WEIDMÜLLER

Next Generation Rotor Blade Monitoring

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Windenergietage 2025, Potsdam

Weidmüller

Agenda

01 **New Hardware and Functionalities**
Unique System Features, Architecture, Global Deployment

02 **Advanced Structural Health Monitoring**
Detectable Damage Types, Actual Cases

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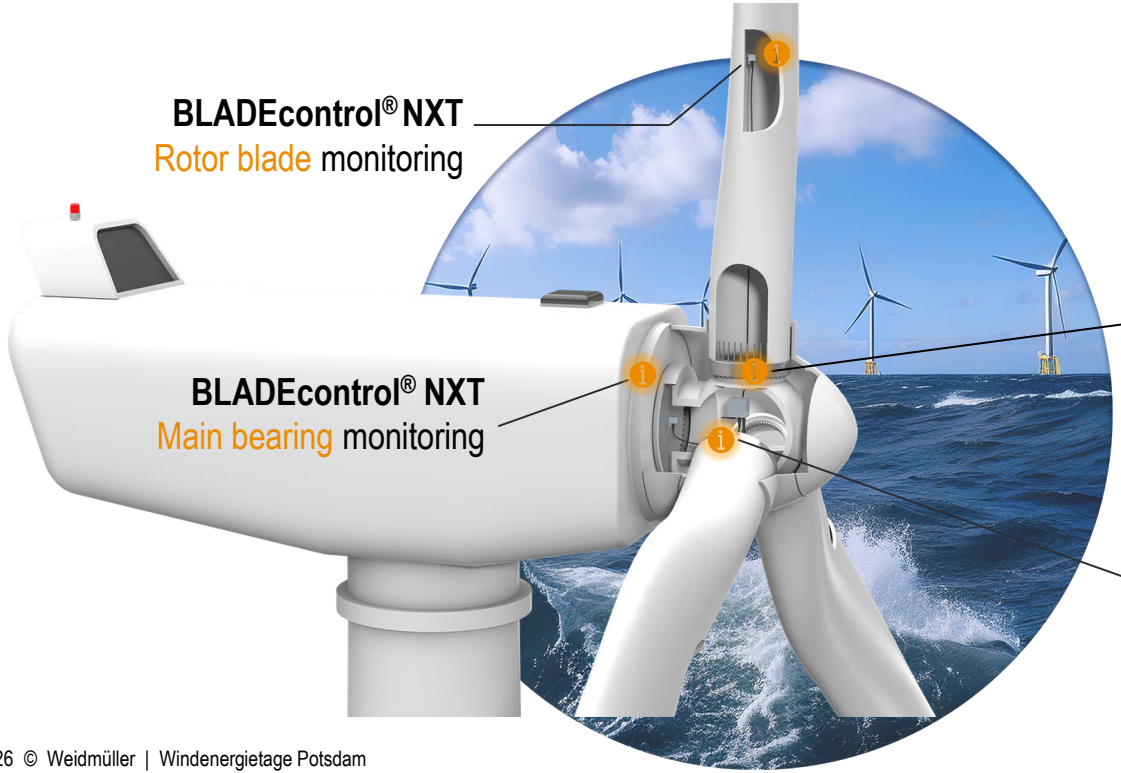
Condition Monitoring for Wind Turbines

