Subcomponent testing of rotor blades

Multi-ScaleStructural Testing andModeling

Arno van Wingerde , Florian Sayer and Malo Rosemeier

Thanks to:

Alexander Krimmer, Alexandros Antoniou, Catherine Lester, David Melcher

Sandia Blade Workshop, Lubbock TX, USA, August 28-29, 2018

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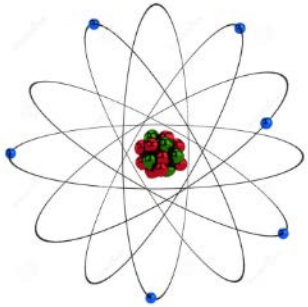
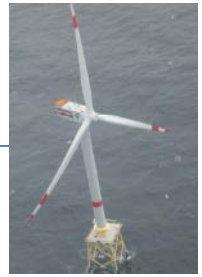
Scales, scales, scales…….



10^{-35} m 10^{-10} m 10^{0} m 10^{2} m 10^{21} m 10^{27} m



10^{-5} m 10^{-2} m 10^{0} m 10^{2} m

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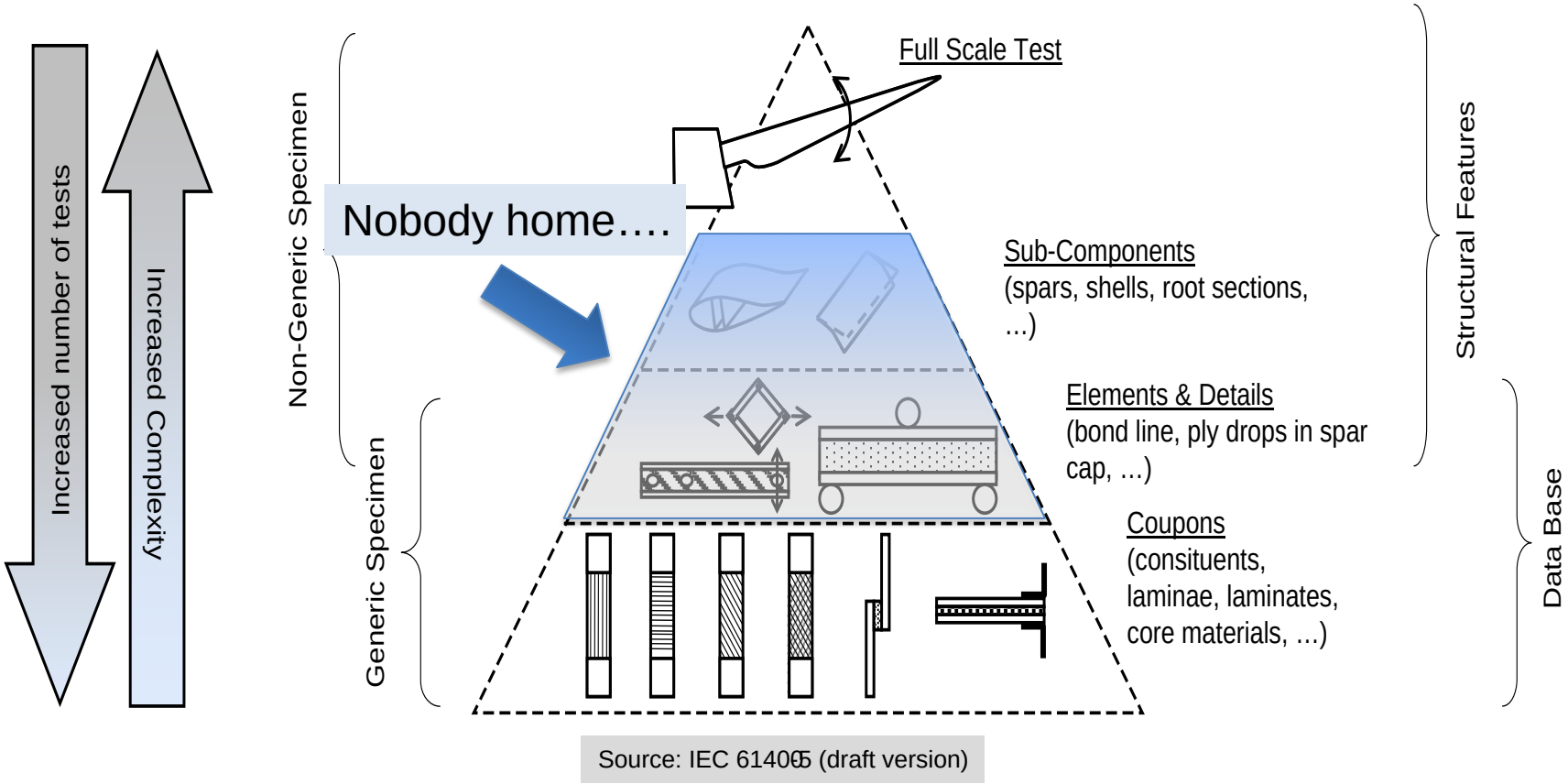
Rotor Blade Testing……. Something is missing



Source: IEC 61400-5 (draft version)

Full-scale blade testing

A.M. van Wingerde, F. Sayer, A.E. Antoniou, F. Bürkner, E. Putnam, “Subcomponent testing for rotor blades of wind turbines”. Proceedings of ICCM 19, Montreal, 2014.

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Full scale blade test

70m Rotor blade test stand, Static test 56m blade: Suction side under Pressure

A.M. van Wingerde, F. Sayer, A.E. Antoniou, F. Bürkner, E. Putnam, "Subcomponent testing for rotor blades of wind turbines". Proceedings of ICCM 19, Montreal, 2014.

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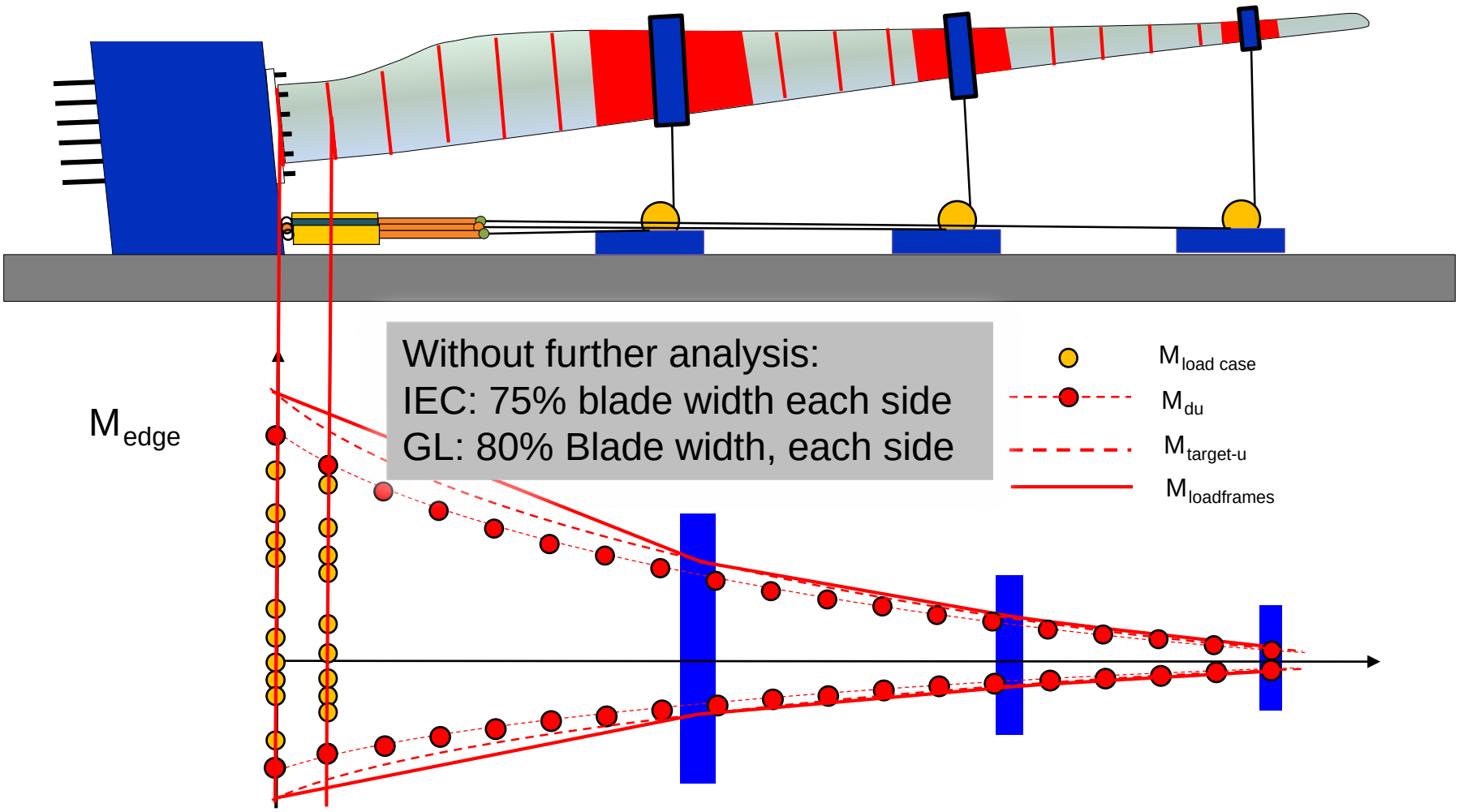
Determination of the test loads



