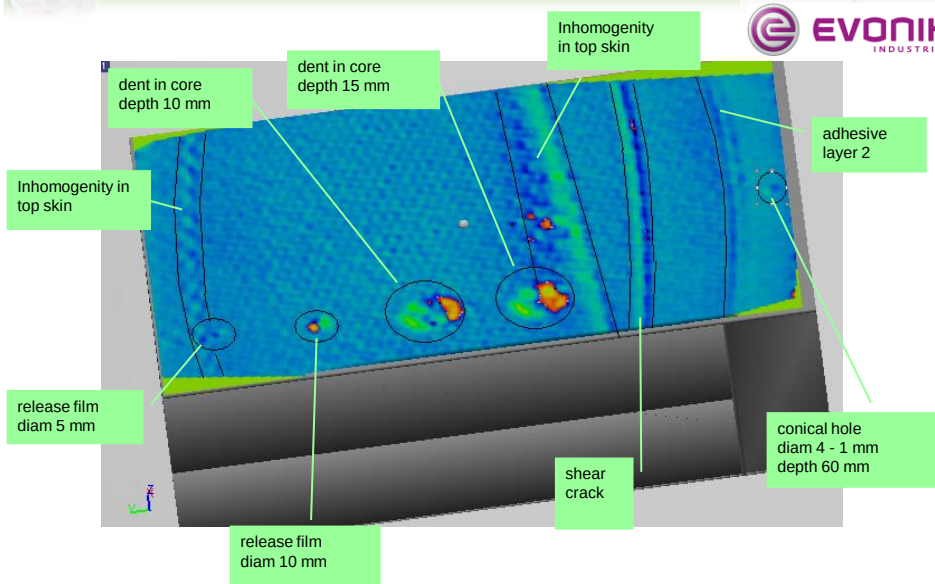
Shearography on Rohacell material

- **NDT of ROHACELL® material**
- **Thermal excitation**
- **Testing time less than 15 seconds**
- **Carbon top skin**
- **Adhesive layers**



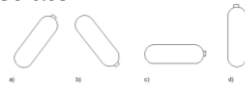
- **Material is used for :**
- Body panels of Boeing's **Delta II, III & IV rockets**
- Stringer structures in the pressure bulkheads of the **Airbus A380/ A340**
- Helicopter applications as **main and tail rotor blades** and **fuselage panels**

Shearography on Rohacell material



Composite Vessel Testing

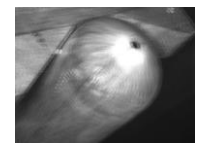
- Composite pressure vessel
- Breathing tank demonstrator
- Type 4, 6,8 l
- Drop tests according to norm EN12245:2002 (D)
- Loaded via internal pressure
- Sensor in pressure chamber



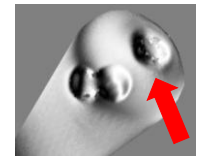
BAM Federal Institute for Materials Research and Testing

Composite Vessel Testing

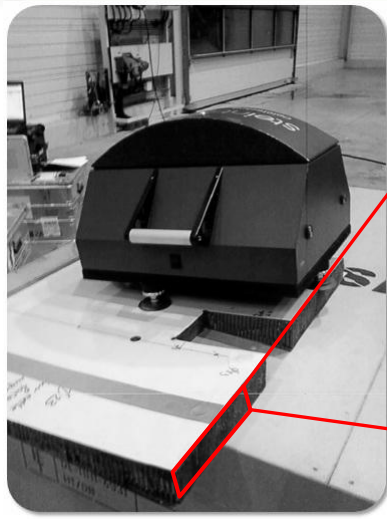
BAM Federal Institute for Materials Research and Testing



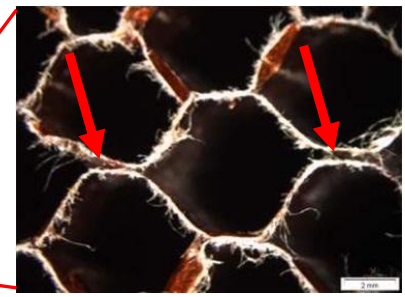
- Defects found on all impacted areas
- Pressure variation for detection (0,5 Bar)
- Analysis shows metric of defects
- Results transferable to other tank designs



