Full-scale structural testing at DTU Large Scale Facility

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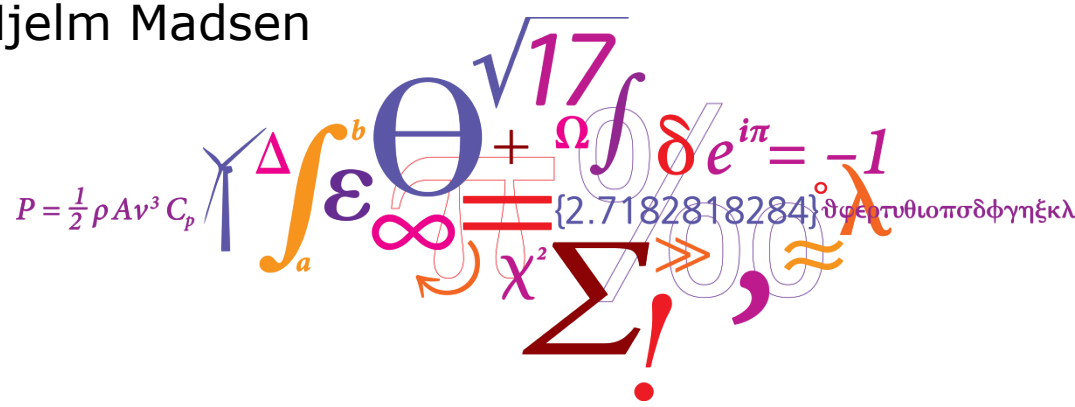


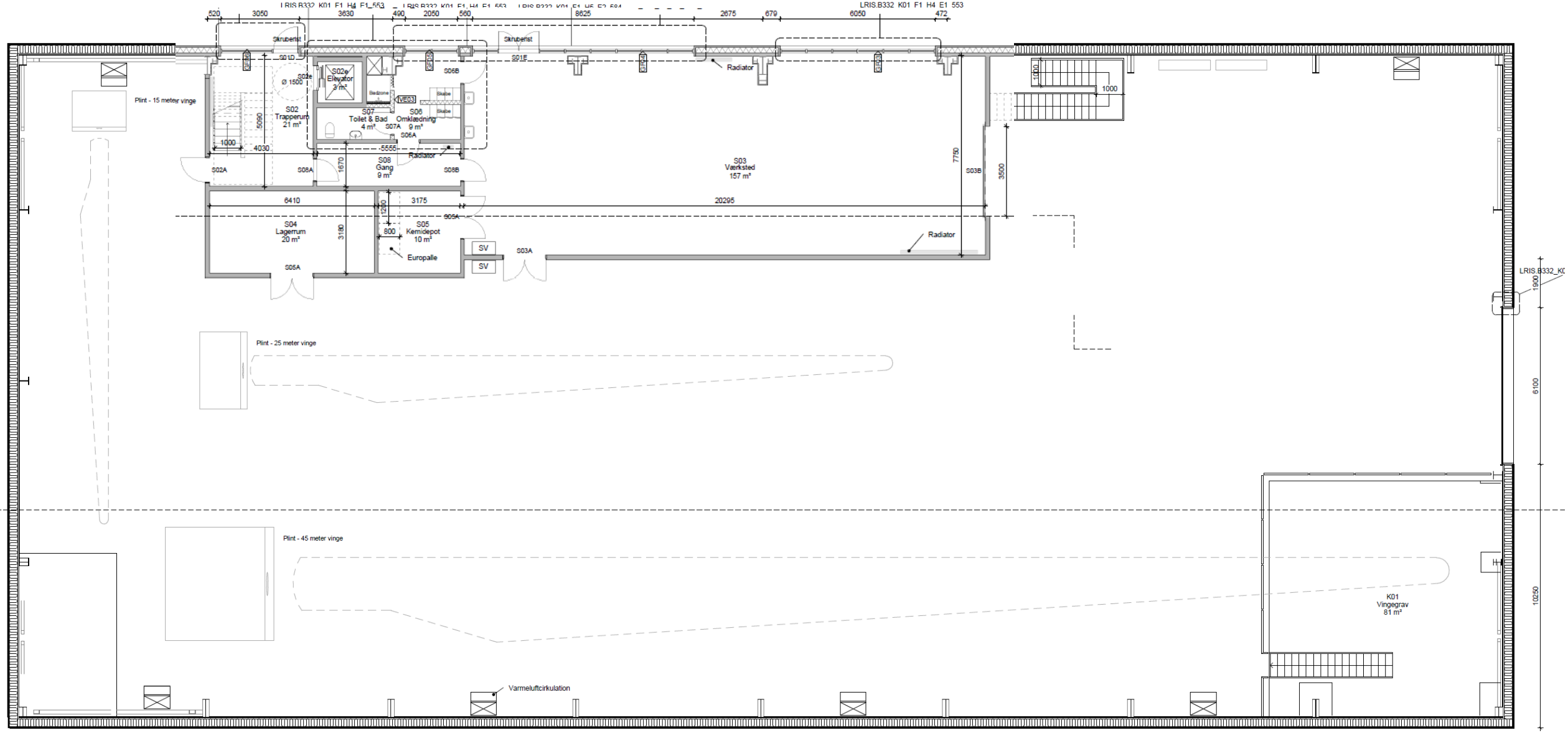
DTU Wind Energy
Department of Wind Energy