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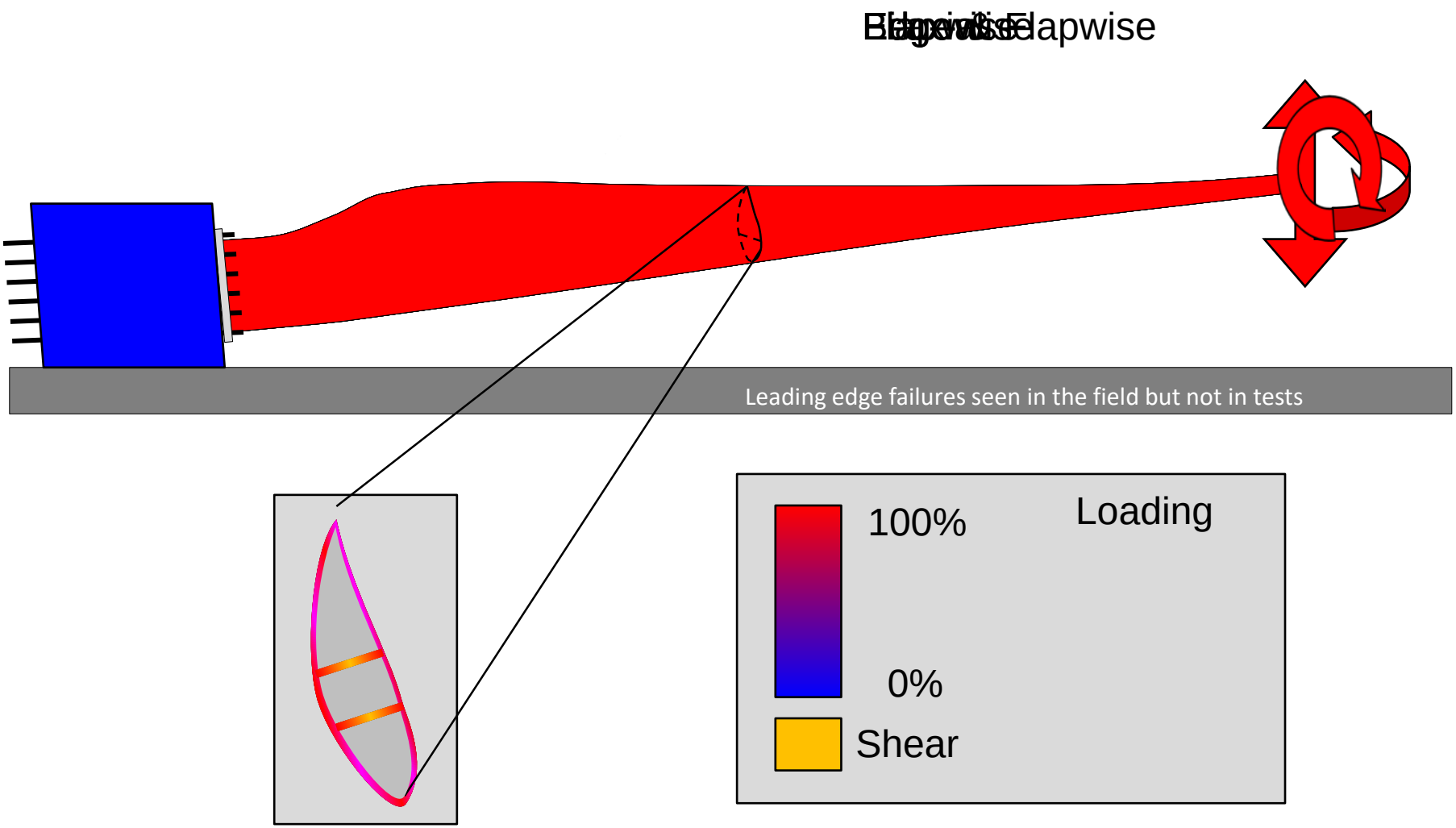
Test directions



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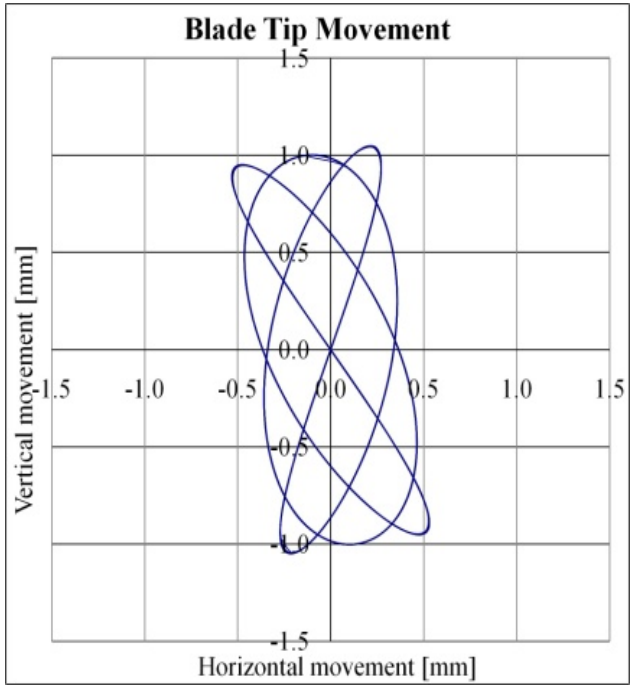
Biaxial Test at IWES



A.M. van Wingerde, F. Sayer, A.E. Antoniou, F. Bürkner, E. Putnam, “Subcomponent testing for rotor blades of wind turbines”. Proceedings of ICCM 19, Montreal, 2014.

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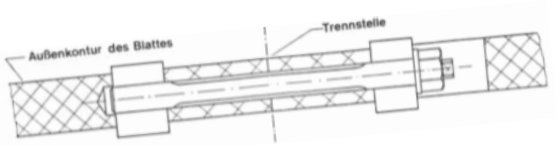
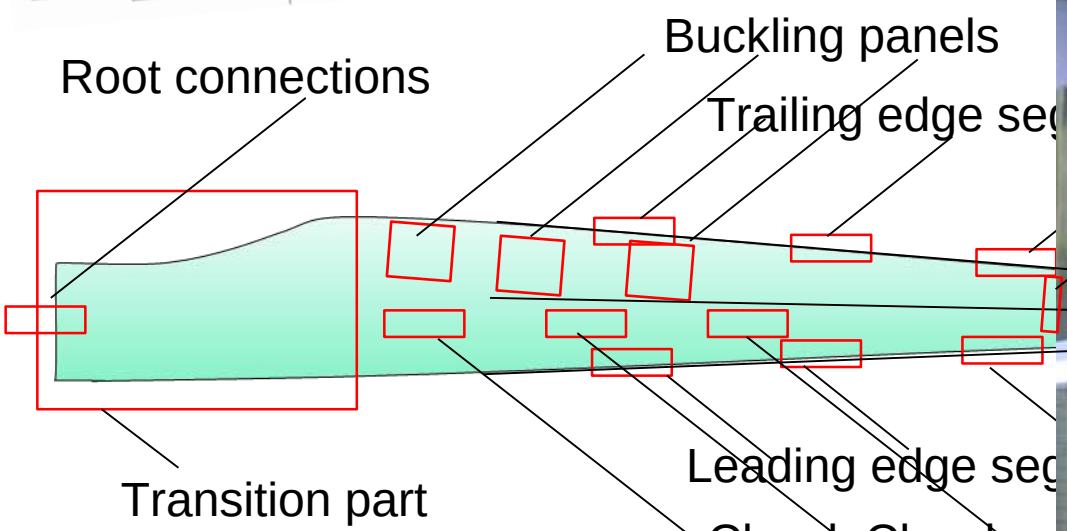
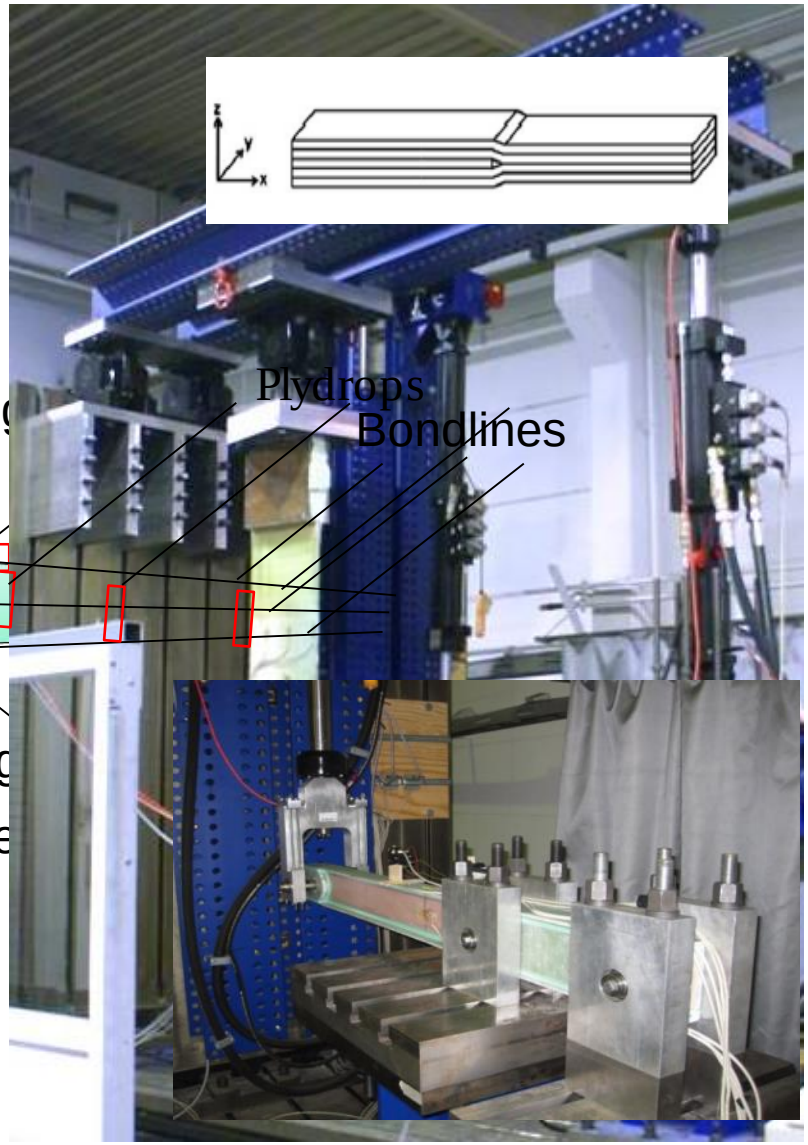
Blade components