Airbus Toulouse



« Performing technical evaluation of shearography to inspect sandwich structures after assembly »



ISIS*mobile* 3000 on **thick** sandwich structures at Airbus in **Toulouse**

AIRBUS by courtesy of Airbus Toulouse

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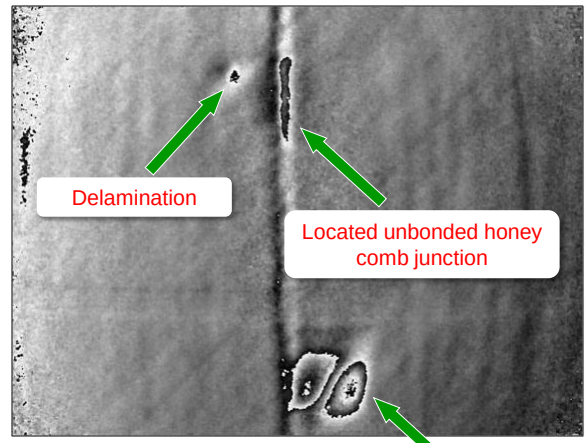
Airbus Toulouse



AIRBUS by courtesy of Airbus Toulouse

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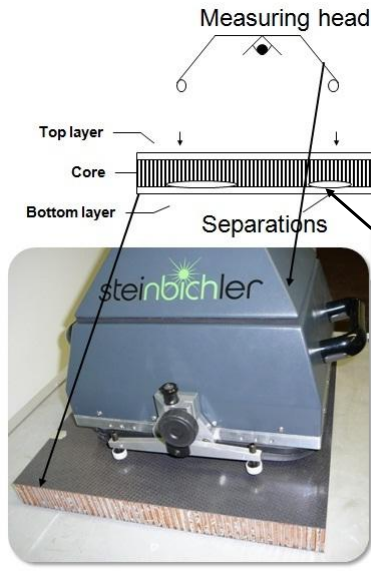
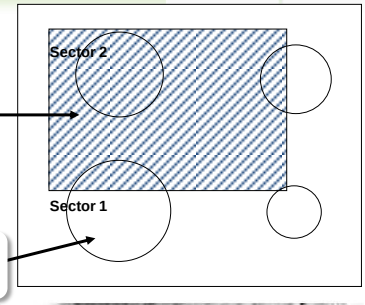
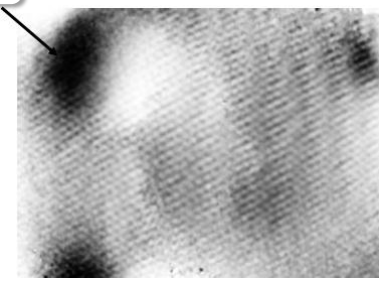
Airbus Bremen



Field of View (FOV)



Delaminations on back side

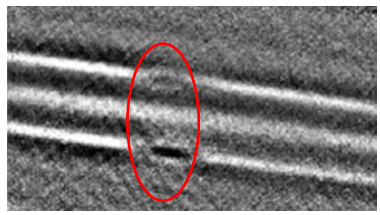


AIRBUS

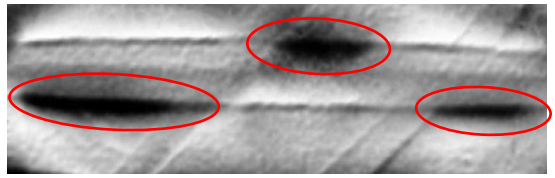
by courtesy of Airbus Bremen

Stringer delaminations – real defects

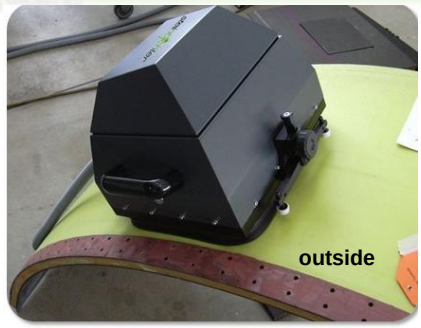
Stringer delamination – difference of stiffness visible