Why do full-scale structural testing?

- Full-scale testing is essential because it is the only type of testing which reveals the reliability of methods for analysis and design.
- Full-scale tests quantify the model uncertainty – an essential element in the overall structural reliability assessment.
- Full-scale testing reveals the full complexity in response and failure of real structures.
- Full-scale testing is invaluable in the fundamental research of developing methods for structural simulation, analysis and design.

Part of Villum Center for Advanced Structural and Material Testing (CASMaT)

DTU Large Scale Facility



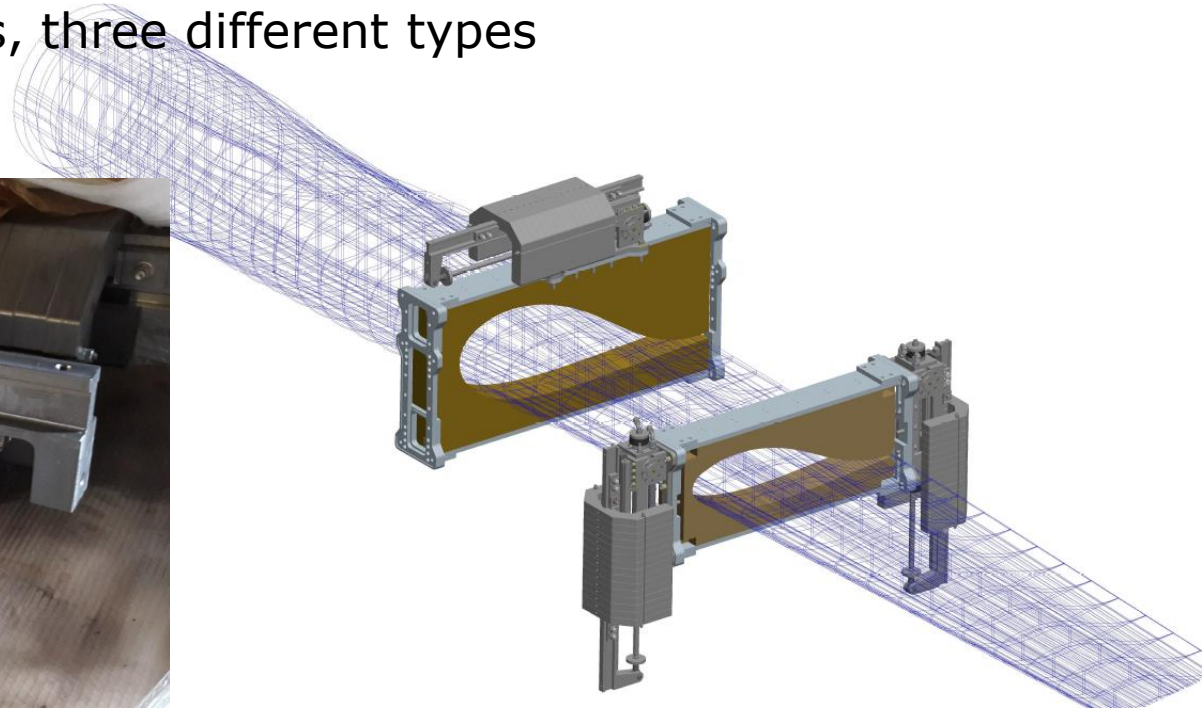
Test stands and strong floor

- The three test stands are designed to withstand the highest static loads in the vertical direction.
- Fatigue loads can be applied in any direction.
- The floor has built-in rails, which makes it flexible to apply loads where needed.