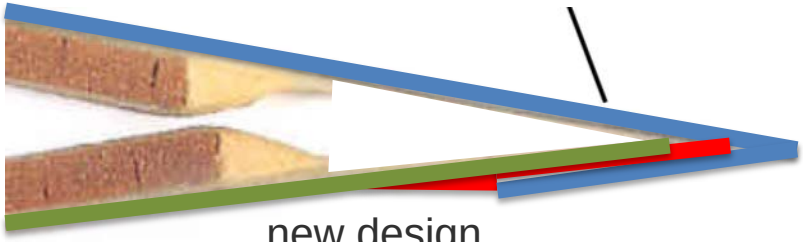


A case for subcomponent testing - KompZert

Aim: verification of blade details

- A detail failed during full-scale blade test (manufacturing errors)
- Changes in blade details

current design



new design

Original Plan: describe a number of blade details, boundary conditions etc. and possibilities for lowered partial safety factors

Problem: it differs a lot what circumstances occur: manufacturer dependent

E.g. in some cases peeling is important load case

More accurate scenarios are necessary

DNV·GL

"KompZert" Einführung von Komponententests als Teil der Entwicklung von Rotorblättern für Windenergieanlagen : Schlussbericht für ein Forschungsprojekt im Rahmen des BMWi Förderprogramms zur Förderung von Forschung und Entwicklung im Bereich erneuerbarer Energien

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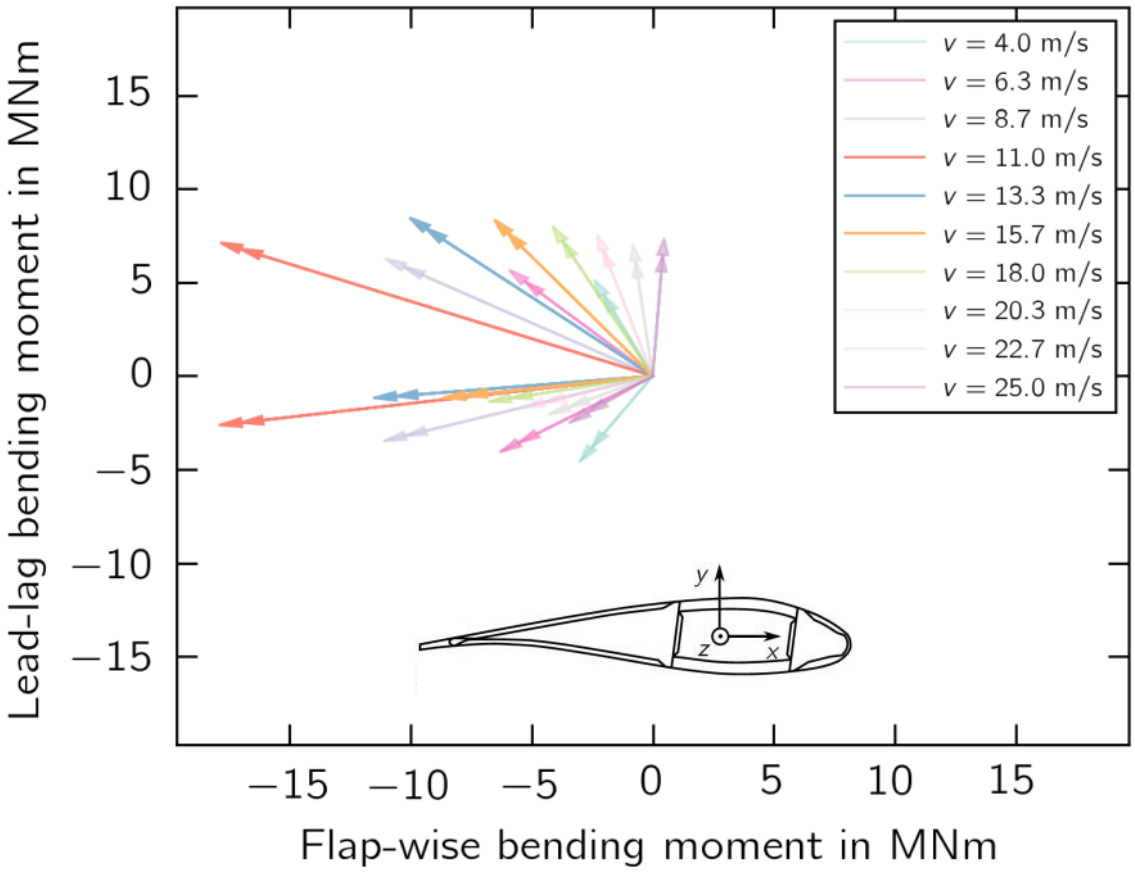
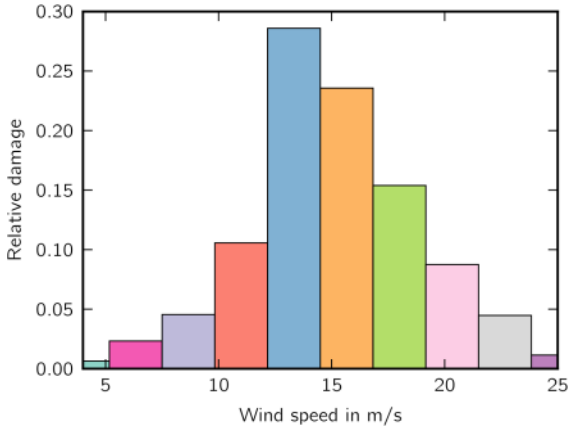
Bending moment vectors due to lead -lag load under f ield conditions





Rosemeier et al. (2018)
Benefitsof subcomponent over full-scale blade testing elaborated on a trailing edge bond line design validation, Wind Energy Science Journal

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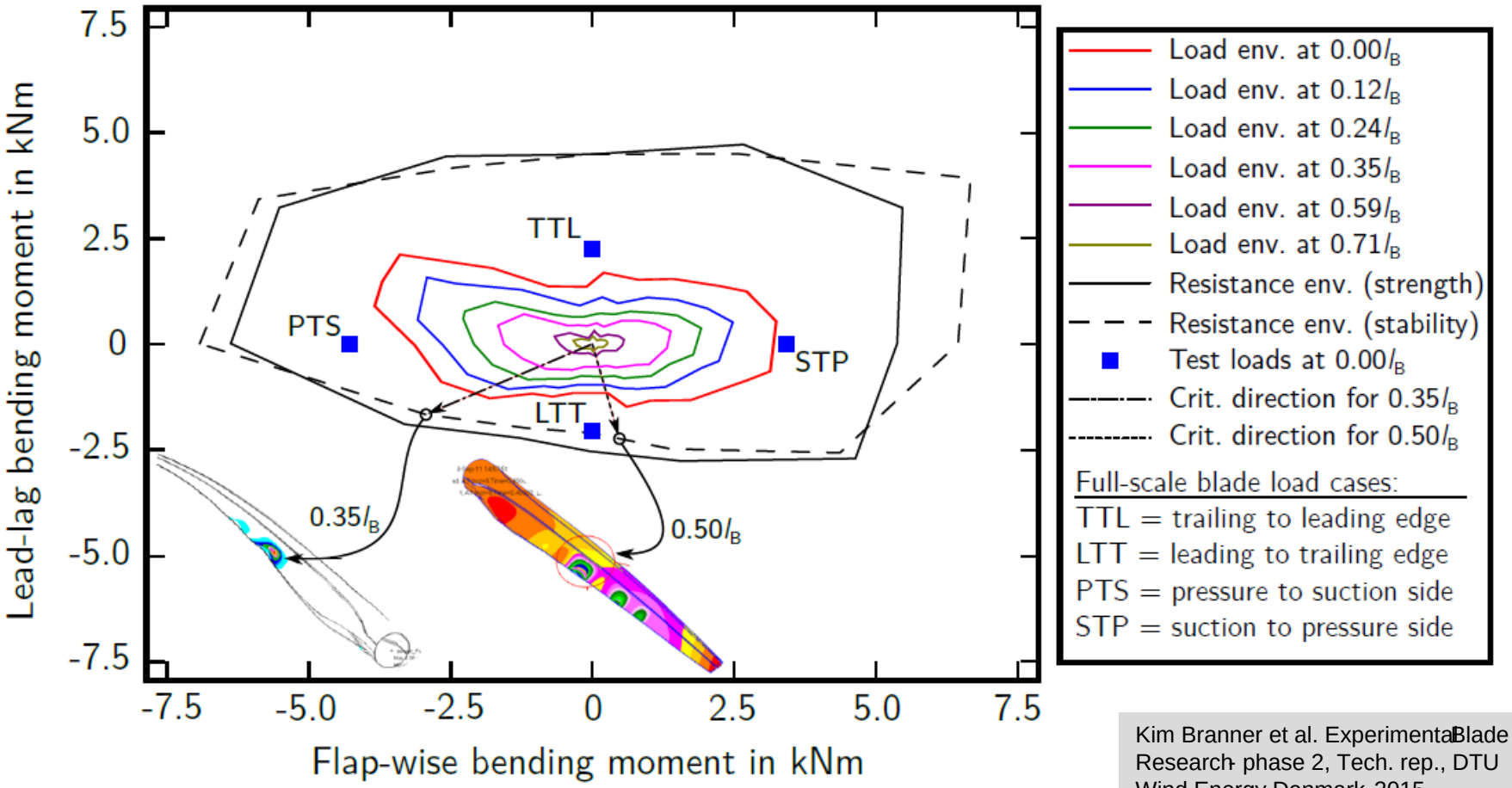
Load directions in the field



Kim Branner et al. Experimental Blade Research - phase 2, Tech. rep., DTU Wind Energy, Denmark, 2015.

