

Non-destructive Testing of Fiber Composite Components - Case Study: Rotor Blades of Wind Turbines

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Thanks to PhD students: M. Kannenberg, A. Künzel, D. Kovacevic

- Introduction
- Rotor blades, BladeTester
- Non-destructive testing
- Examples
- Conclusion and outlook

Motivation: Manufacturing faults and defects

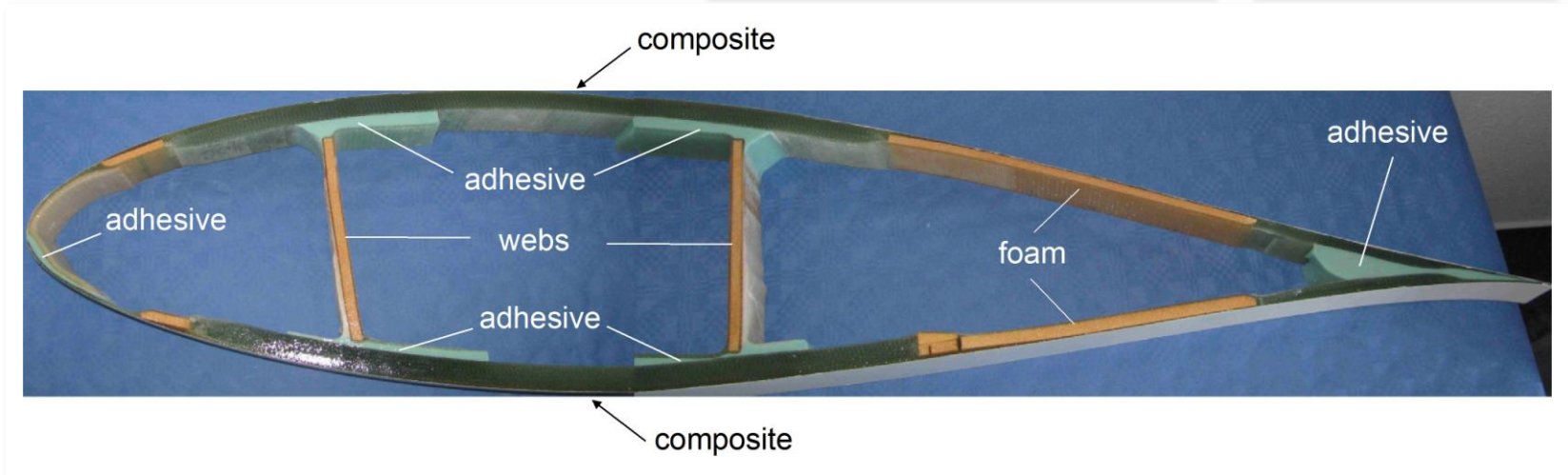
Deformation under dead weight



Deformation in operation



Handwork



Extensive hand work, various materials, blind bondings and cost pressure cause several manufacturing defects in rotor blades, which can be critical in operation



Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Joint research project **BladeTester** -
Automated approach for serial integrity tests of rotor blades
2011-2015

Partners

Technische Universität Berlin, Verbundkoordinator

BAM Bundesanstalt für Materialforschung und -prüfung

Steinbichler Optotechnik GmbH



Associated Partners

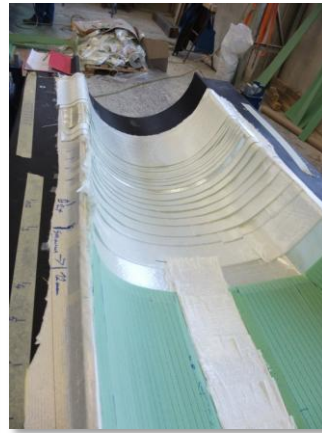


Ingenieurbüro
Werkhausen



Rotor blade „tuners“

5 real rotor blades for industrial wind turbine + incorporated manufacturing faults as experimental specimens



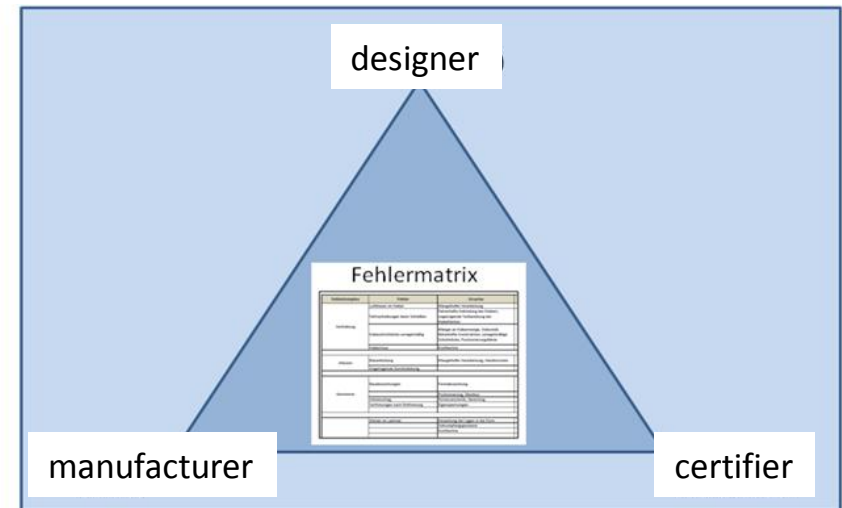
Rotor blade tuners:

- 1 RB without special faults
- 2 RB with special faults
- 1 RB possibly fault-free
- 1 RB with faults (coated)



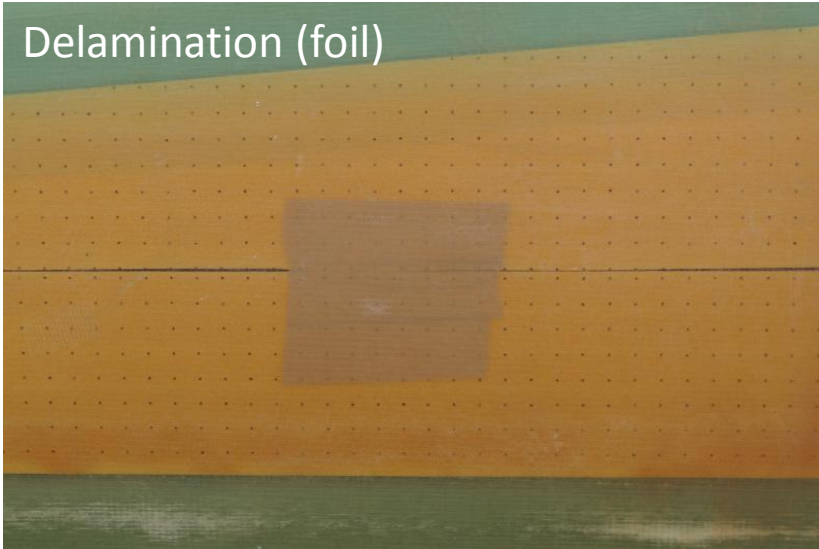
Systematic fault analysis by partners is documented in a fault matrix, which categorizes faults with respect to

- relation to components
- defect type
- defect causes
- defect rate
- consequences for manufacturer
- relevance w.r.t. RB integrity
- detectability