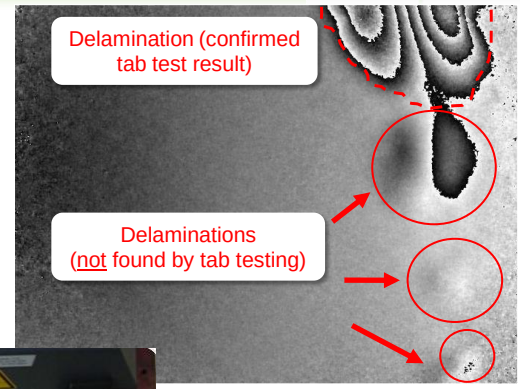


Delaminations



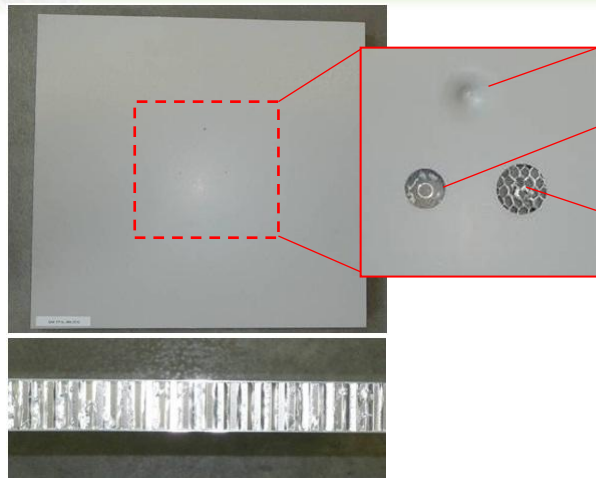
Aircraft Engine Cover





- One shot > 4 results
- Thermal loading
- Field of view: A4 paper size

Aluminium Honeycomb



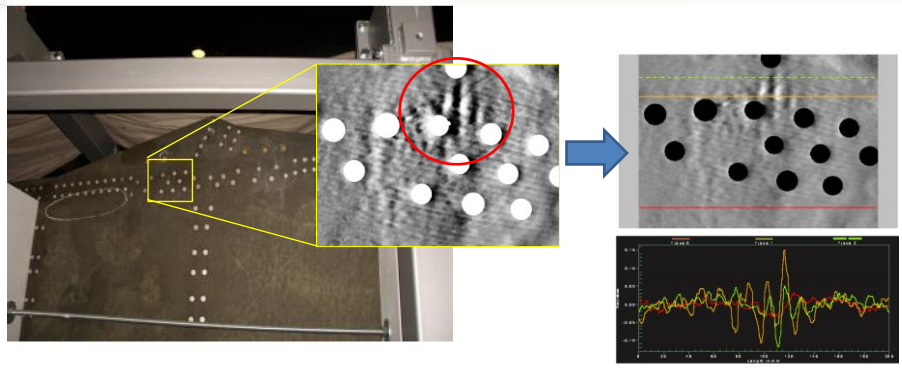
Impact
(7 mm depth with sphere 32 mm diameter)

Delamination: Top Layer - Core
(25 mm diameter, depth 25 mm)

Delamination: Core - Rear Layer
(30 mm diameter, depth 12 mm)

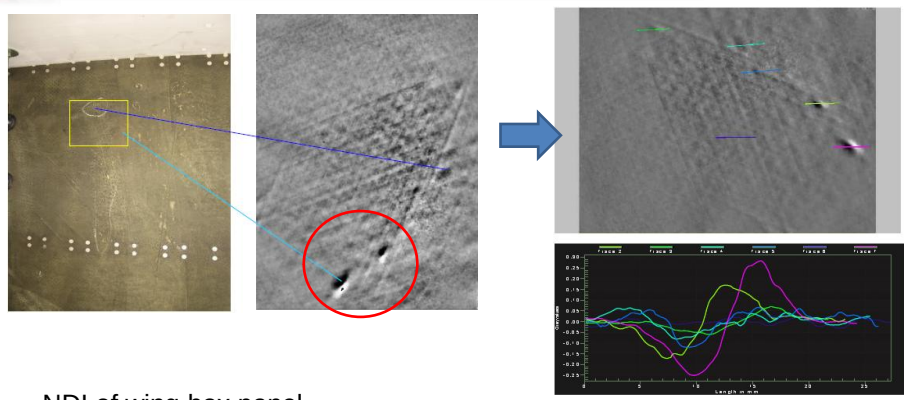
Detection of artificially induced
defects on backside with ISIS*mobile* 3100