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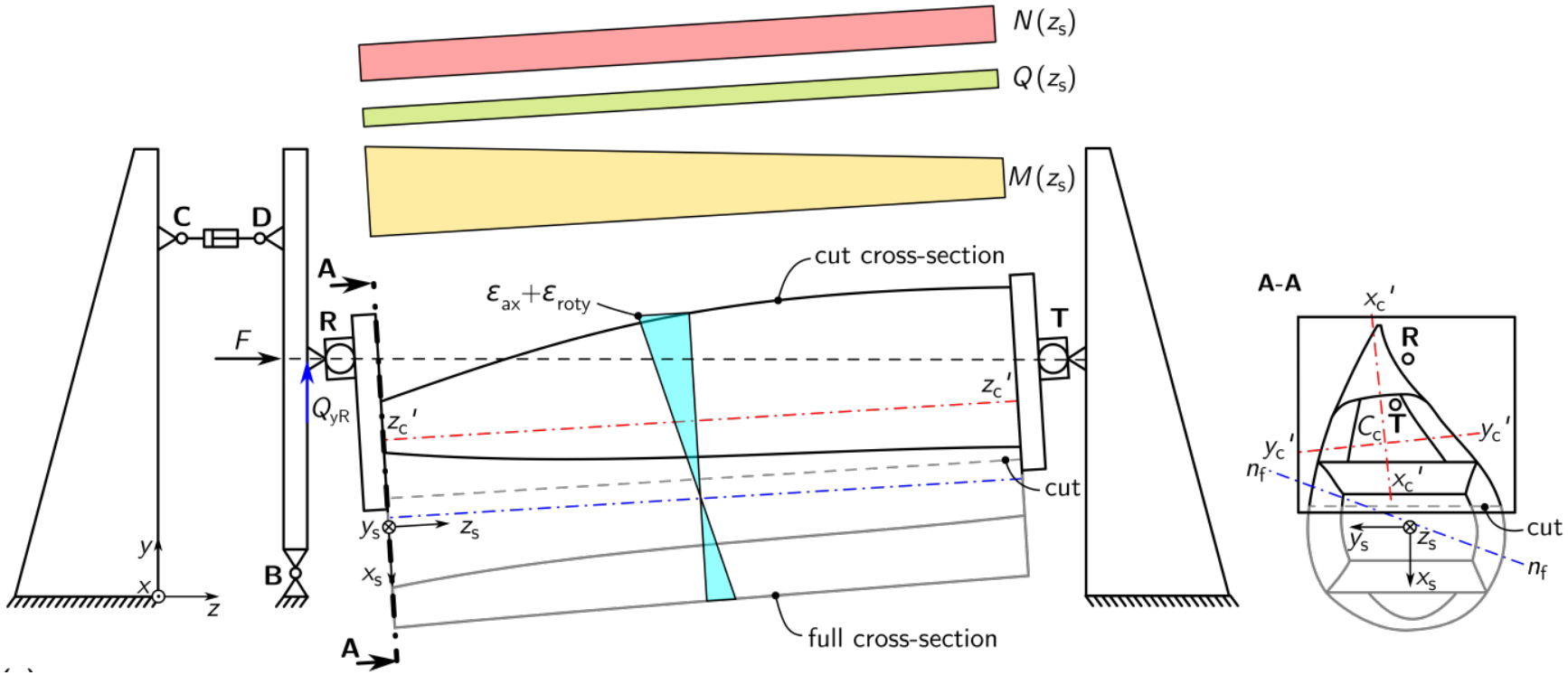
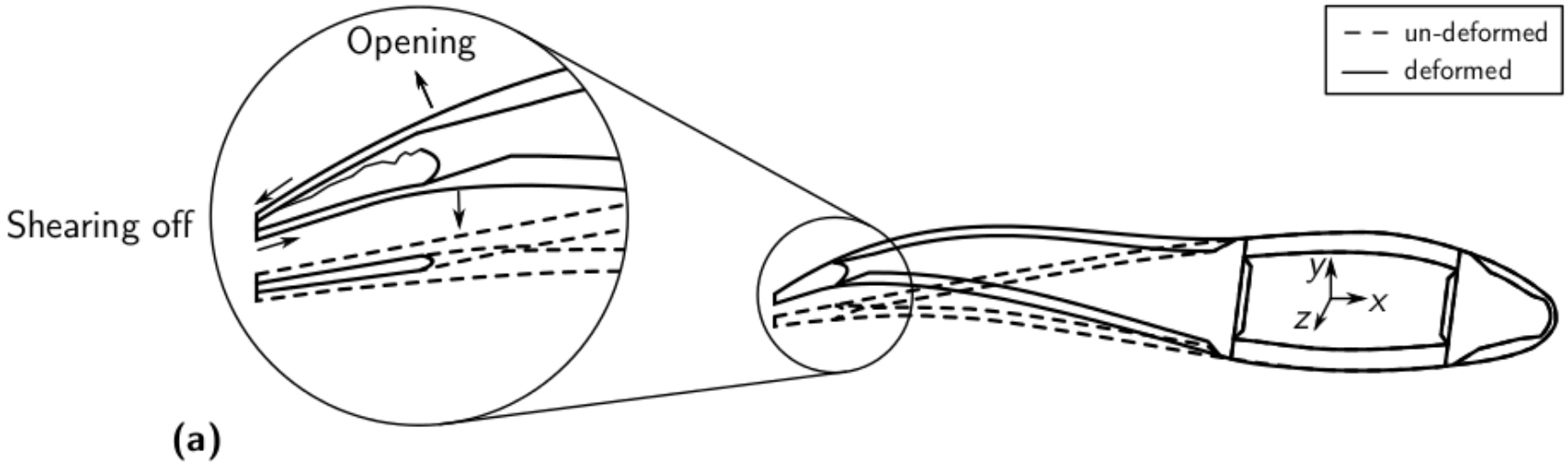
Experimental setup



Rosemeier et al., 2017A novel single actuator test setup for combined loading of wind turbine rotor blade sub-components

Deformation of the cross -section

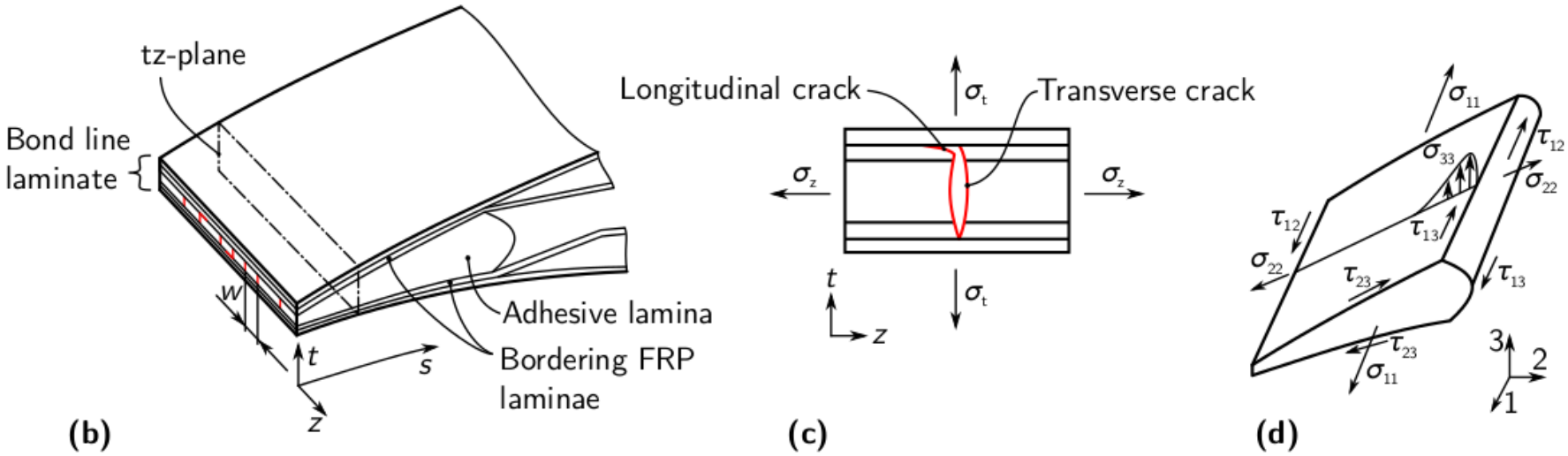
- "breahting" or "pumping" effect opens/ closes the cross-section depending on the load direction



Rosemeier et al. (2019), Multi-Axial Damage Impact on the Trailing Edge Bond Line of Wind Turbine Blades, submitted to AIAA Scitech 2019

Research questions

- How significant is the contribution of peeling stresses to the bond line fatigue?
- What is the actual mechanism leading to crack initiation?