Rotor blade condition monitoring for higher availability and optimum efficiency



BLADEcontrol® NXT
Rotor blade monitoring

BLADEcontrol® NXT
Main bearing monitoring

BOLTcontrol
Bolt breakage monitoring

TwinCap®
Blade bearing monitoring

Global Deployment BLADEcontrol®

Sold systems, in total: >7,000* (> 25 GW)
Turbines in monitoring: >3,500*

Monitoring background

- Over 31,500* machine years of monitoring experience

Market distribution

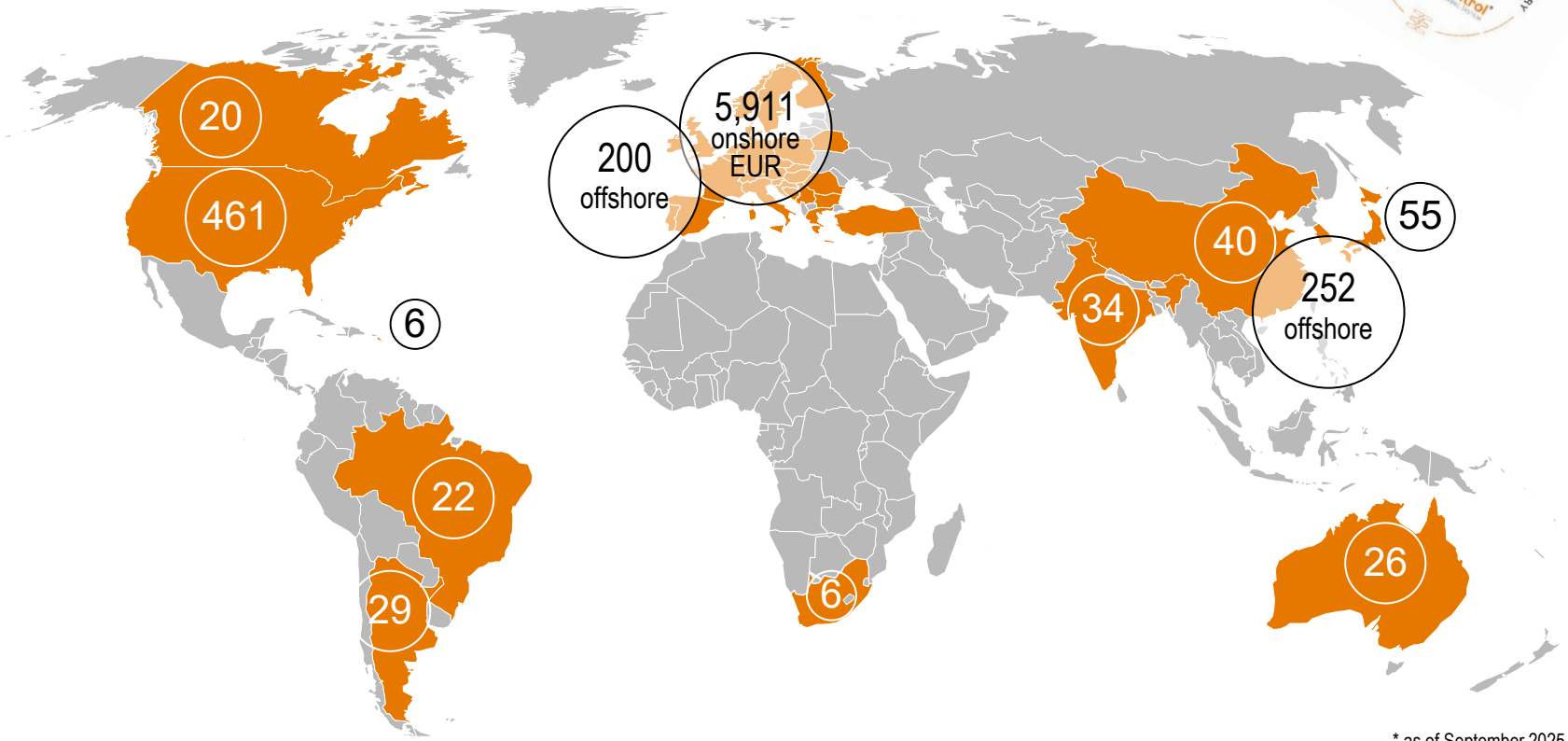
- System of choice of major OEMs and large operators (serial, optional, project-based)
- Covering a wide variety of turbine (>230) and blade types (>100), on- and offshore

Pioneer in rotor blade monitoring

- Ice Detector first certified in 2008; Condition Monitoring System first certified in 2013