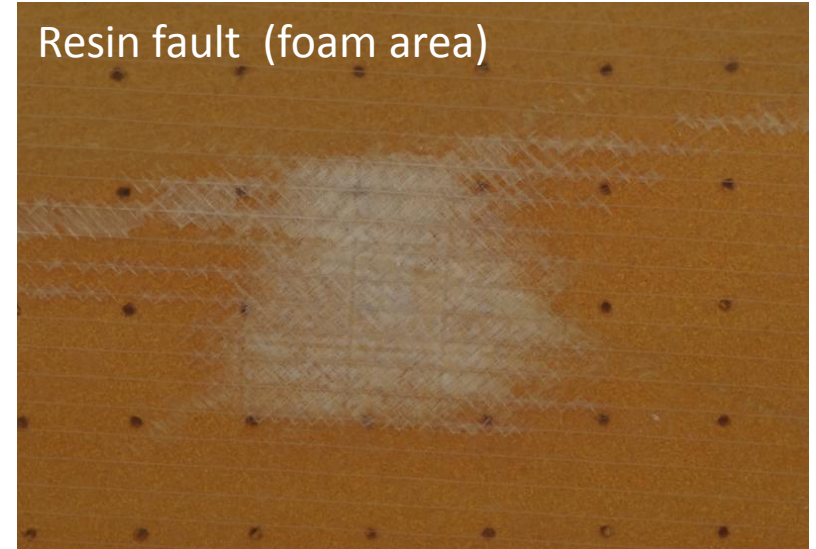


Some examples of manufacturing faults

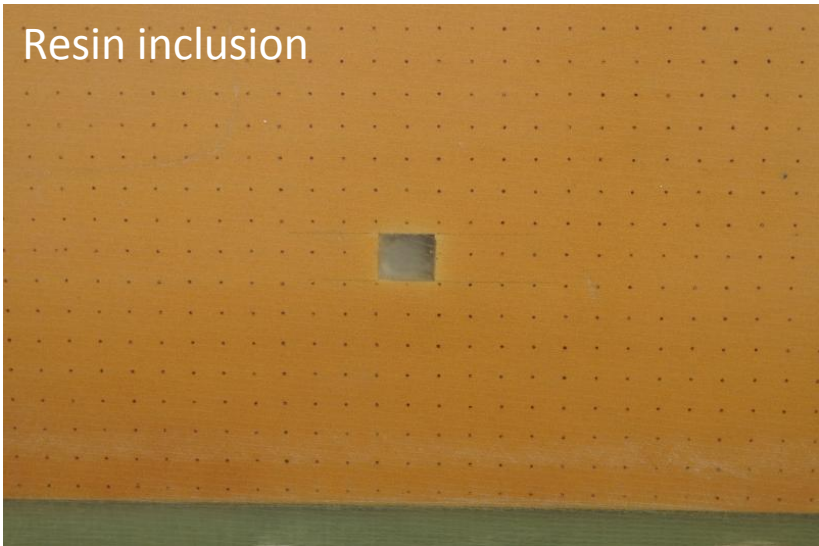
Delamination (foil)



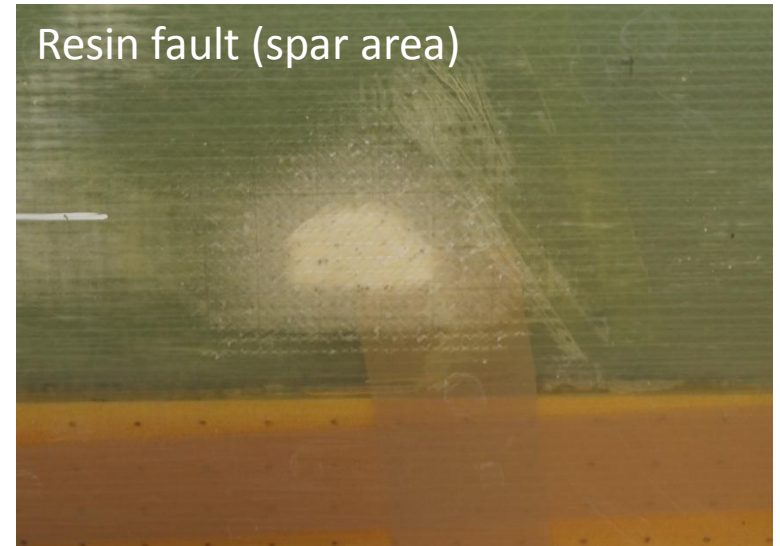
Resin fault (foam area)



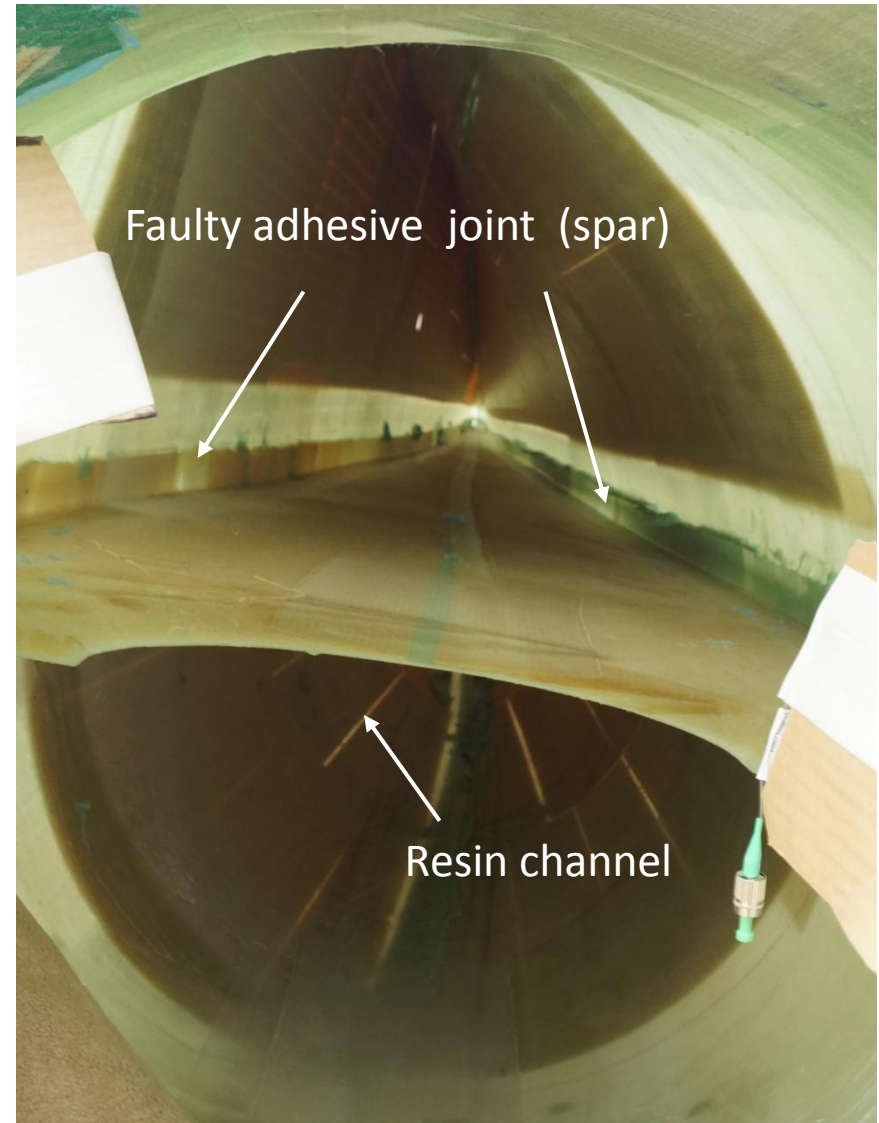
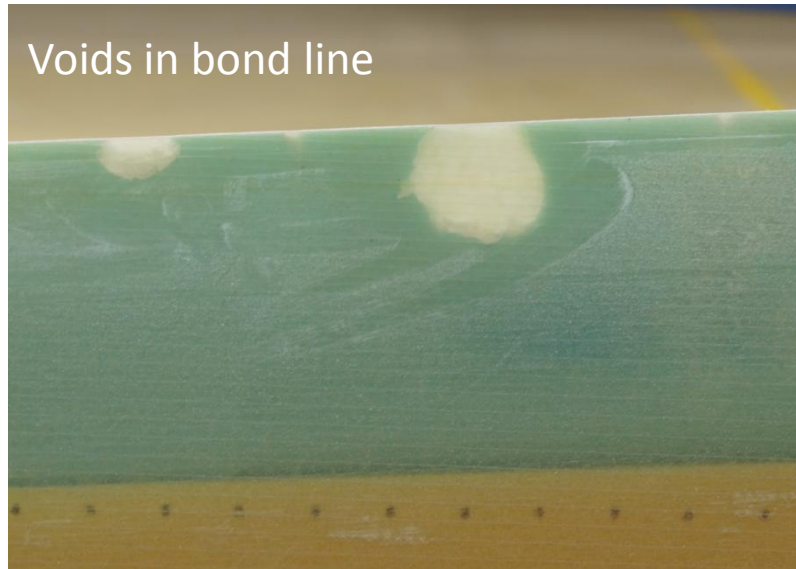
Resin inclusion