Wing-Box NDT: Wrinkles



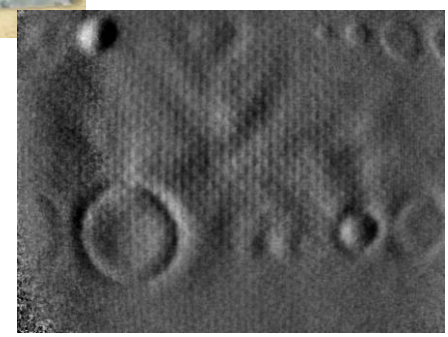
- NDI of wing box panel
- Wrinkles detected by Shearography
- Section analysis shows cut wrinkle details

Wing-Box NDT: Delaminations



- NDI of wing box panel
- Delaminations and linear anomalies detected by Shearography
- Section analysis shows delamination details

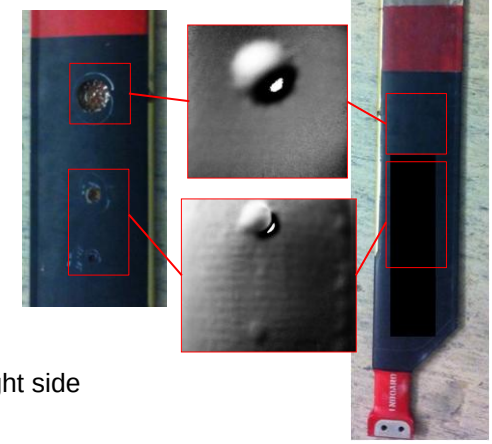
Carbon Nomex Fuselage Material



- Fuselage material
- Artificially induced defects
- Defects displayed in right image
- Image below: side view of material

Shearography on helicopter tail rotor blade

Backside

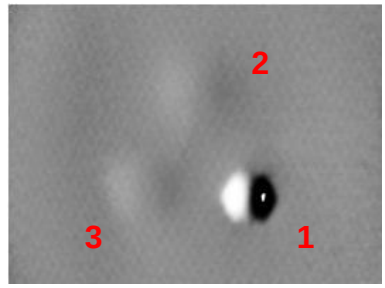


- Helicopter tail rotor blade
- Artificially induced drillings (50mm, 20mm, 10mm)
- Delams simulated
- Found defects displayed on the right side

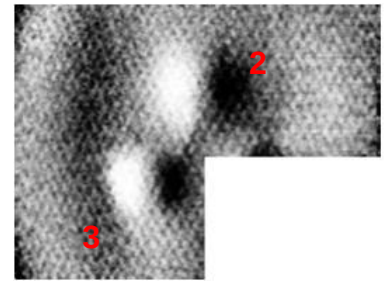
Aluminium Honeycomb

Vacuum excitation (Δ 40 mbar)

1: Delamination Top Layer – Core Impact
2: Impact
3: Delamination Core - Rear Layer