* as of September 2025

Global Deployment BLADEcontrol®



* as of September 2025

BLADEcontrol® NXT – Next Generation Rotor Blade Monitoring

Multiple sensor technology – optical link inside rotor blade

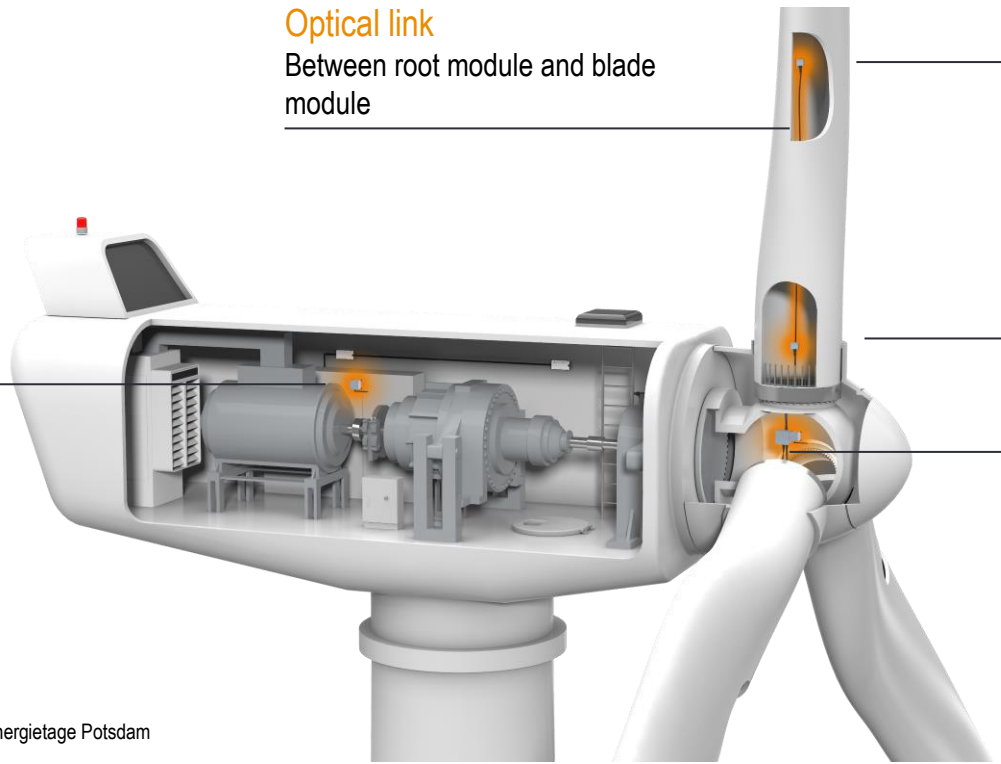
Optical link
Between root module and blade module