	45 m test stand	25 m test stand	15 m test stand	
Maximum bending moments on test stands				
Static	20.0	3.5	1.0	MNm
Dynamic, amplitude	6.0	1.0	0.4	MNm
Maximum deformations during test				
Static tip deflection	13.5	10.0	5.0	m
Dynamic tip-to-tip	11.0	6.0	4.0	m

Loading equipment

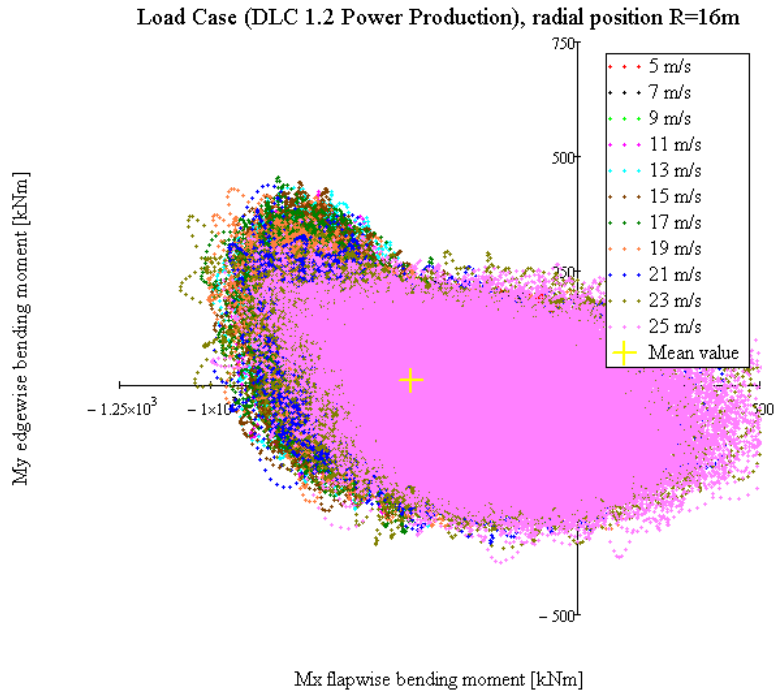
- Hydraulic Power Unit (HPU) with 500 lpm
- Three independent pipe system (one per test stand)
- More than 50 fatigue rated actuators (mostly from MTS) covering testing range from 5kN to 5000kN
- 6 Hydraulic Winches, two different types
- 8 Single Servo Actuator Mass Resonance Exciters, three different types
- 1 Low Friction Hydraulic Servo Actuator