Unscaled result image



Scaled result image

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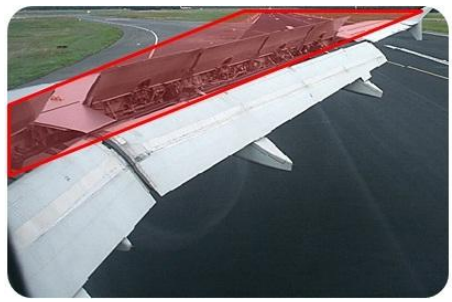
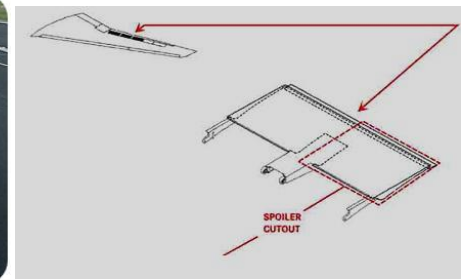
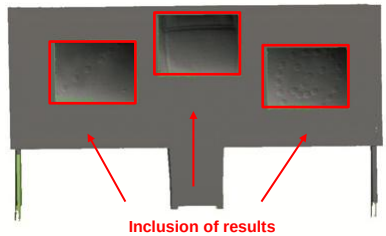
Delaminations on Spoiler

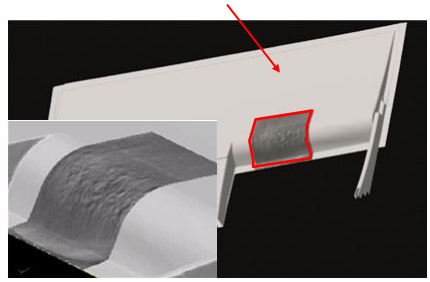




- Scanning of complete spoiler
- Detection of delaminations on composite material
- Comparison between ultrasonic and shearography

Delaminations on Spoiler





- Automatic inclusion of results into report and CAD data
- Comparison of scanning time: (complete spoiler scanned)

Ultrasonic	**approx. 1 hour**
Shearography	**approx. 5 minutes**

AIRBUS by courtesy of Airbus Bremen, Mr. Scherling

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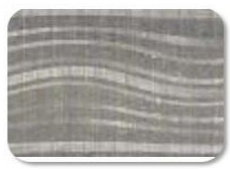
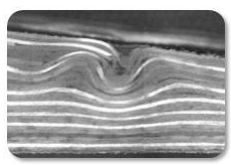
GKN – NDT on Wrinkles

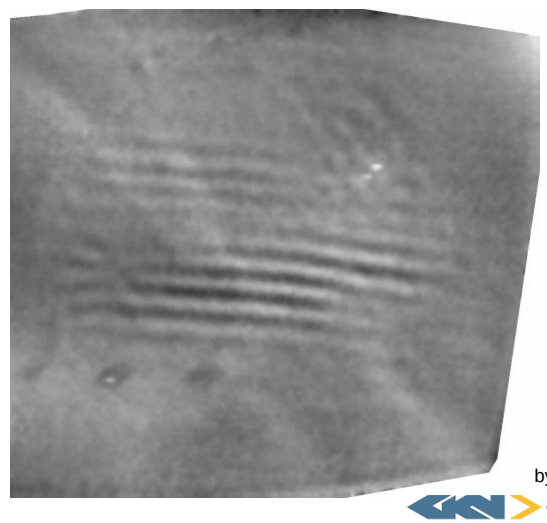
Wrinkles

wave



wrinkle





by courtesy of GKN AEROSPACE GmbH

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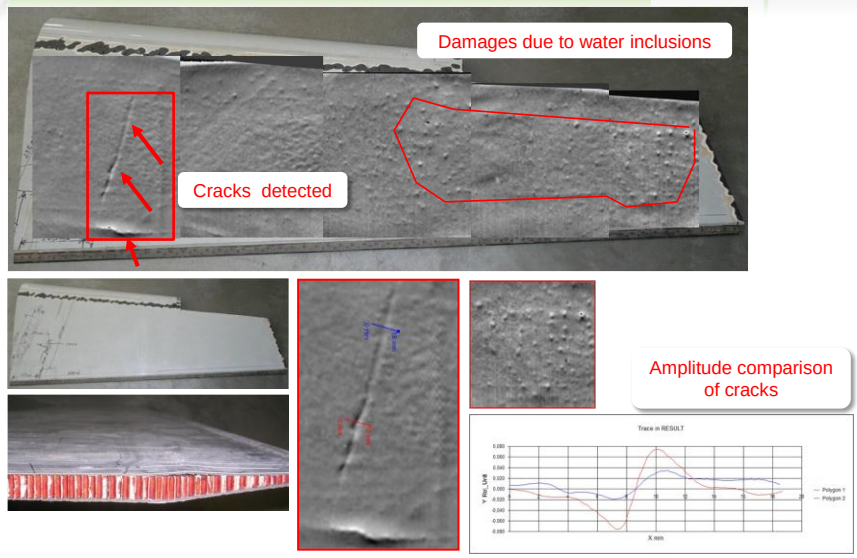
Airbus Madrid – Cracks / Water Inclusions