Resin fault (spar area)

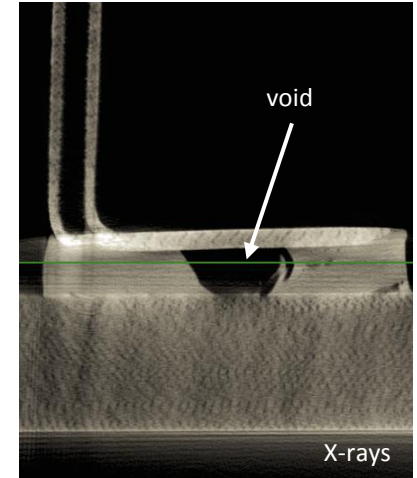
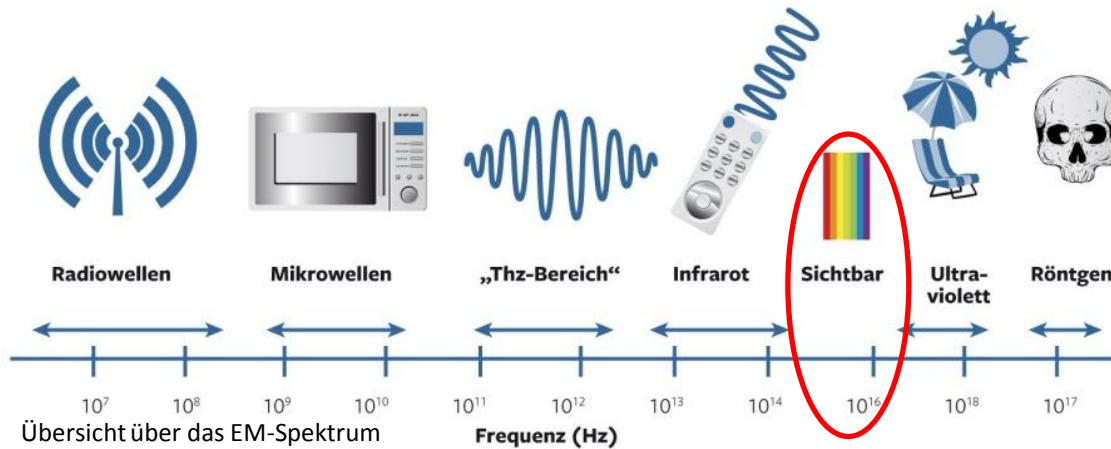


Some examples of manufacturing faults



Systematic testing of various NDT techniques w.r.t. manufacturing faults

Electromagnetic waves

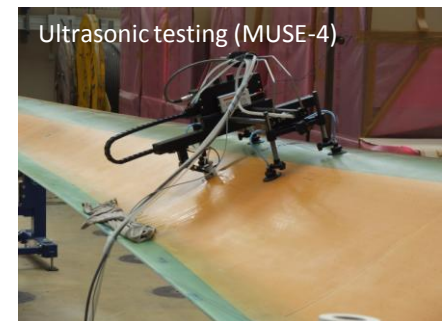


Mechanical testing techniques

- **Ultrasonic waves**
- Shearography
- guided waves

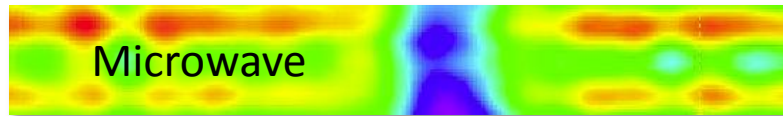
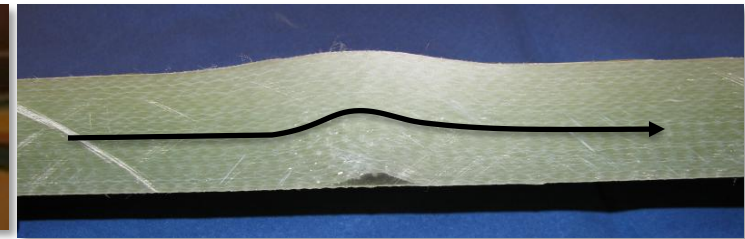
Selection criteria

- Detectability
- Repeatability
- Resolution
- Testing time / cost



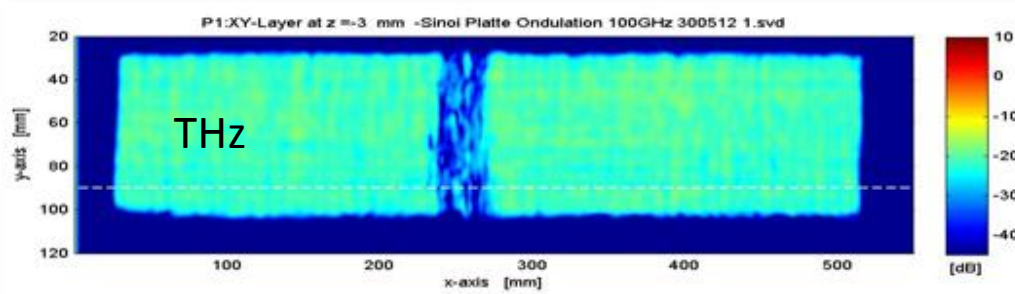
NDT on specimen

Hidden ondulation in composite, stress field disturbance, potential failure source



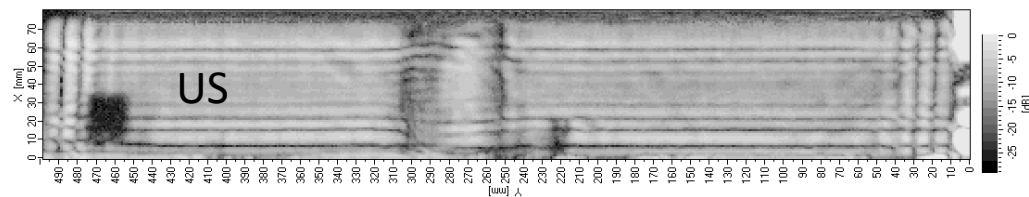
- μ -waves C-Scan (FIT-M)
10 GHz, wave length 3 cm