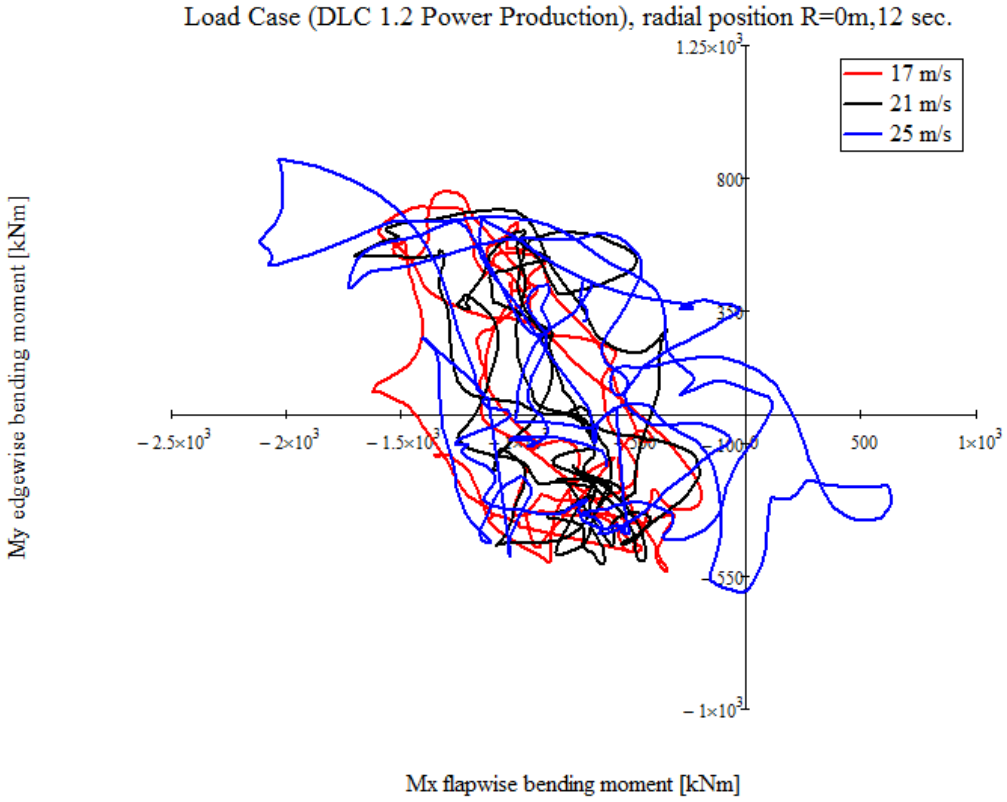
Static testing

Fatigue testing

- According to IEC61400-23 blades shall be tested in fatigue:
  - In flapwise direction
  - In edgewise direction

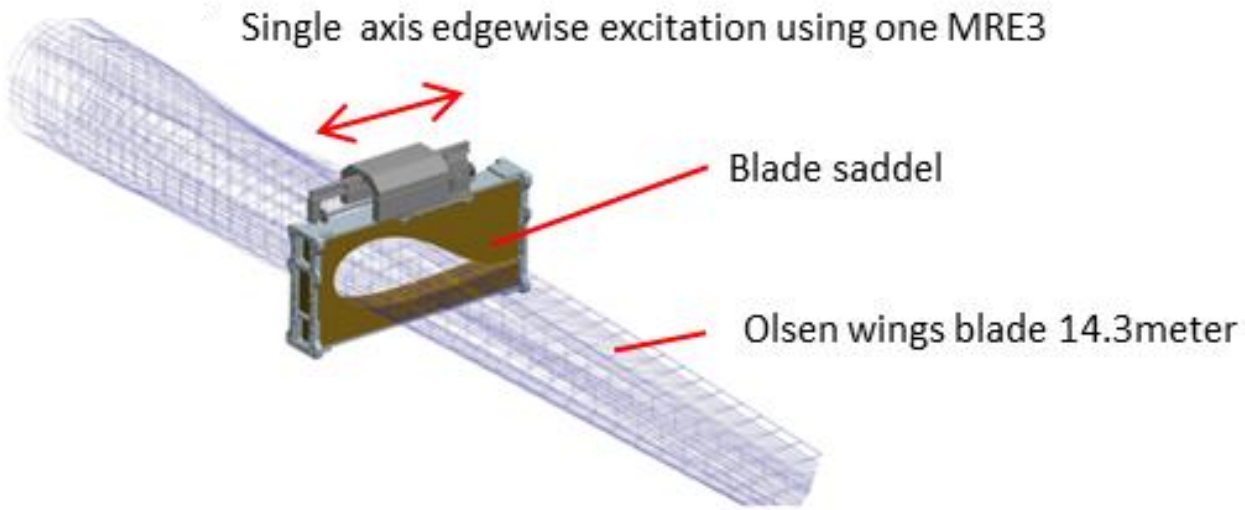


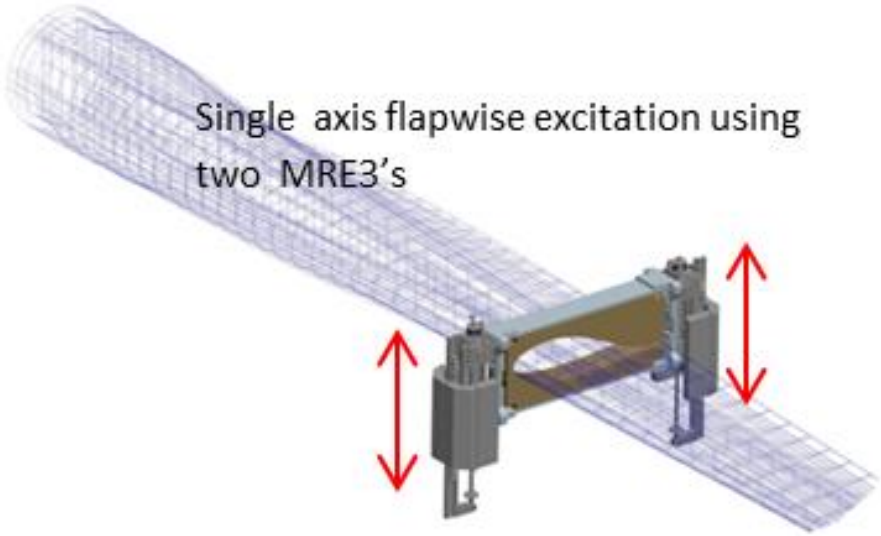
Complete load cloud at the SSP 34m blade cross section at R = 16m