Rosemeier et al. (2019), Multi-Axial Damage Impact on the Trailing Edge Bond Line of Wind Turbine Blades, submitted to AIAA Scitech 2019

Specimen preparation impressions

Grind off, casting

(a)

(b)

(c)

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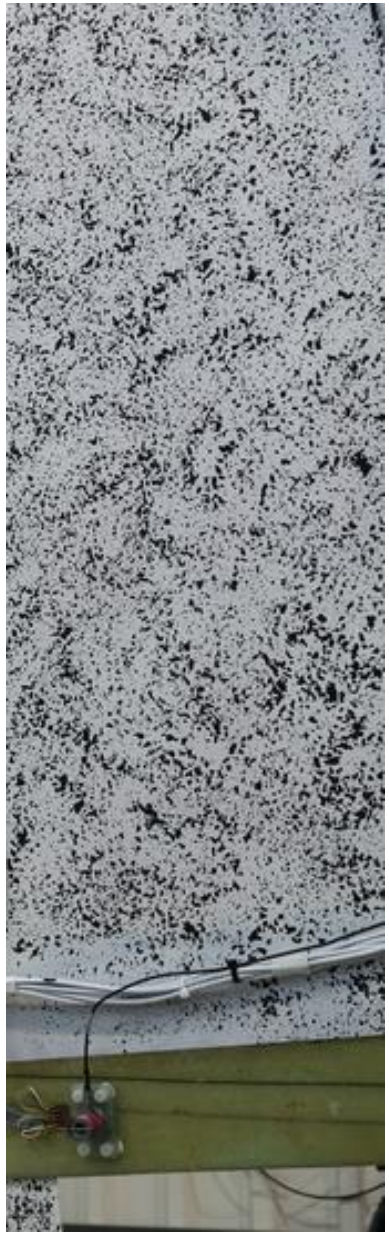
Specimen preparation impressions

SGs, dot pattern



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Experimental setup impressions

PS view, ball joint, root adaptor plate, dot pattern

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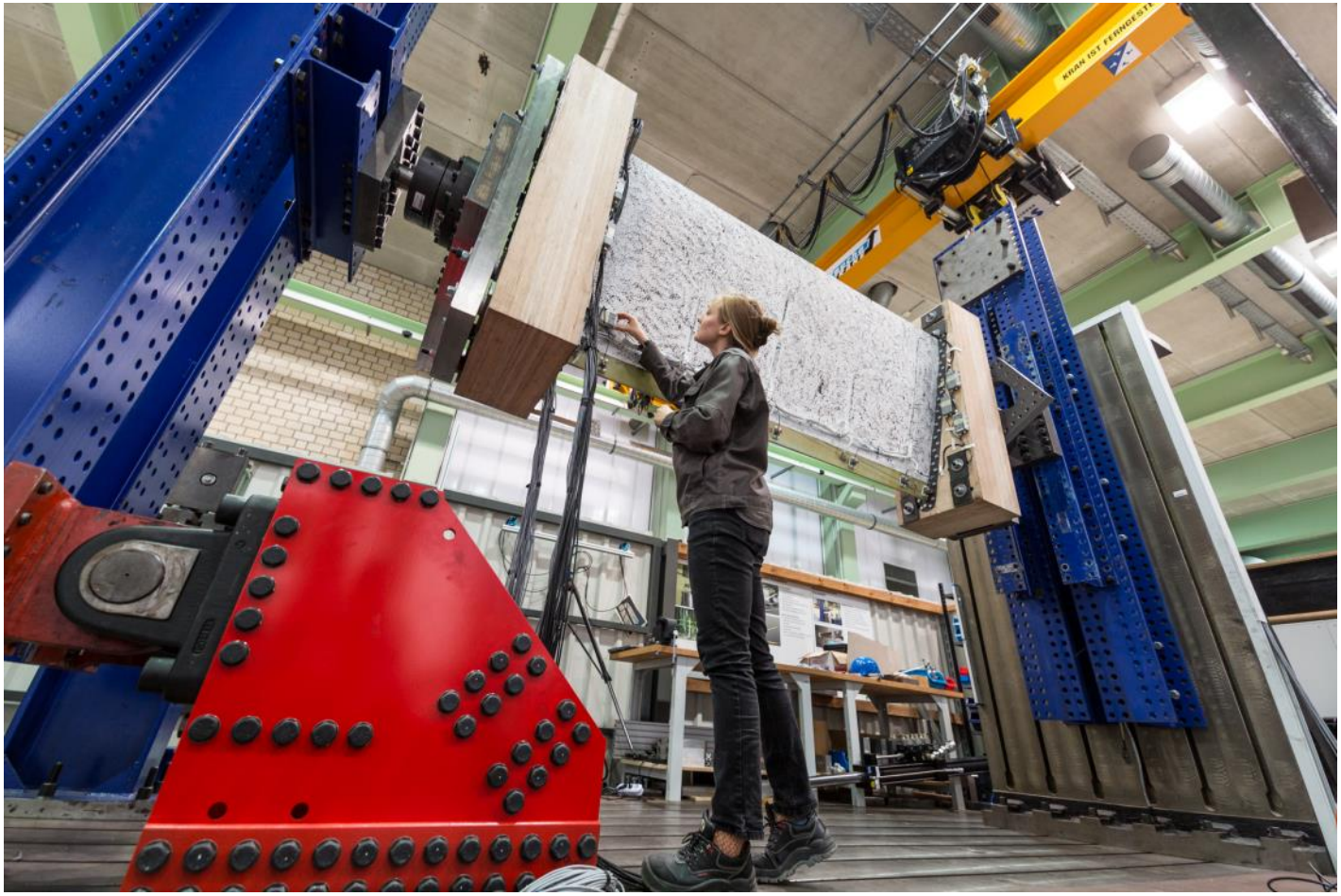
Experimental setup impressions