- Inspection of wing section cut
- Detection of delaminations due to water inclusions and cracks

AIRBUS by courtesy of Airbus

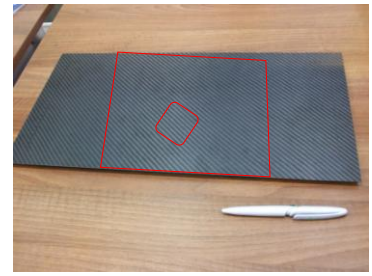
Airbus Madrid – Cracks / Water Inclusions



AIRBUS by courtesy of Airbus

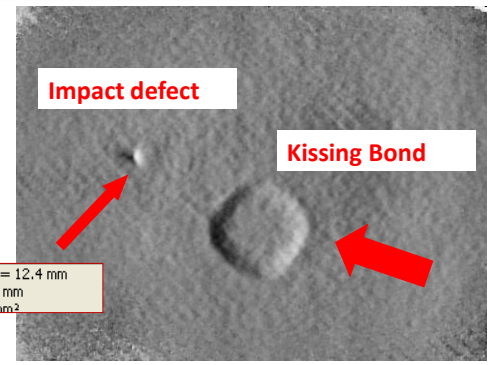
Kissing bond NDT

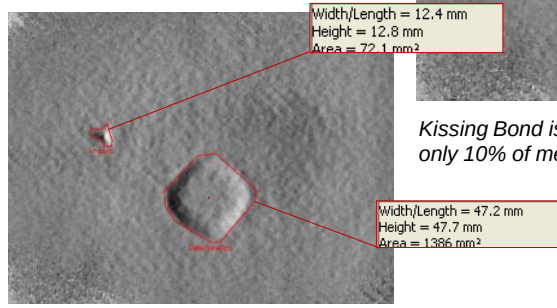
- NDT of a Kissing Bond
- CFRP top-layer foam core material
- First approach with demonstrator material for in-field detection
- Artificially prepared with foil insert before lamination



Kissing bond NDT

- Kissing Bond detected
- Thermal excitation (1s)
- Impact detected
- Result within 10s obtained





Kissing Bond is defined as a bonded area with only 10% of mechanical properties

First approach to NDT – ISIS1100

System for non-contact NDT:

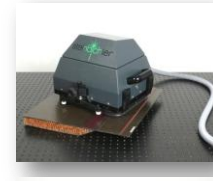
- Portable System
- Flexible
- Easy to use
- On tripod
- Compact Electronic
- Adjustable to various tasks
- Easy upgradable

Modularity of ISIS Systems

Sensors

Electronic Unit

ISIS 3100



ISIS 3010

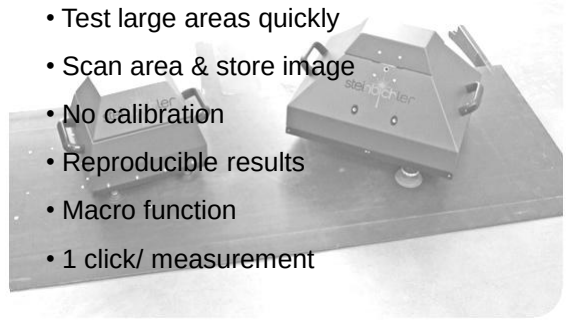
Hood systems – Two Inspection Sizes

Industrial solutions

AOI:
A4 Paper Size

Exitation:
Heat & Vacuum

- Test large areas quickly
- Scan area & store image
- No calibration
- Reproducible results
- Macro function
- 1 click/ measurement