Electro-magnetic waves



- THz-Scan (Becker Photonik)
100 GHz, wave length 3 mm

mechanical waves

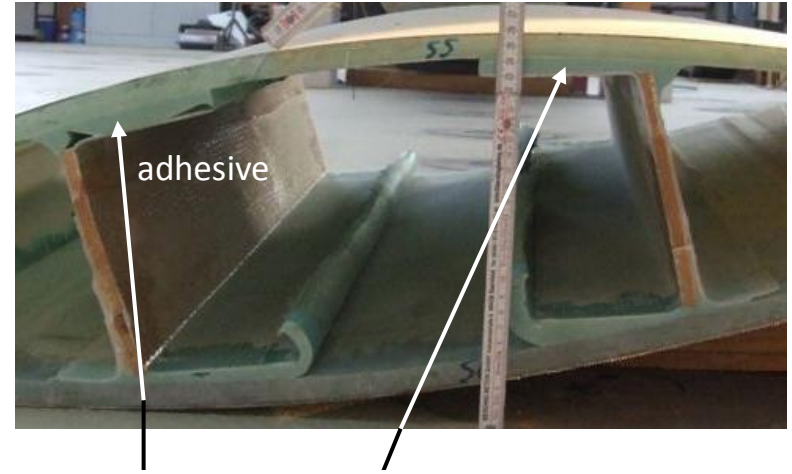
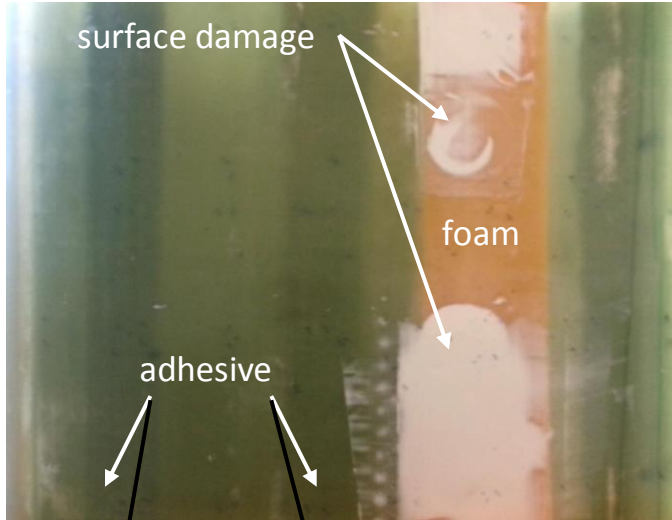


- US-Scan (MUSE Z-400
Dr. Hillger)
0.5-1.0 MHz

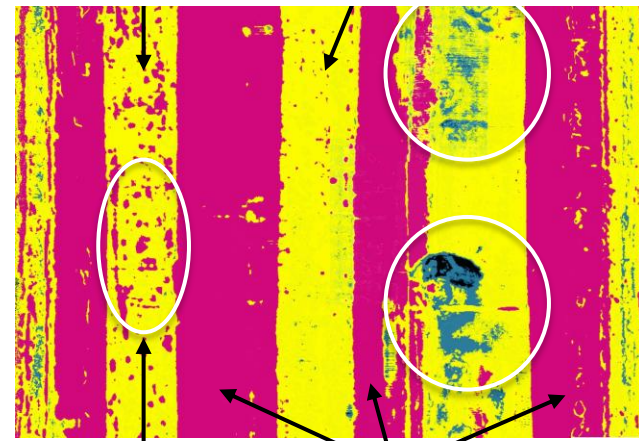
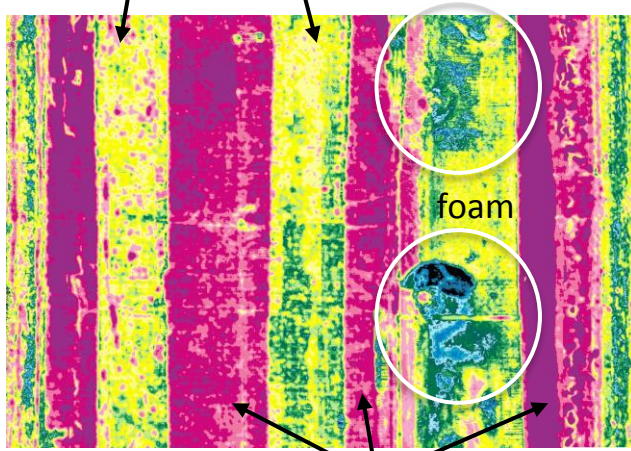
Other applied techniques: thermography, shearography, x-rays

US testing on rotor blade segment

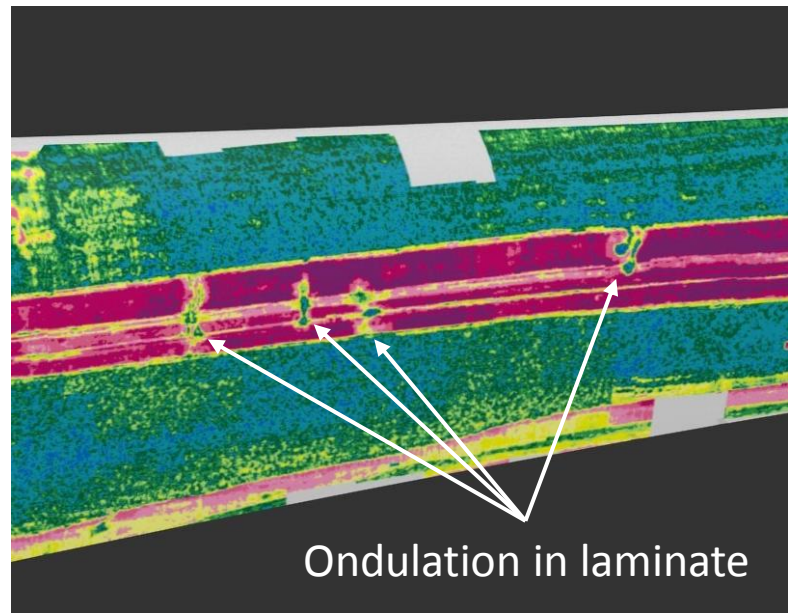
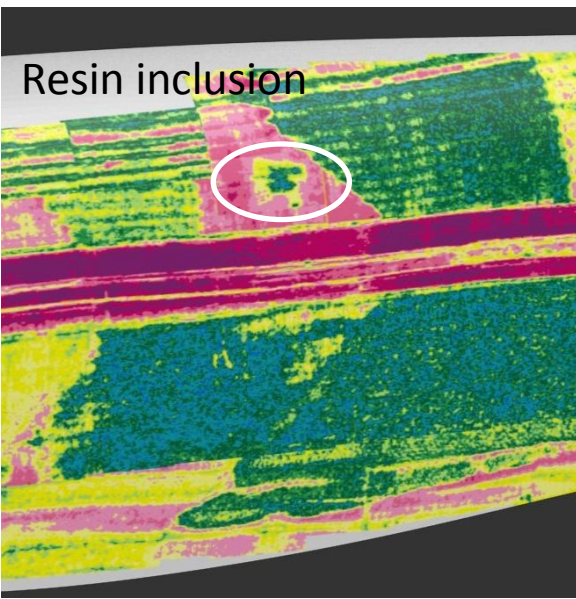
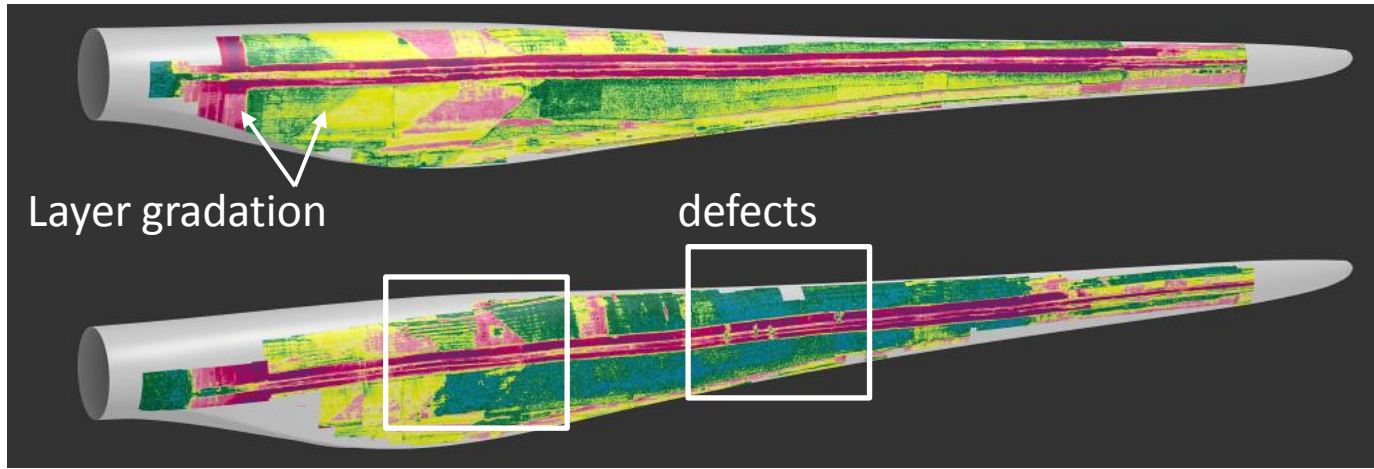
Section of rotor blade with several defects