SS view, hinges

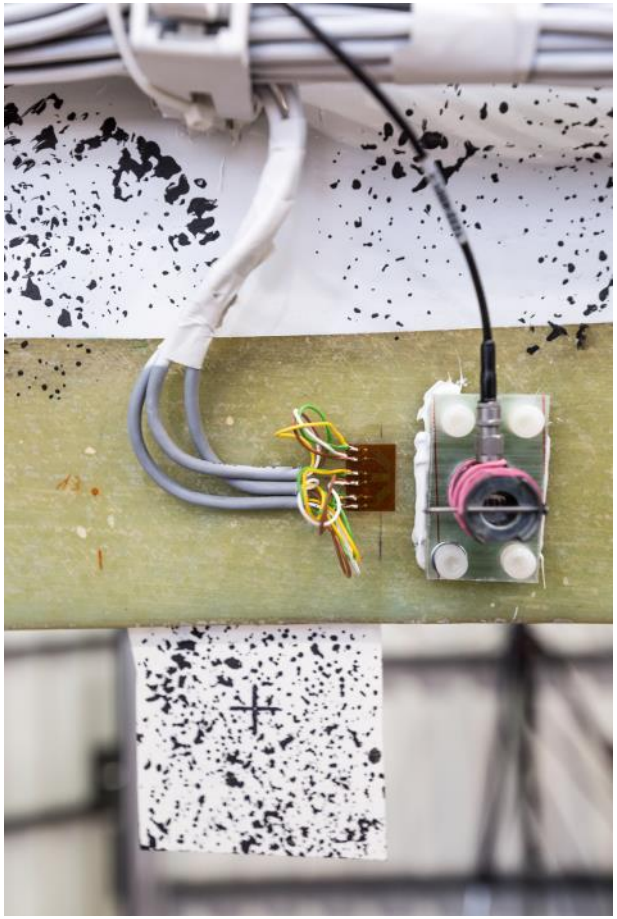


Experimental setup impressions

Overview, actuator, vertical beam, DIC

Experimental setup impressions

Load frame, SG, acoustic emission



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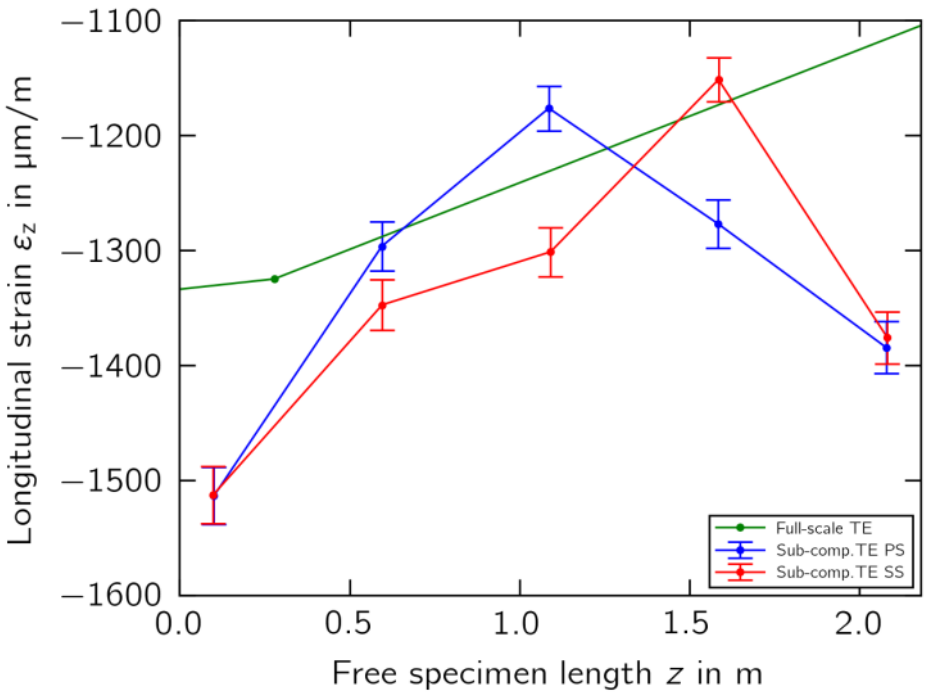
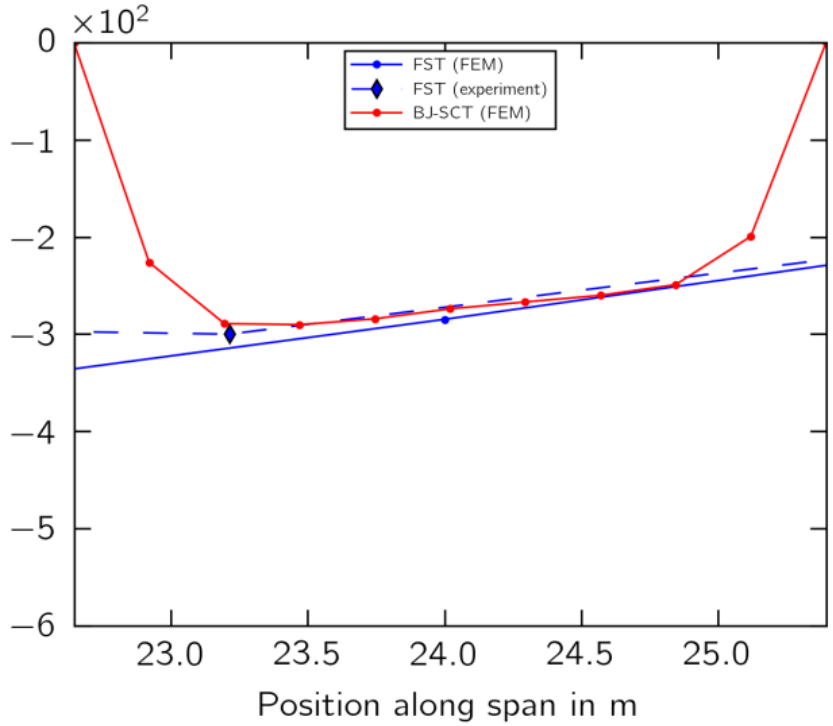
Experimental results (LTT load case)

Longitudinal strain along the trailing edge





Rosemeier et al. (2018) Sub-Components of Wind Turbine Blades – Proof of a Novel Trailing Edge Testing Concept, Proceedings of the Society of Experimental Mechanics, June 4–7

Rosemeier et al. (2016) Tailoring the design of a trailing edge sub-component test. 3rd annual IRPWind / EERA Joint Programme Wind R&D Conference (IRPWind conference), Amsterdam, the Netherlands, 19–20 September 2016

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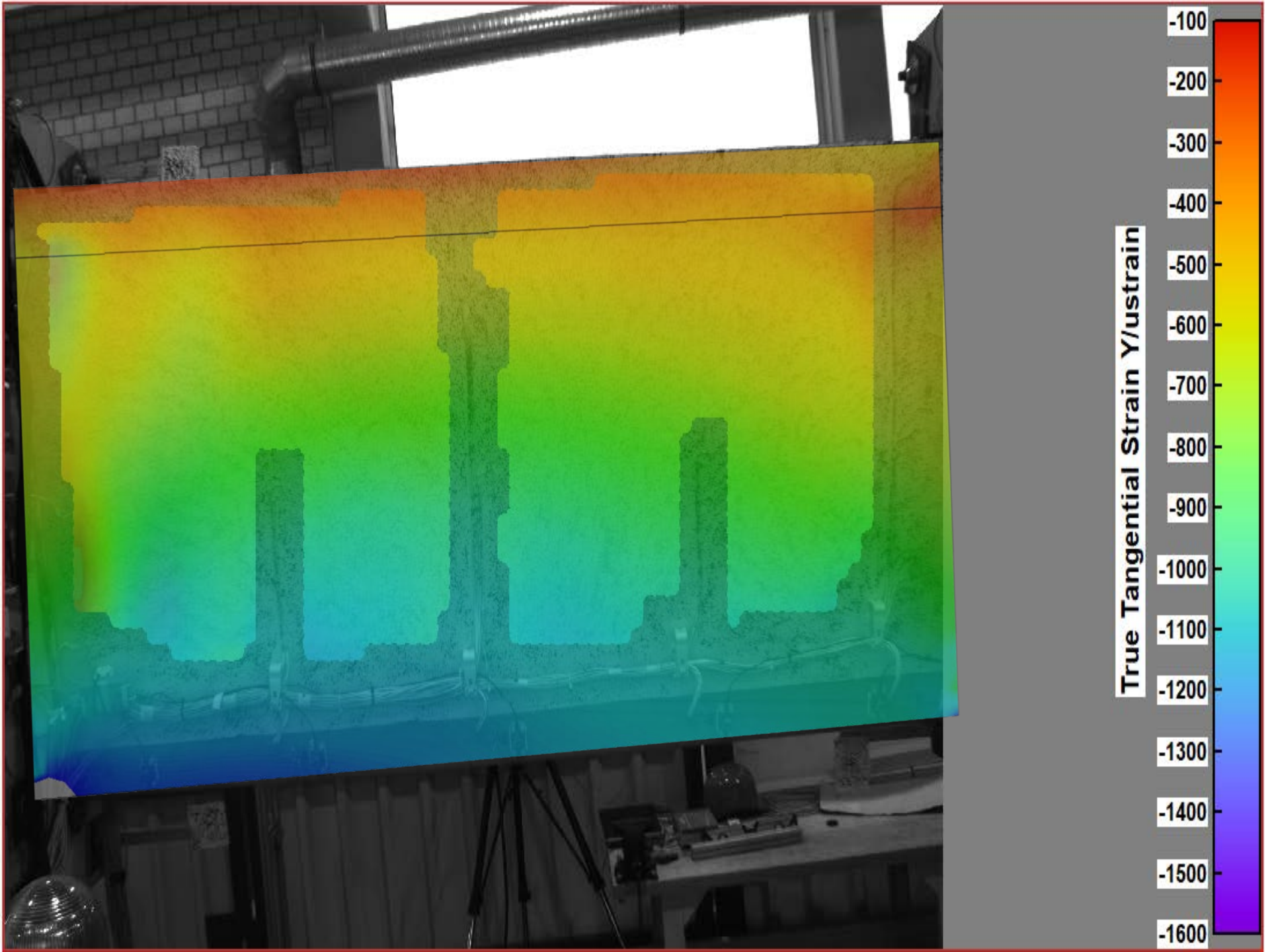
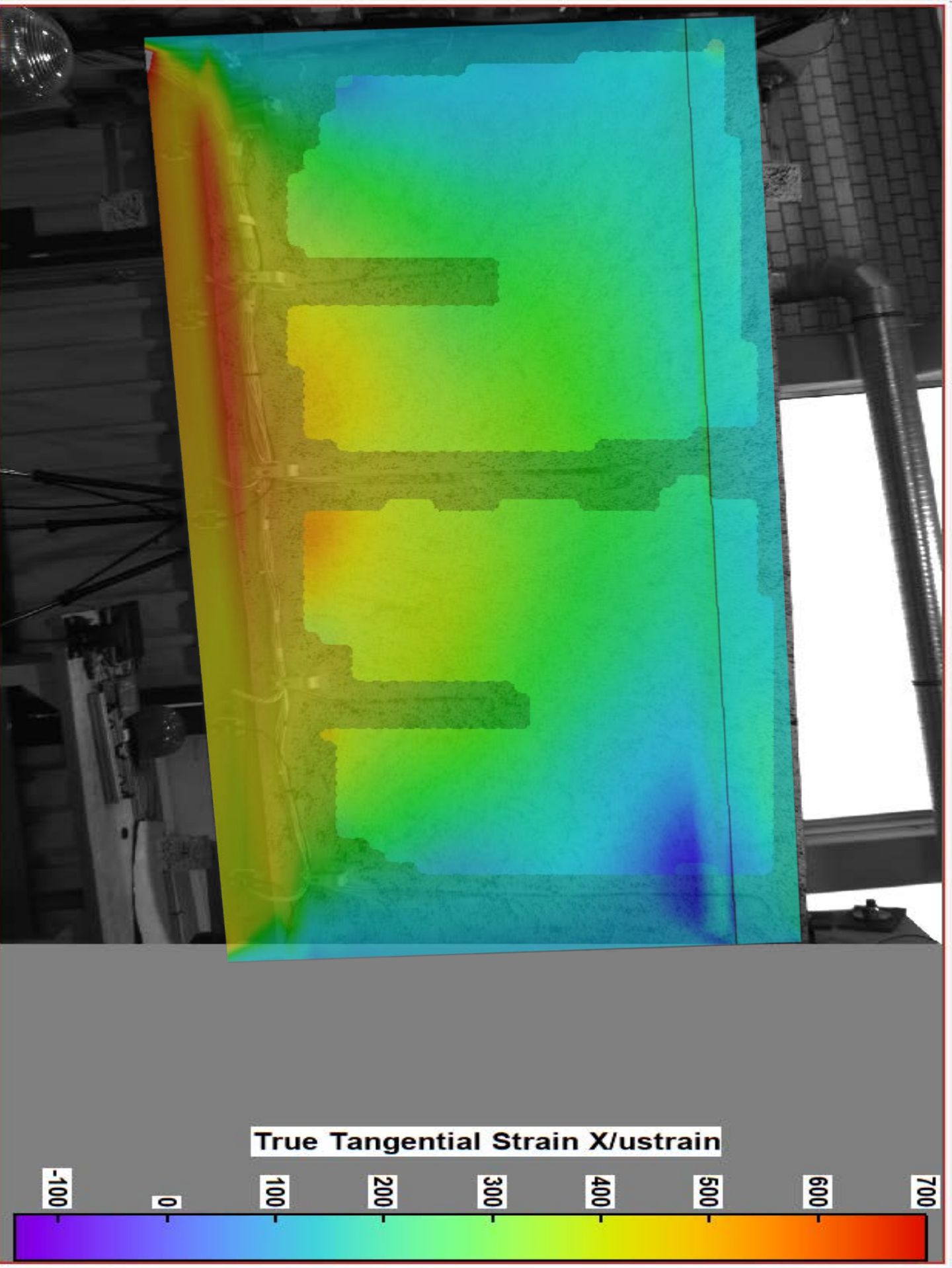
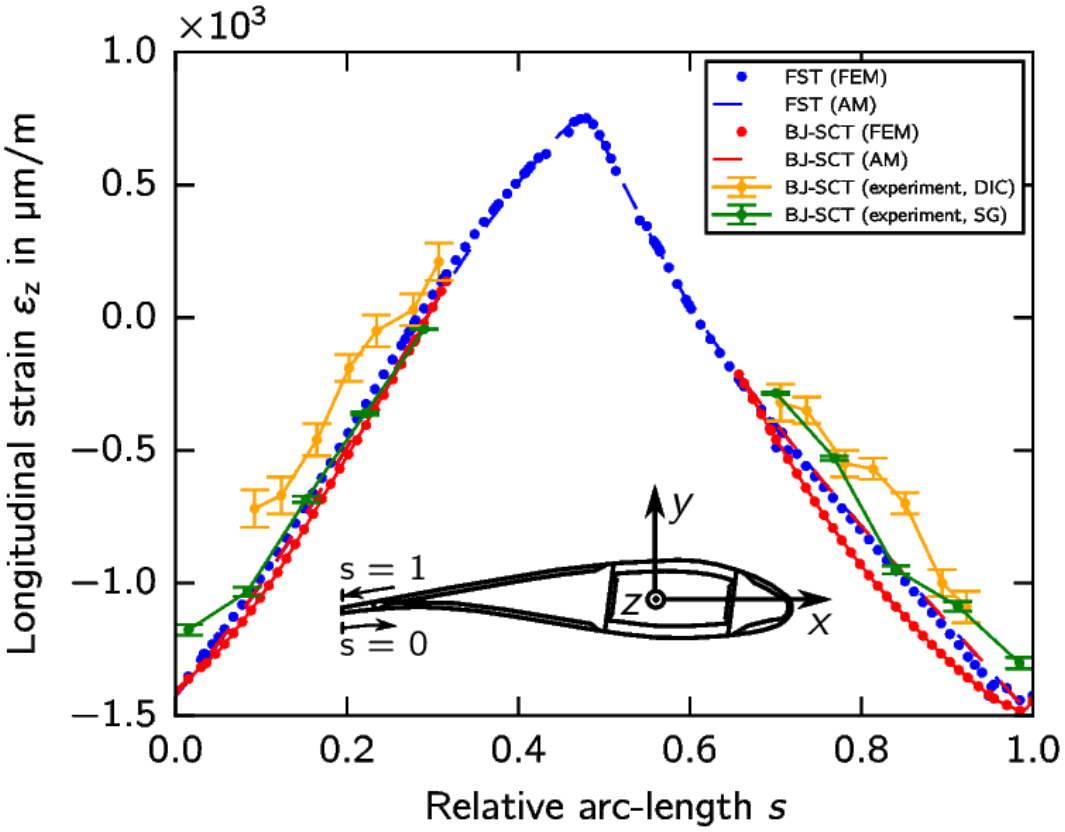