AOI:
A3 Paper Size

Excitation:
Heat

Automatization

- Robot solutions
- Stationary units (x,y,z axis rail)

100 % Automation

Quanitative Mesurement

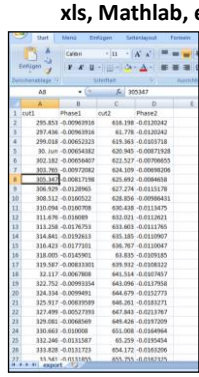
• From qualitative Testing…

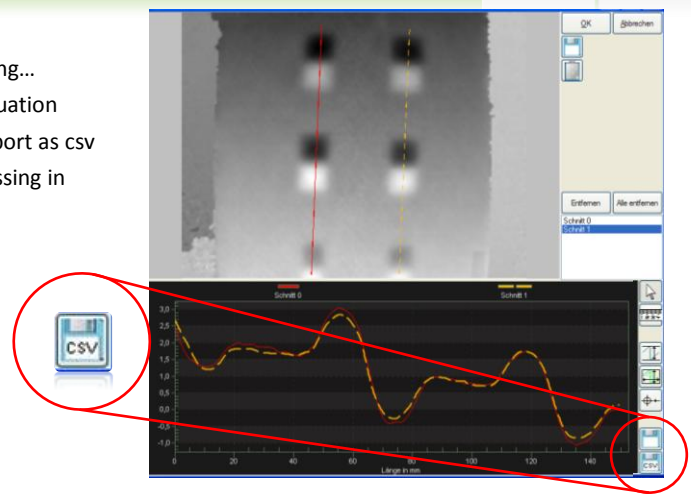
…**quantitative** Evaluation

• Numerical data export as csv

• Enables postprocessing in

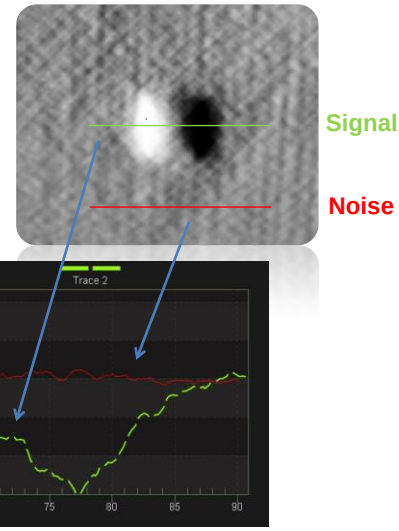
xls, Mathlab, etc.



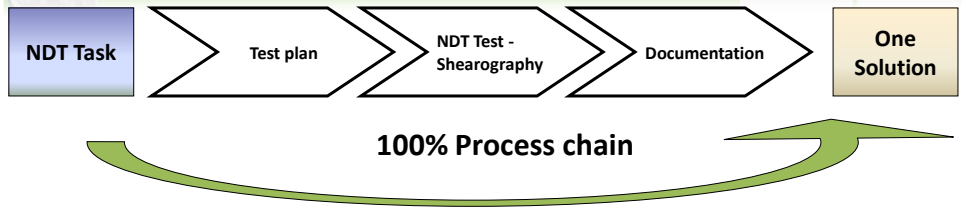


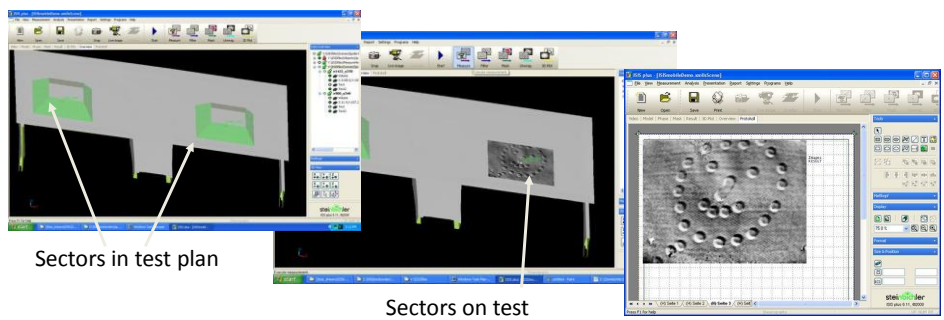
Signal to noise ratio (SNR)