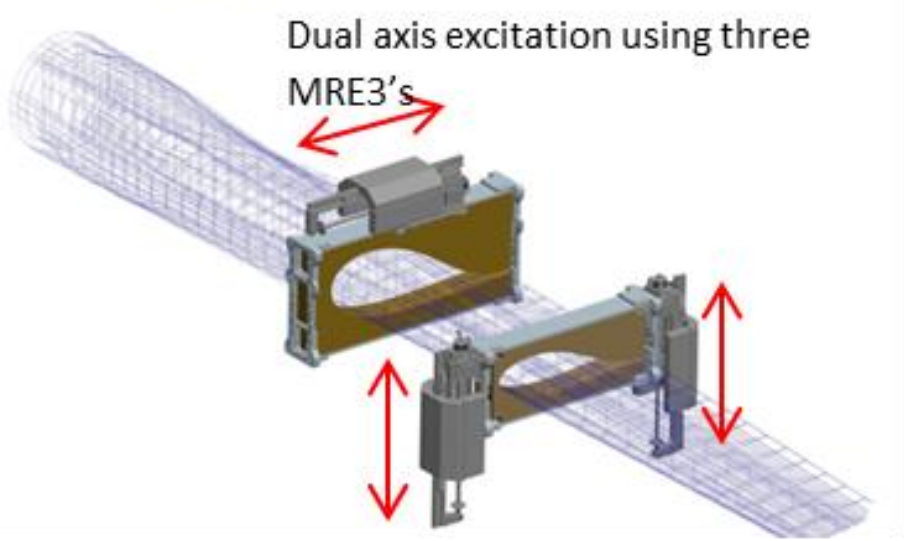


A 12s sample of load cloud at 17m/s, 21m/s and 25m/s at the SSP 34m blade root section

Dual-axis testing





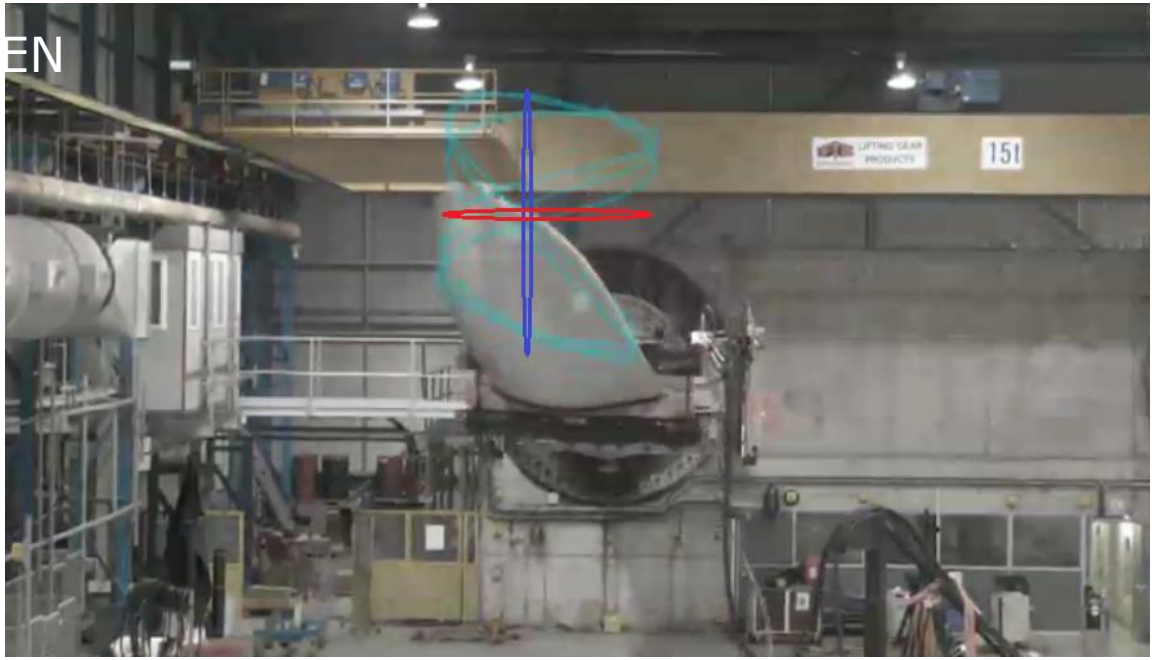


BLATIGUE - Fast and efficient fatigue test of large wind turbine blades

A project supported by EUDP and VILLUM FONDEN

Project partners:

- DTU Wind Energy
- Siemens Wind Power A/S
- R&D A/S
- Blade Test Centre A/S (BLAEST)
- Olsen Wings A/S
- DNV GL
- Zebicon A/S
- DONG Energy Wind Power A/S

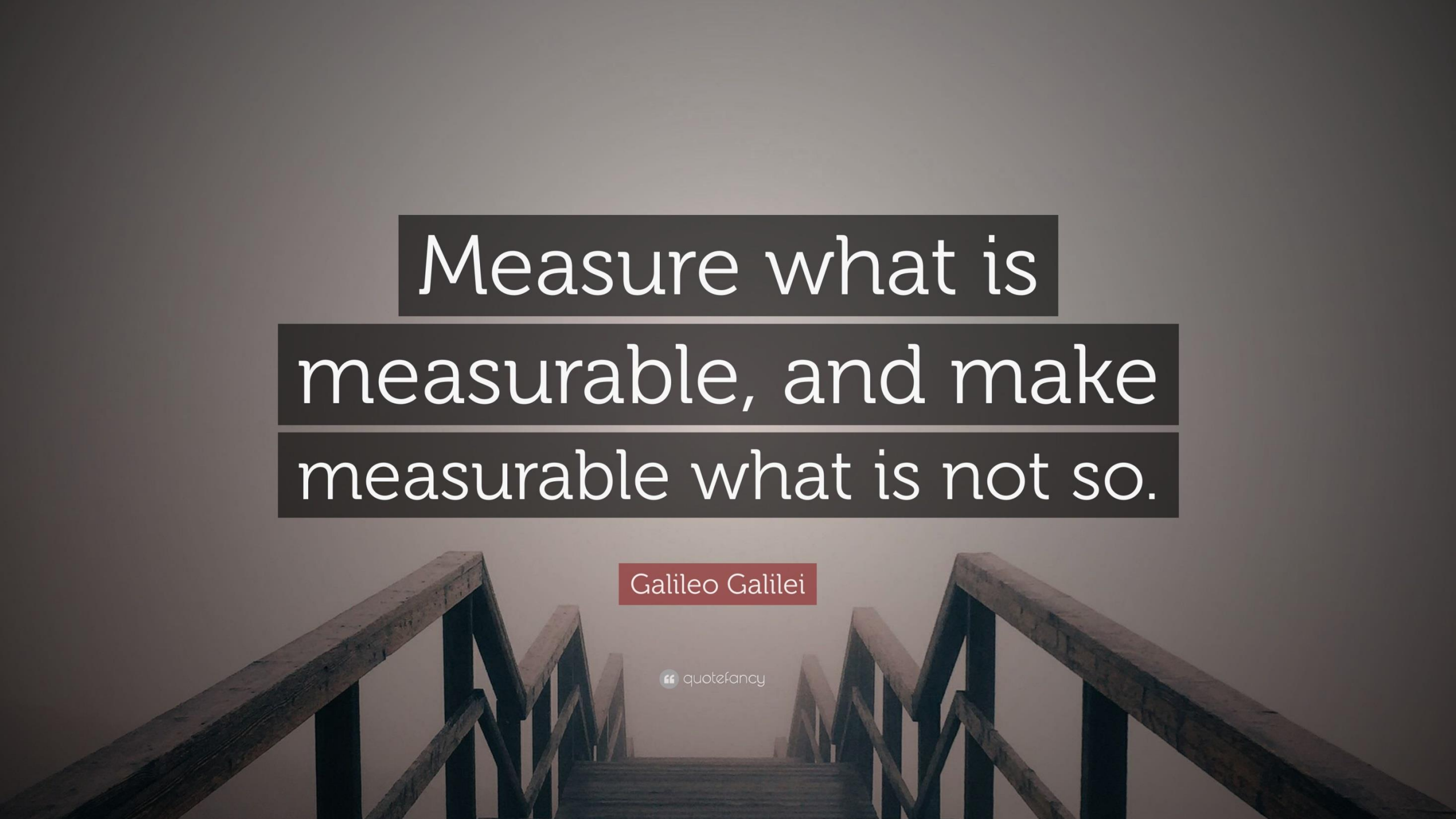


Dual-axis fatigue test at ORE Catapult in UK

The objective of BLATIGUE is to develop **fast and efficient fatigue test methods** for large wind turbine blades and to develop **equipment to excite the blades** under such tests.