True Tangential Strain Y/ustrain
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600


True Tangential Strain X/ustrain
-100
0
100
200
300
400
500
600
700

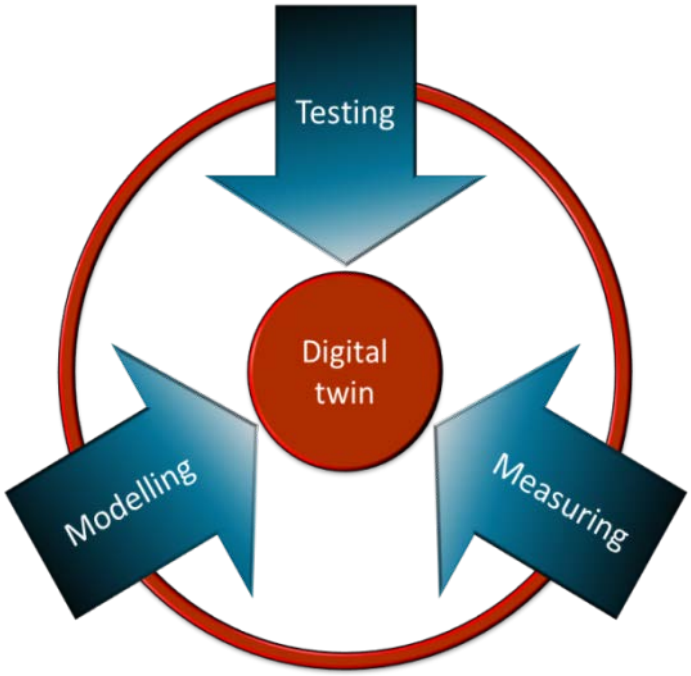
Experimental results (LTT load case)

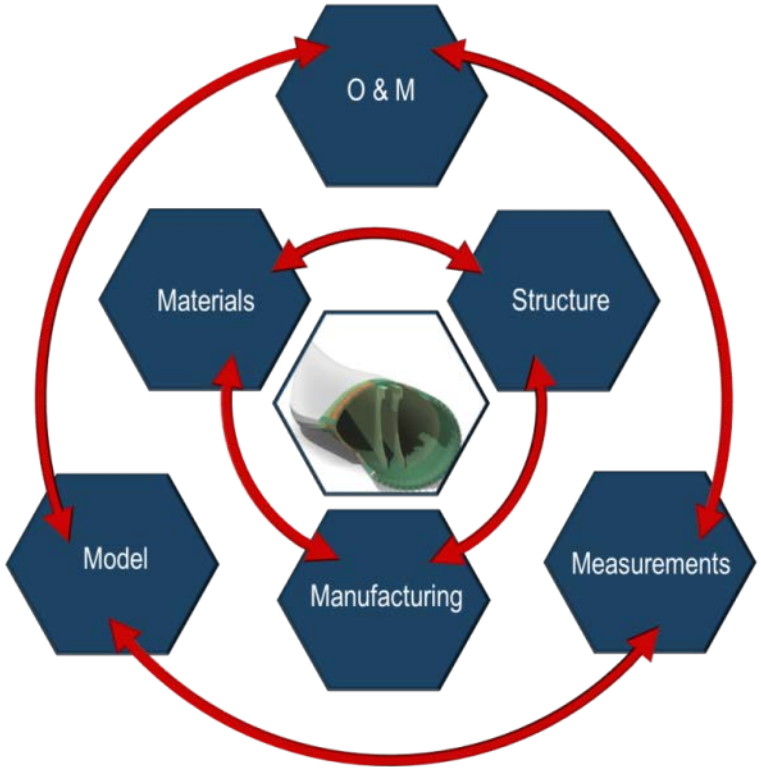
Longitudinal strain across the target cross section