US scan with reduced colours



NDT on rotor blades



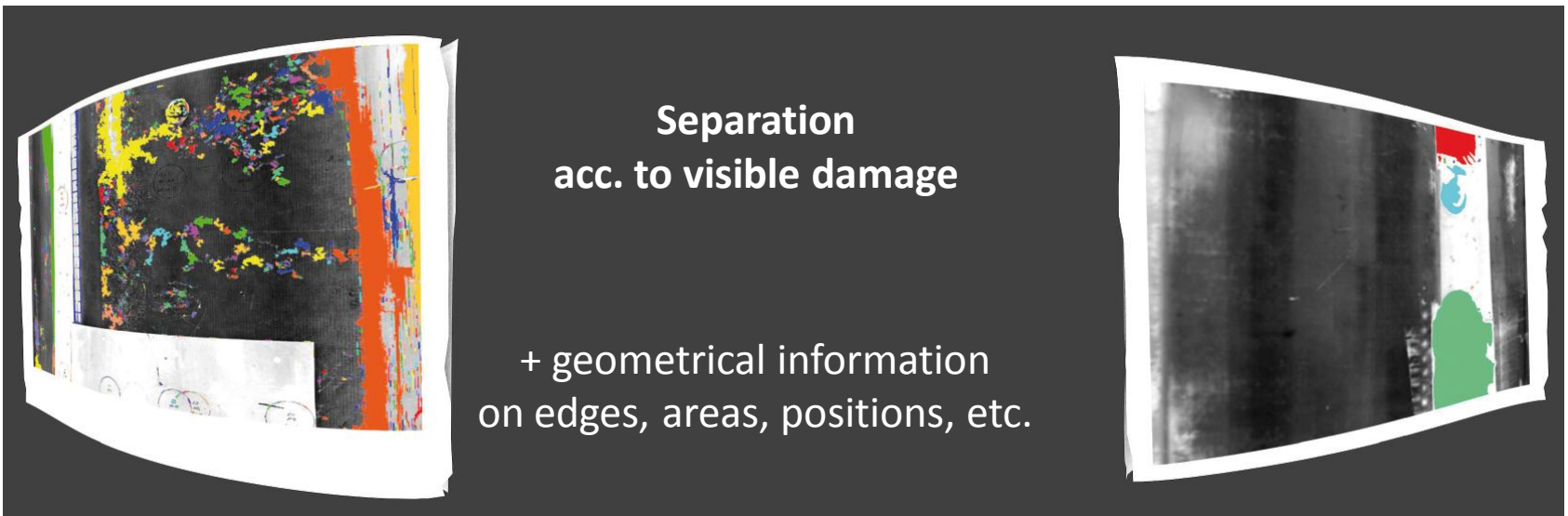
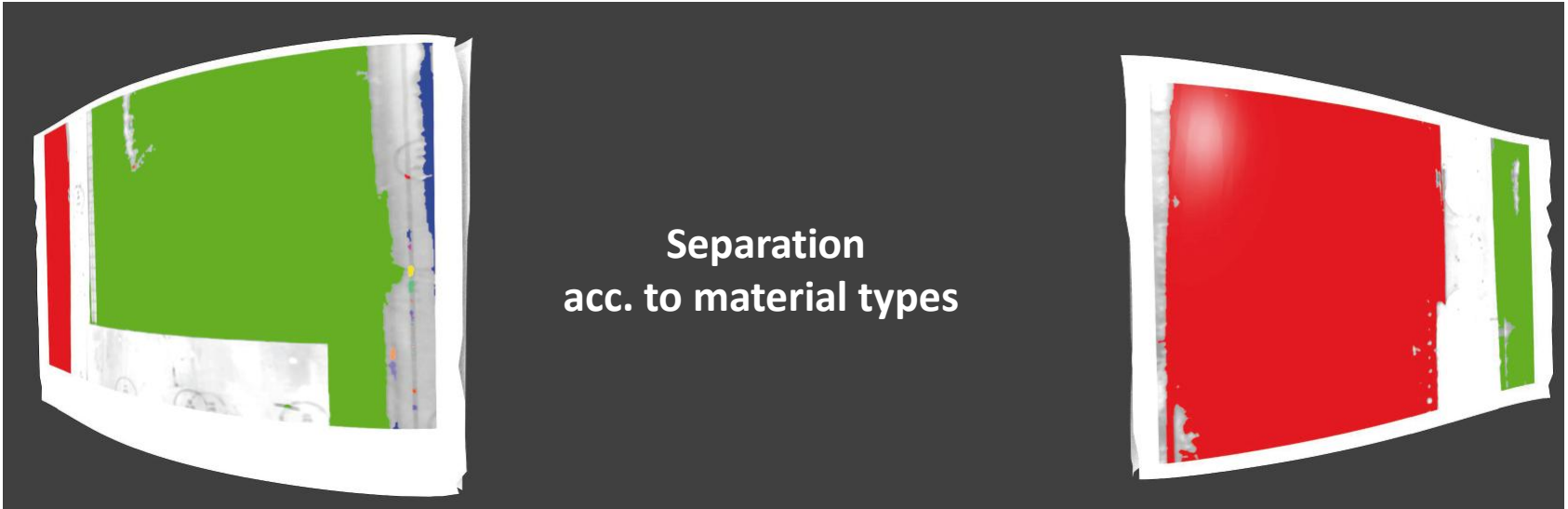
- easy access
- low cost
- automatable
- rapid
- camera + software



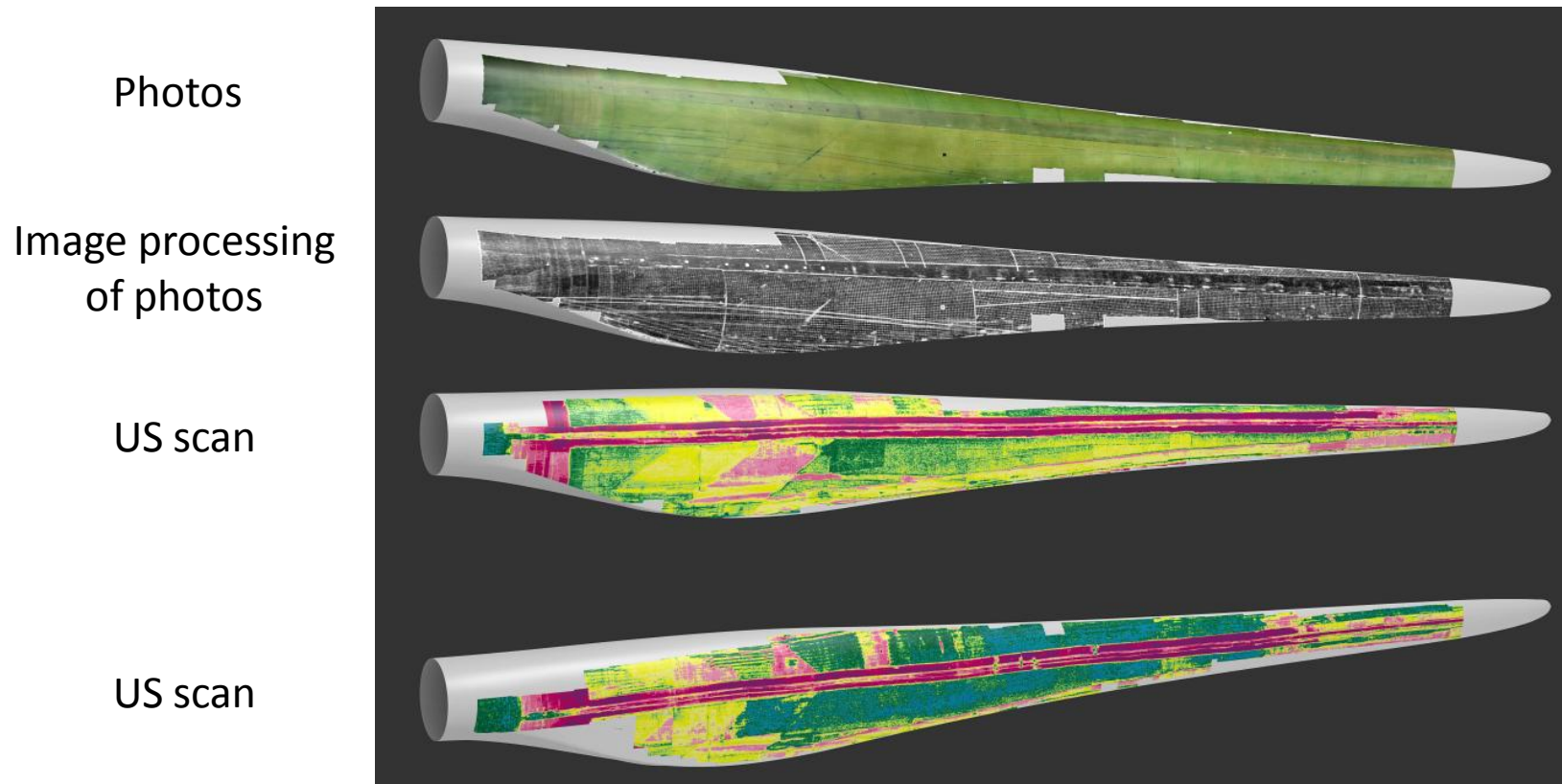
- visible information
- close to the surface