- Period: Dec. 2016 – May 2020
- Total hours: 30730 h

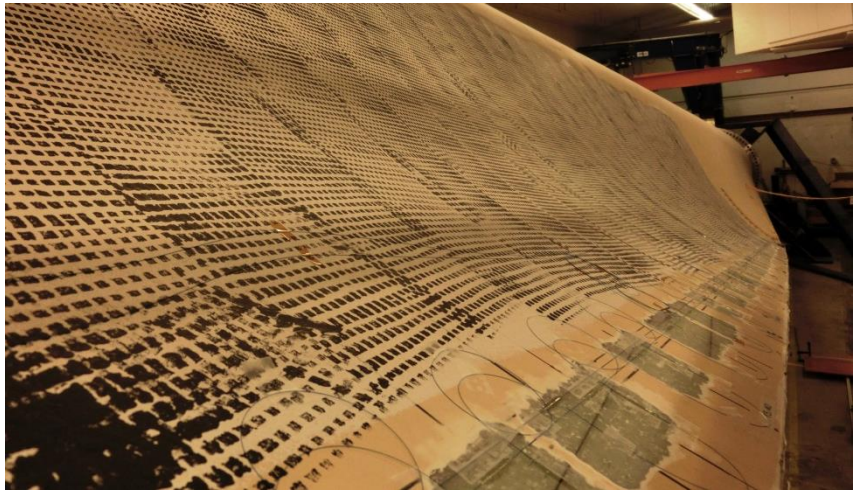
Energiteknologisk udvikling og demonstration

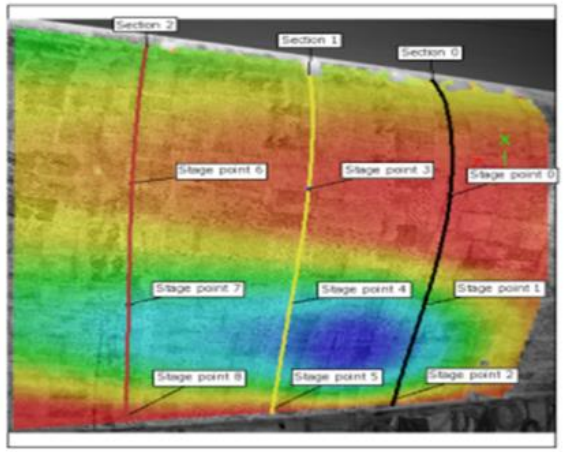

Measure what is measurable, and make measurable what is not so.
Galileo Galilei
quotefancy

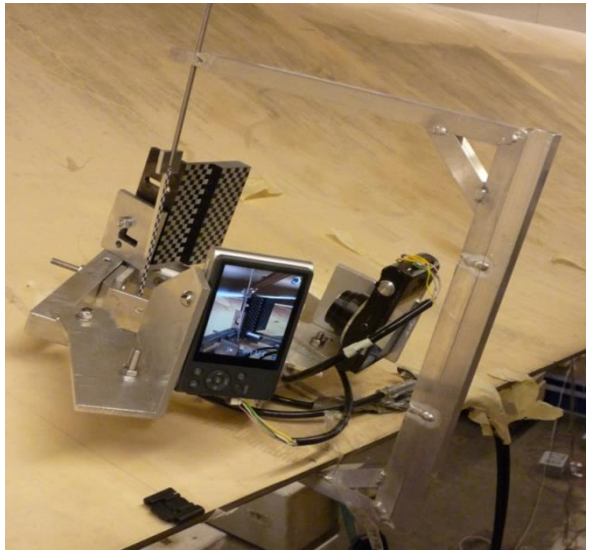
Measuring equipment

The facility has many possibilities to do advanced measurements and data acquisition.