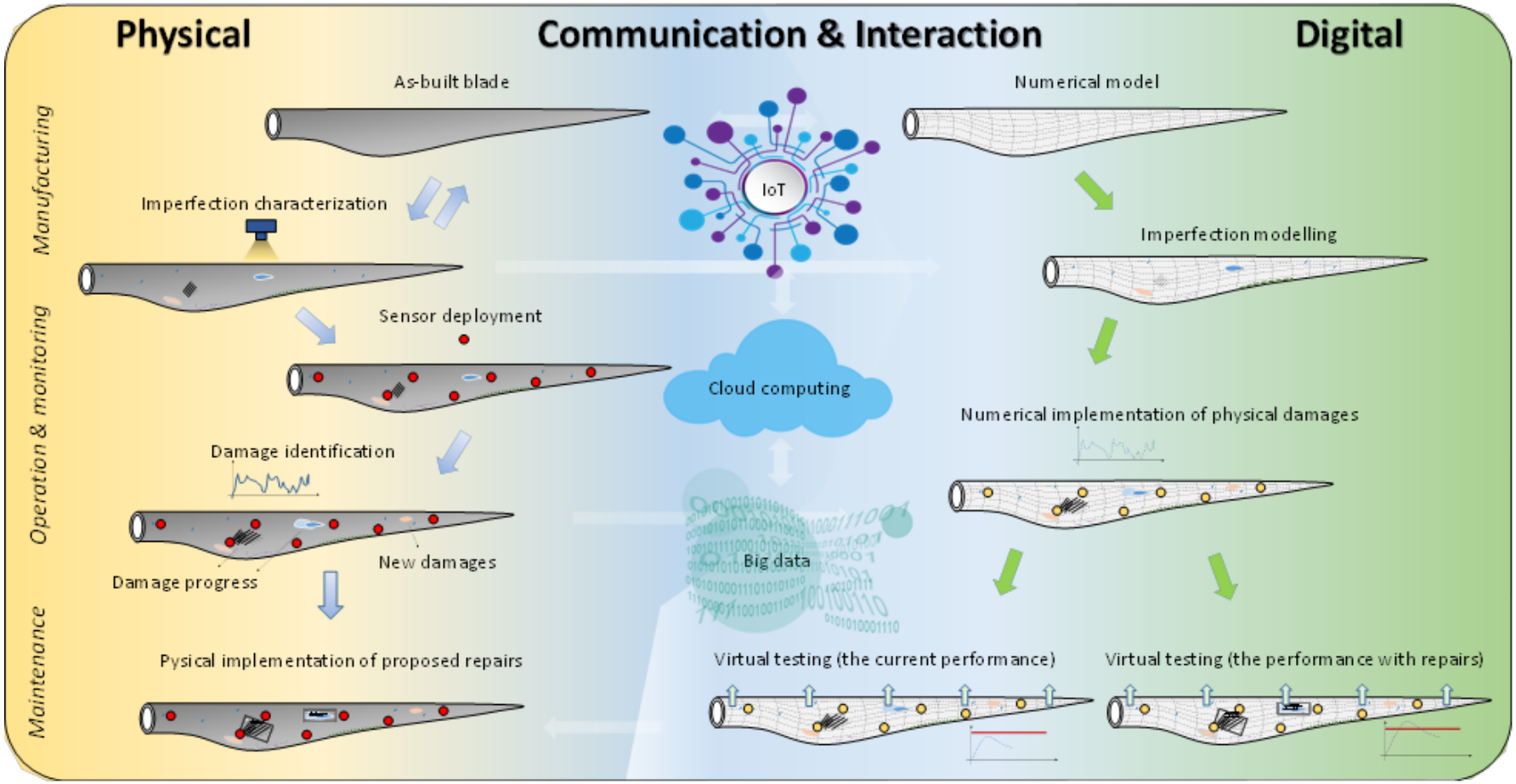
Rosemeier et al. (2018) Sub-Components of Wind Turbine Blades Proof of a Novel Trailing Edge Testing Concept, Proceedings of the Society of Experimental Mechanics, Jun 7

Basic principles behind Reliabl(ad)e





Digital twin



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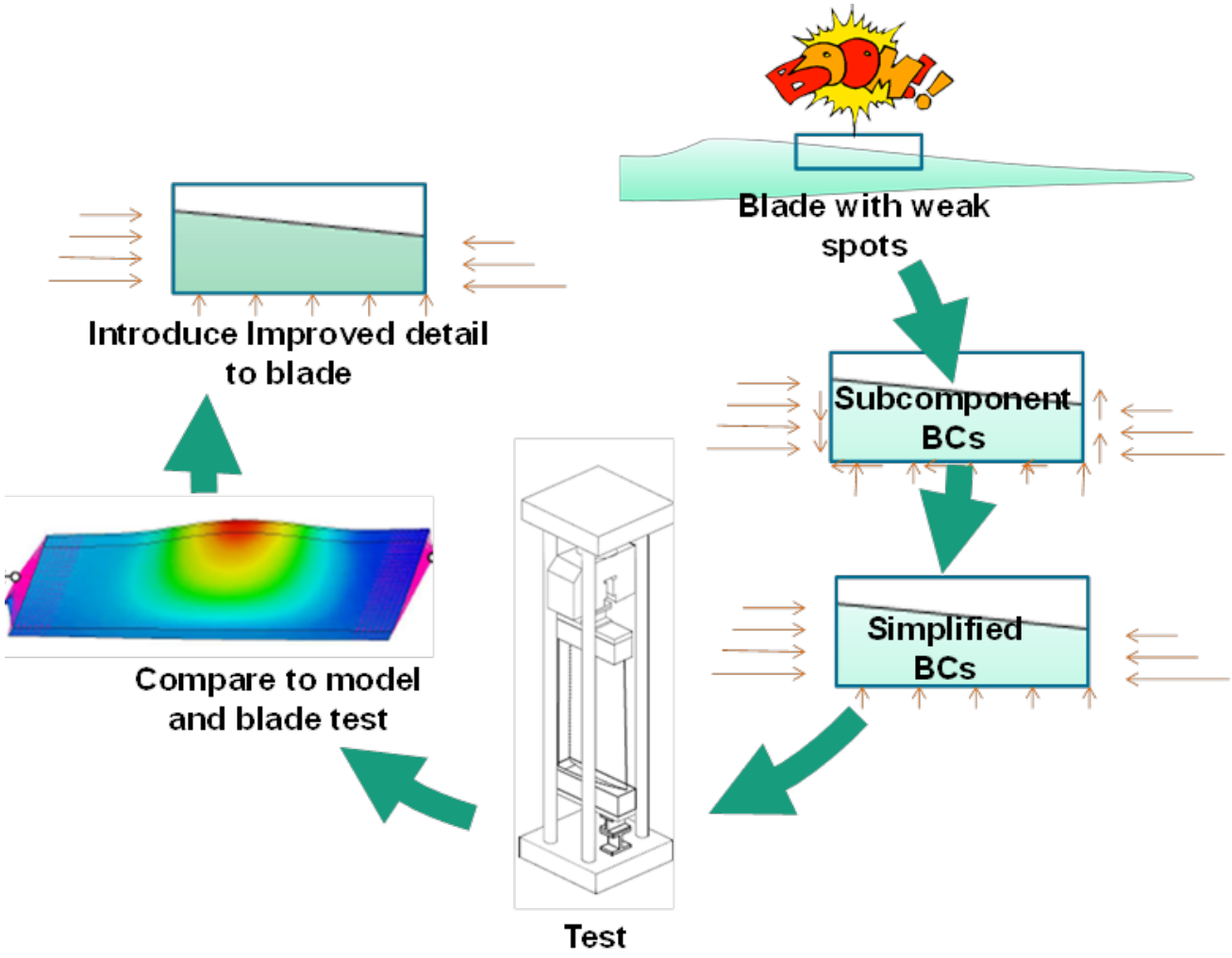
Subcomponent testing in blade certification



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Set-Up of the program

- 3 year project, however, set up as 4 year project
  - Project start: 01-11-2018
  - Participation of other partners to be started before 01-01-2020
  - Before that background work

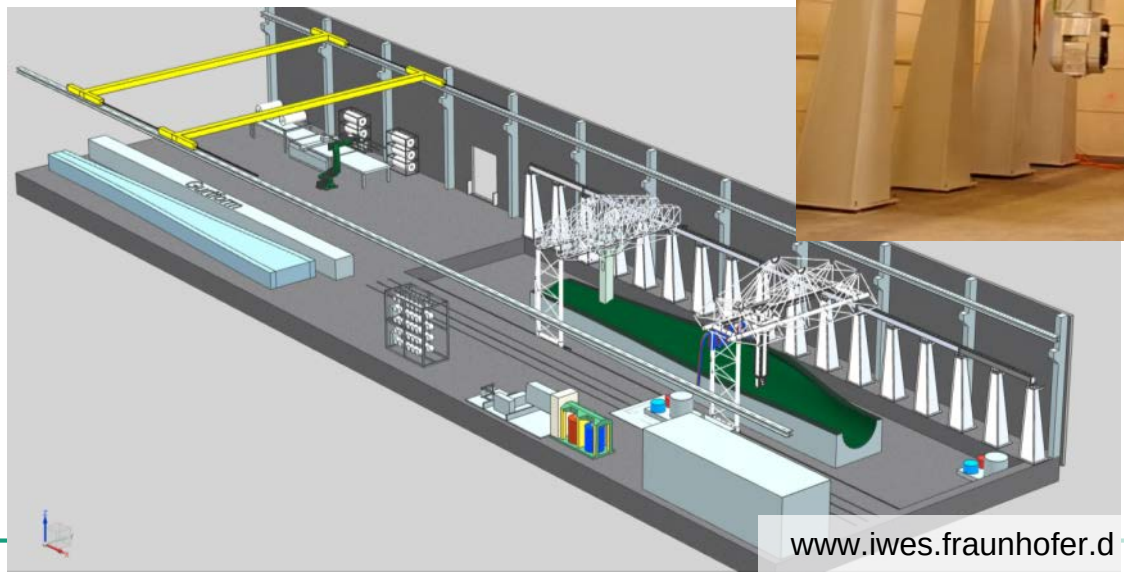
- Set up a basis with two countries, with high chance of getting funding

- Open for participants from other countries
  - Discuss with funding agencies of existing partners in case more partners come in: redistribution of tasks.
  - Bring your won funding: each country pays for its own part

BladeMaker Demo center

Supported by:
Federal Ministry for Economic Affairs and Energy
BladeMaker on the basis of a decision by the German Bundestag

- Vorabnahme für 1. Portal in Kiel erfolgt
- Abnahme 2. Portal folgt im Dezember
- Fundamentierung ab Mitte Oktober
- Eröffnung Februar 2016 (Einladungen folgen)



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Federal Republic of Germany

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Federal Ministry of Education and Research

European Regional Development Fund (ERDF):

Federal State of Bremen

- Senator of Civil Engineering, Environment and Transportation
- Senator of Economy, Labor and Ports
- Senator of Science, Health and Consumer Protection
- Bremerhavener Gesellschaft für Investitions Förderung und Stadtentwicklung GmbH

Federal State of Lower Saxony

Thank You For Your Attention

Any questions?

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