Partner: GFAI

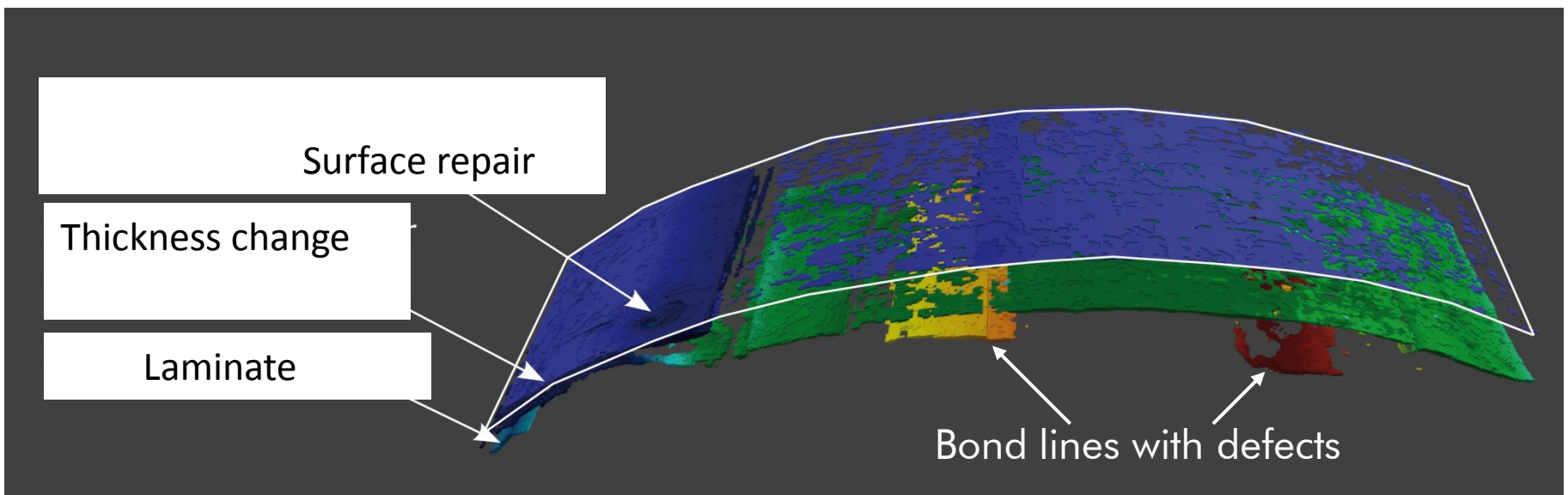
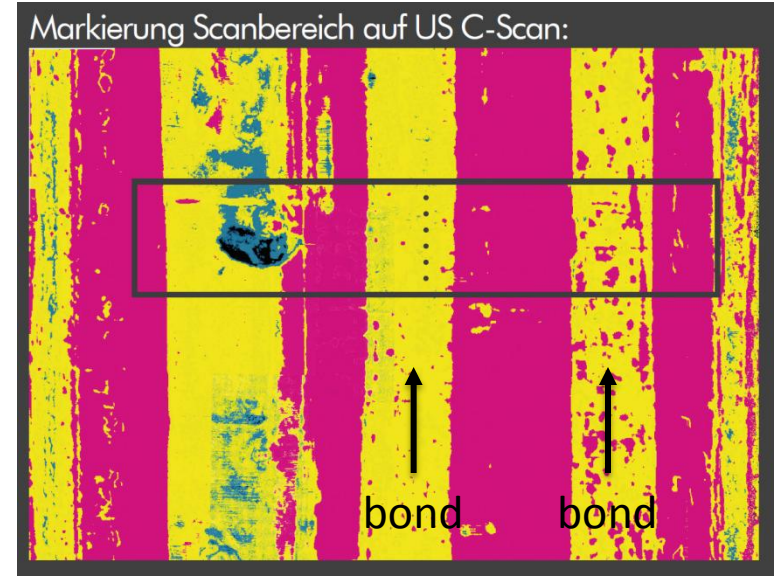
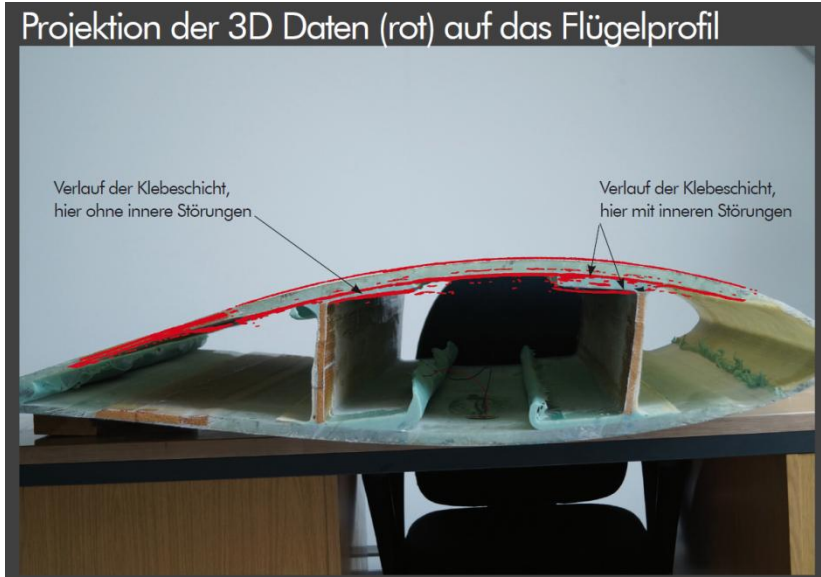