Blade module
Installed at 1/3 of blade length

Root module
Installed at blade root

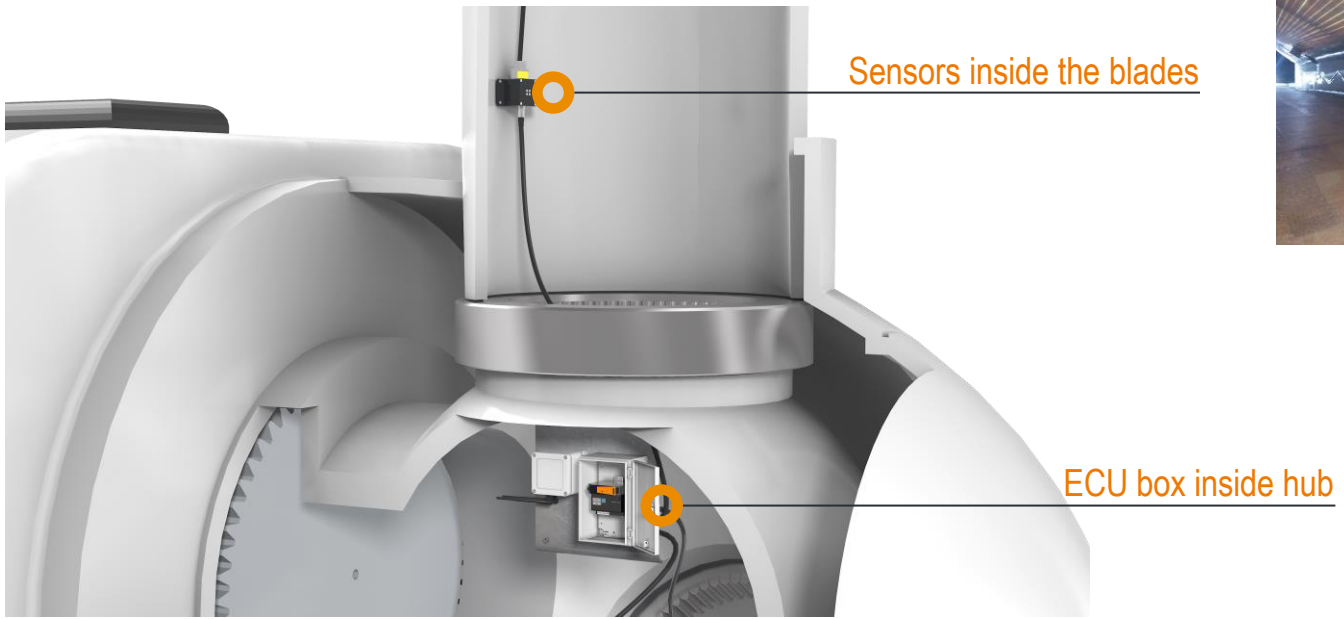
ECU box
Access point optional

Access point
Optional



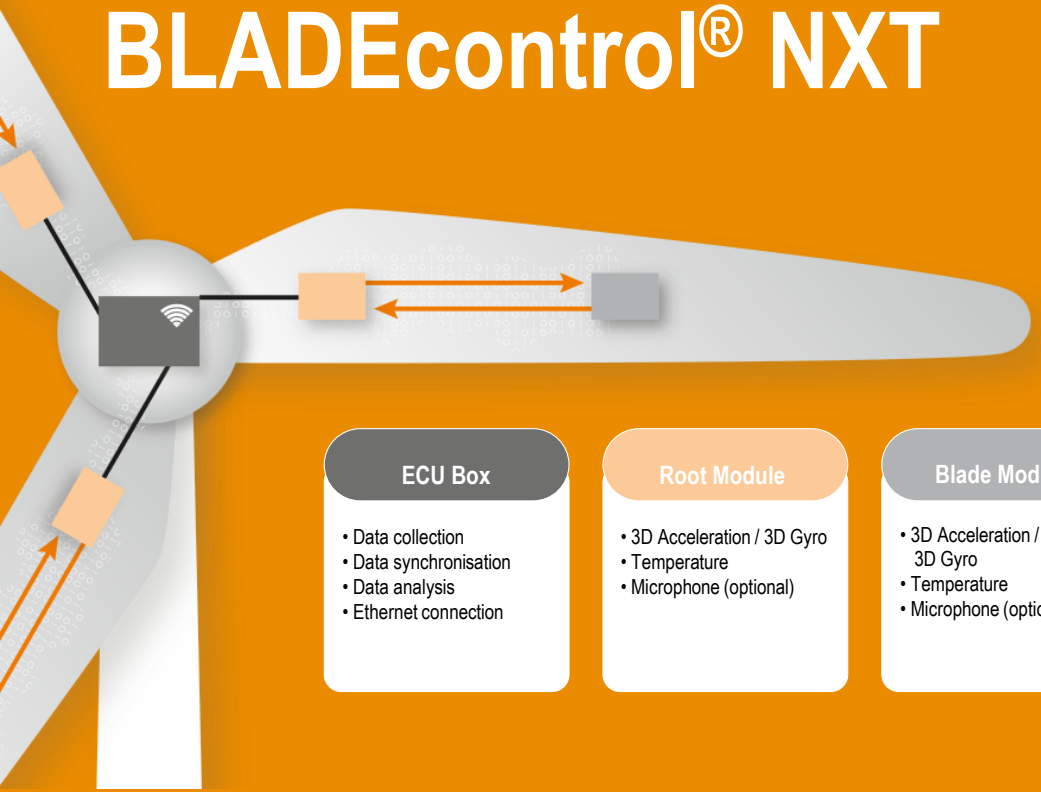
BLADEcontrol® NXT – Next Generation Rotor Blade Monitoring

Multiple sensor technology – optical link inside rotor blade



SYSTEM DESIGN

BLADEcontrol® NXT



ECU Box	Root Module	Blade Module	Electrical Cable	Optical Cable
• Data collection • Data synchronisation • Data analysis • Ethernet connection	• 3D Acceleration / 3D Gyro • Temperature • Microphone (optional)	• 3D Acceleration / 3D Gyro • Temperature • Microphone (optional)	• Data and power transfer from ECU-Box to root module	• Data transfer between root module and blade module • Power transfer from root module to blade module