- 3D full field displacements with digital image correlation systems
- Strain gauges (quarter, half and full bridge) and Fiber Bragg Grating sensors
- Displacements with LVDT and ASM
- Scanning laser Doppler vibrometer for vibrations and modal analysis
- High speed cameras, video and thermal imaging camera
- Failure and cracks can be studied with Acoustic Emission, ultrasound and X-ray imaging



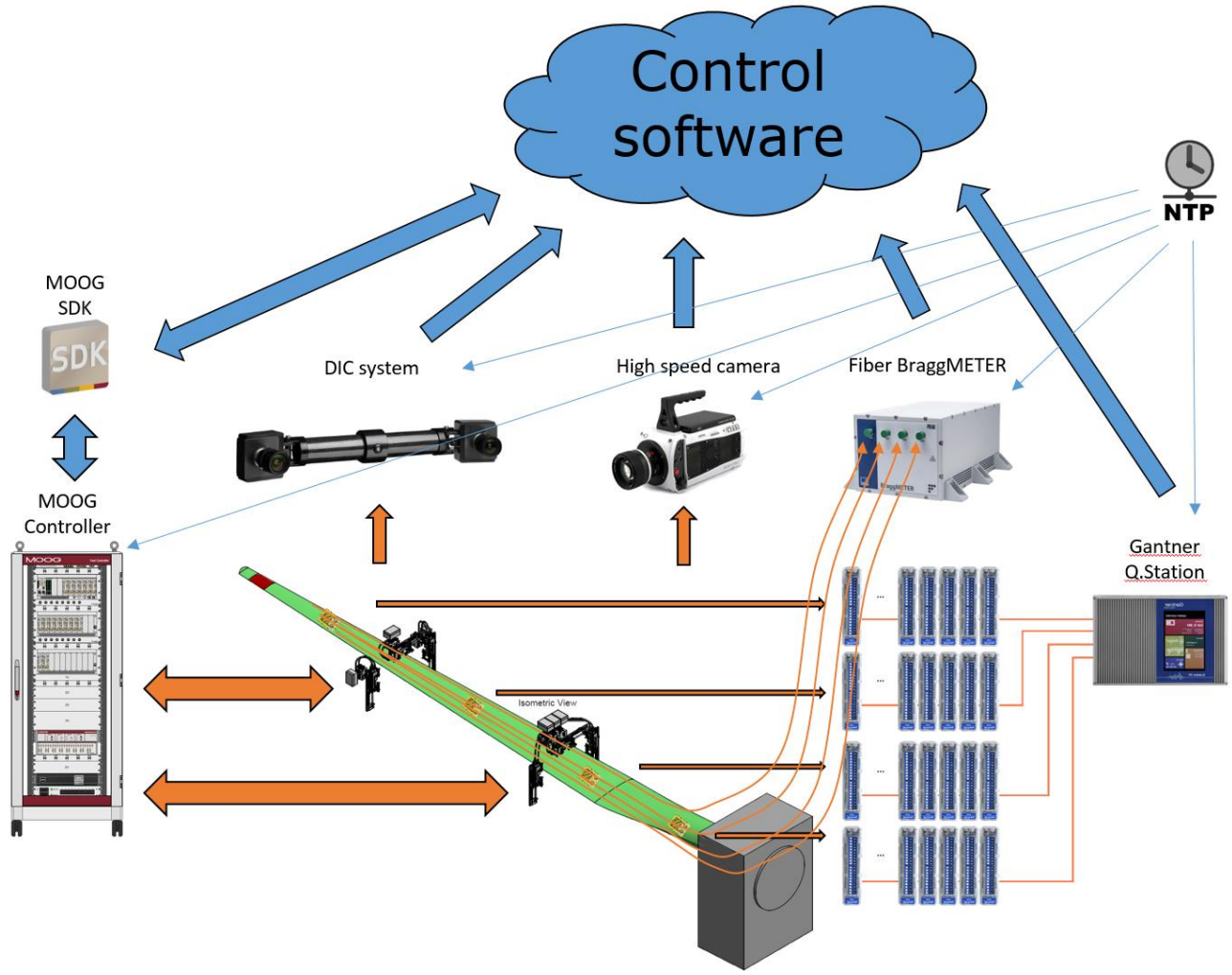




2nd bending

Lab interfacing overview

- MOOG controller is used for controlling movements of all actuators according to the test program.
- Gantner Q-stations are used for data acquisition from different types of sensors mounted on the blade (strain gauges, accelerometers, etc.).
- All measurements are synchronised via NTP based timestamping.
- A top level controlling system is implemented using LabVIEW software as well as MOOG and Gantner software development kits (SDK).



Possible projects and activities

- Blade testing, static and fatigue (single and dual axis)
- Dynamic and Modal analysis
- Demonstration of new sensors and measuring equipment
- Develop special test setups that require much space
- Develop new advanced test methods for large components and substructures
- Design, manufacture and test small blades in order to make cost-effective and fast pilot tests of new concepts before scaling up to full size
- Having a digital twin of the tested structure to better understand response and failure

Acknowledgements

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