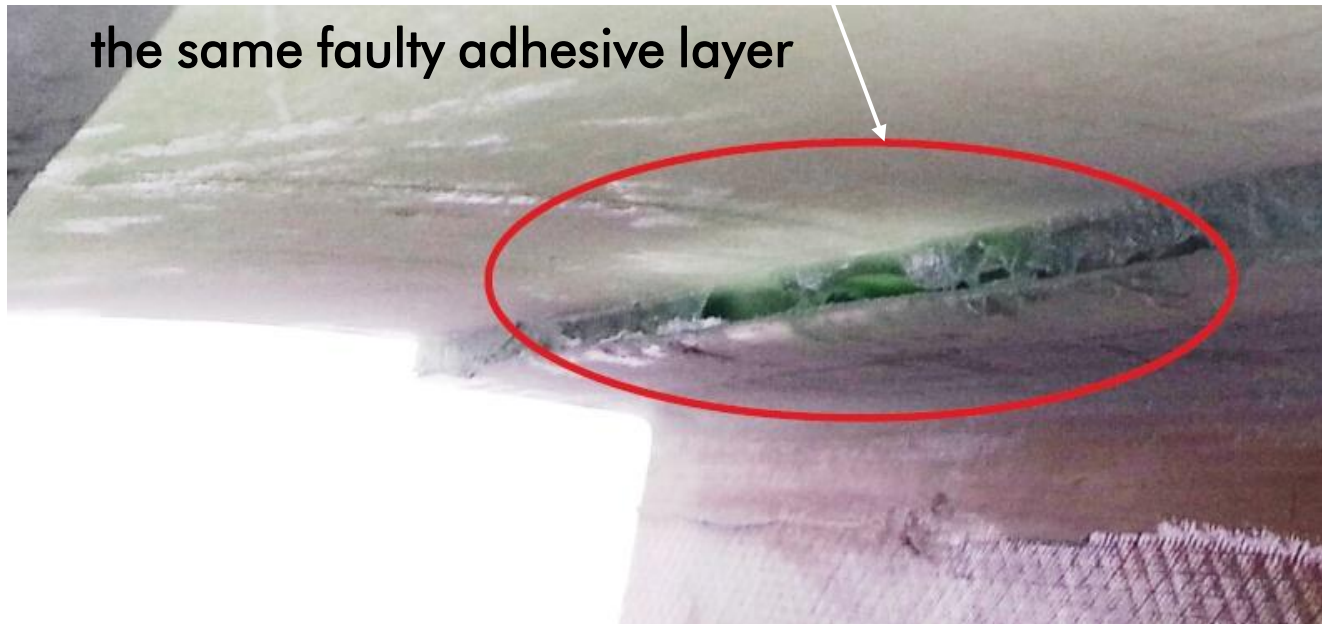
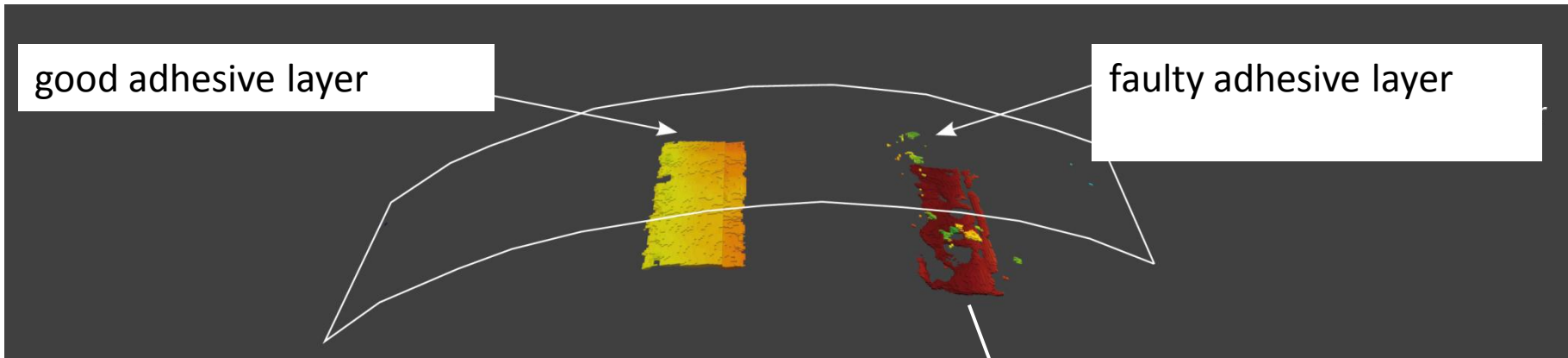


A combination of rapid image processing and specialized US testing provides a reliable information on the setup and manufacturing faults of rotor blades

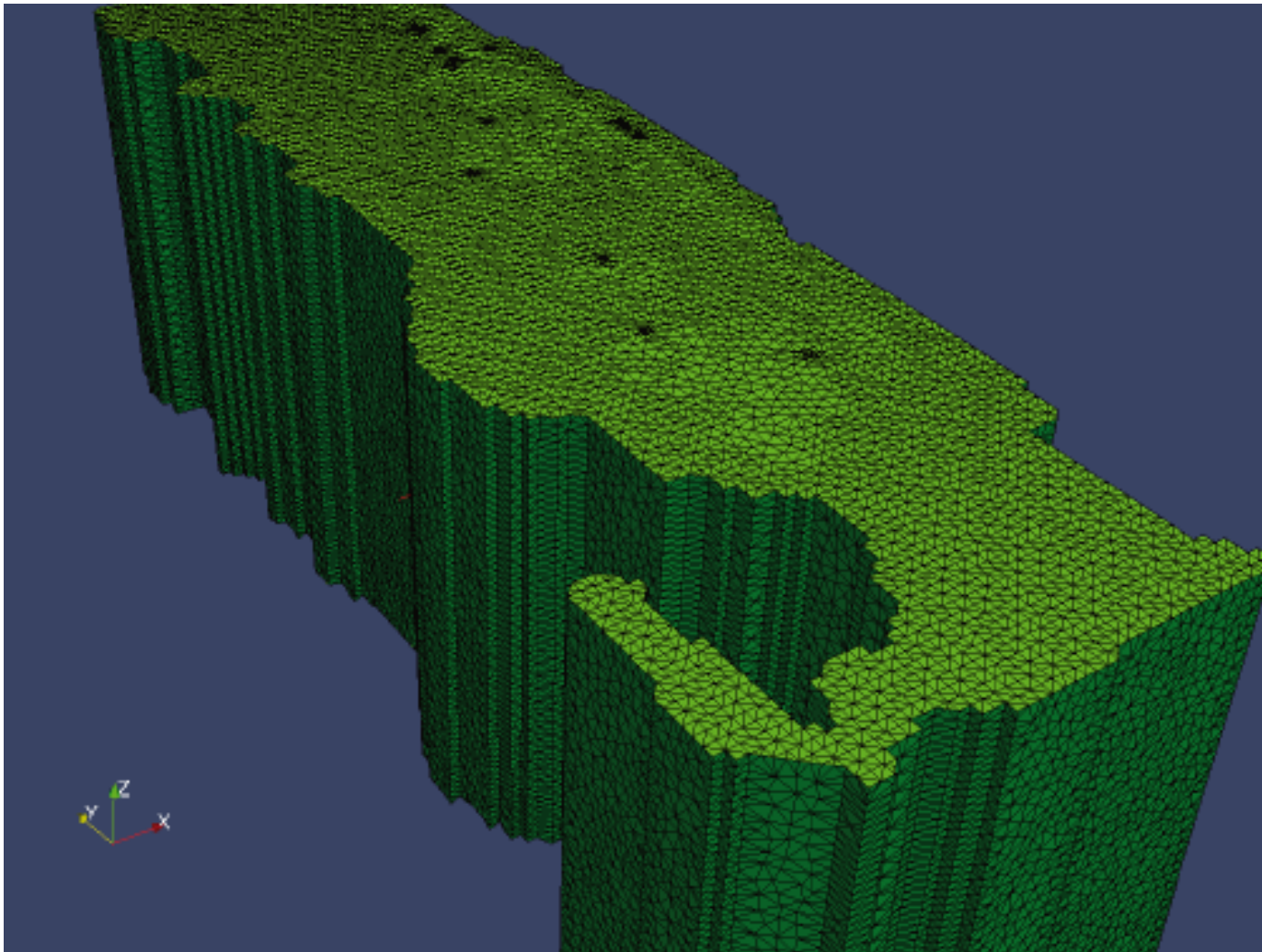


However, the assessment of **“effects of defects”** remains a challenge without a proper **computer simulation**.