- Signal to noise ratio (SNR)
- Numerical values
- Indication of quality to NDT staff
- Direct comparison to UT → **dB** values



Documentation process chain





Sectors in test plan

Sectors on test

Automatic reporting

Successful Cooperation with the Industry

ISIS*mobile* 3000 in operation at Airbus Hamburg

ISIS*mobile* 3000 in operation at Airbus Toulouse

…for constant improvement of our products

References

Hochschule Esslingen
University of Applied Sciences
Taiwan power company
NPS
Hochschule München
TUM Technische Universität München
BOMBARDIER
BOMBARDIER AEROSPACE
EADS
bias
NT NEVA TECHNOLOGY
mtu
AIRBUS
RESHETNEV COMPANY
Universidade de Vigo
AVIADVIGATEL
NRC·CNRC
Universidad Complutense Madrid
EC TEST SYSTEMS
SAMSUNG
BAM Federal Institute for Materials Research and Testing
PREMIUM AEROTEC

Summary

- **Non-Contact analysis**
- **Fast inspection**
- **Full-Field results**
- **Ideal for composite materials**
- **Numeric data export**
- **SNR**
- **Production & maintenance**

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Turbine Blade NDT in MRO

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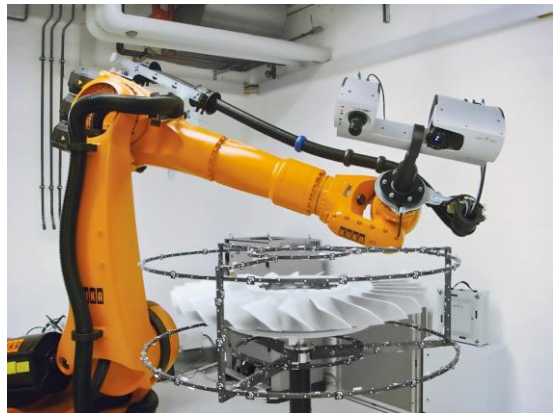
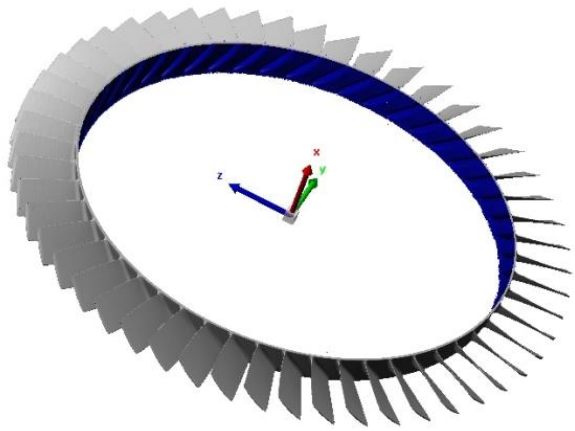
Automated bisk measurements



Areas of use:

- Blade designers
- Blade manufacturers
- Turbine manufacturers
- Turbine & Blade MRO

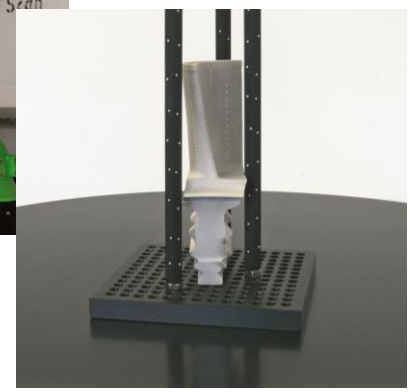
Automated bisk measurements



Results:

- 3D point cloud
- STL generation
- Result to CAD fit
  - Detection of abrasion
- Feature measurement
  - Length
  - Centre point
  - Angles
  - Radius

Single Blade Digitizing



Single Blade Digitizing

Results:

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Automated Cell – Modular Concept

New approach:

- Mobile modular measuring cell with L3D 5M Digitzing Senor