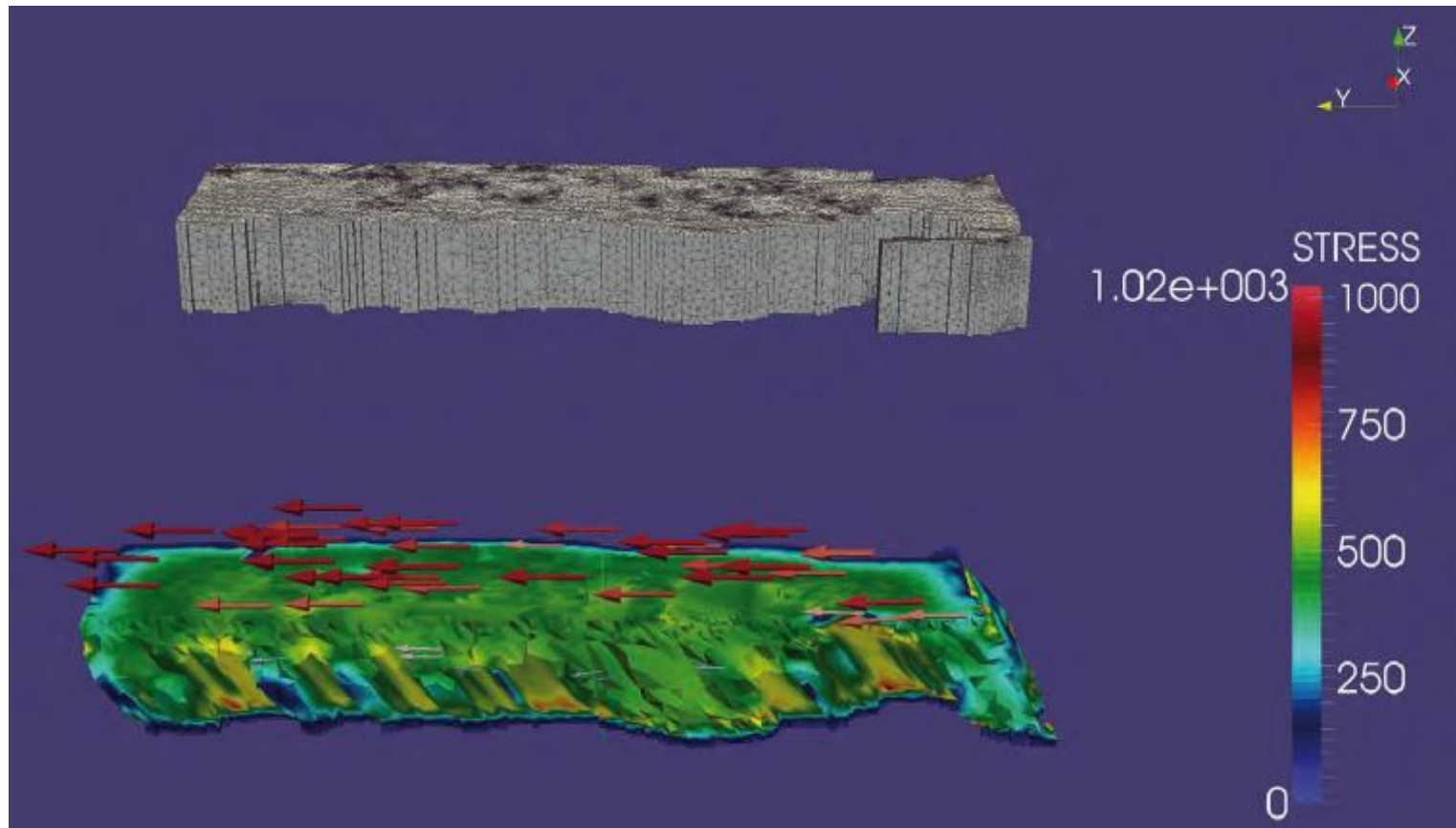




“real” adhesive layer transferred to FE model

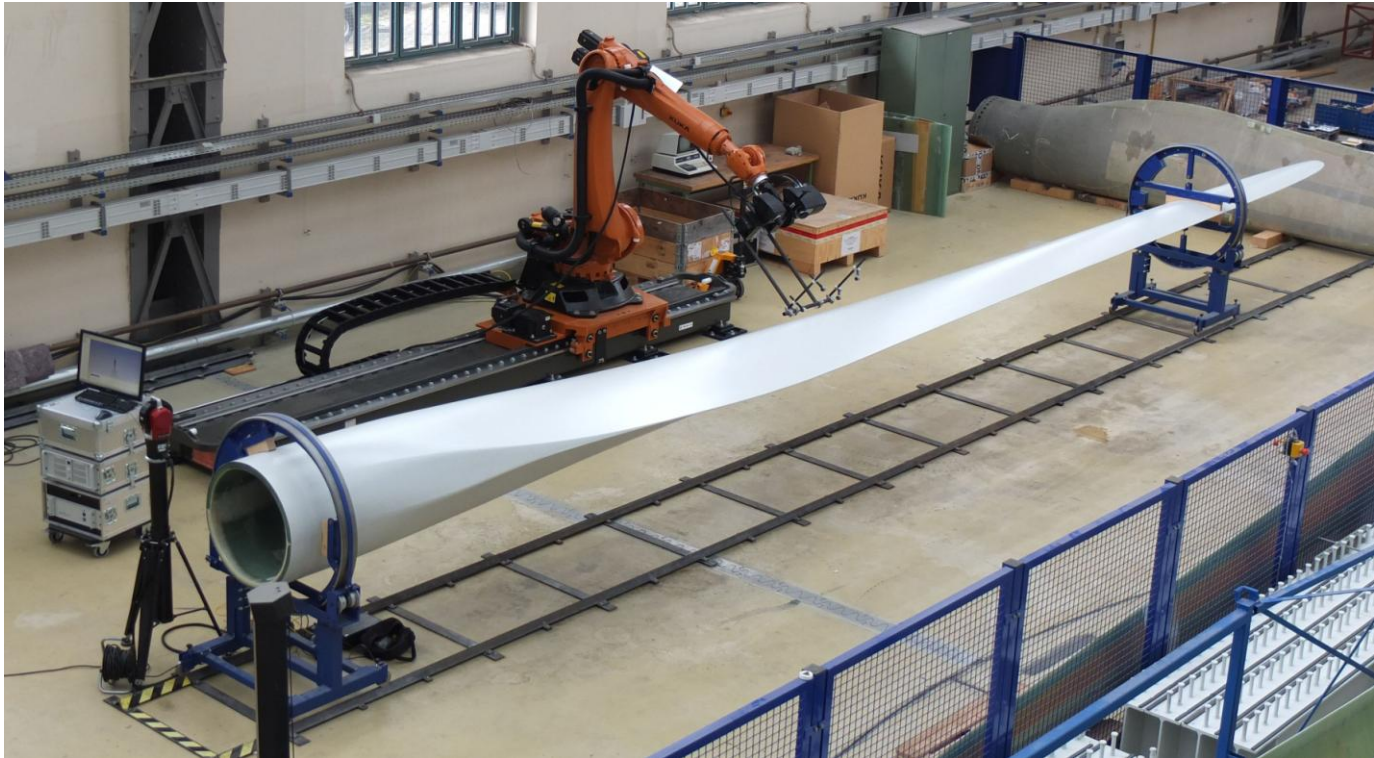


The adhesive layer between two laminate surfaces is filled with volume elements and subjected to shear loading by use of FE simulation



This approach (NDT+FEM) shall provide much more realistic predictions of structural integrity since it is based on real/measured data

We are looking for industrial partners for a joint project!



Thank you for your attention