BLADEcontrol®

NXT

YOUR BENEFITS

Enhanced Condition Monitoring
Additional sensors, two measurement points, MEMS sensor technology, maintenance free

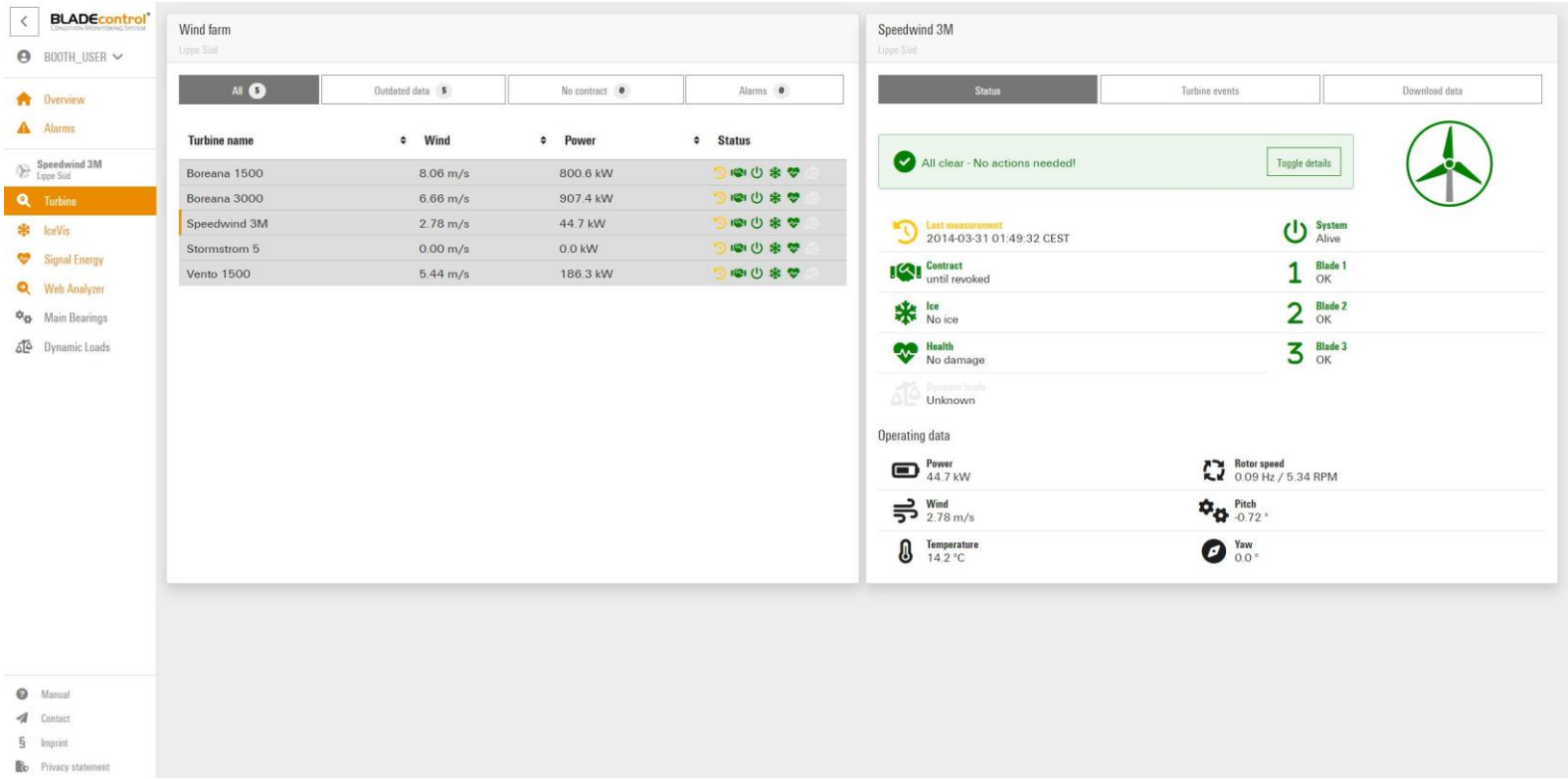
Integration into all turbine types
Onshore and offshore, optical data and power transfer, lightning-safe

Additional acoustic damage detection
Detection by correlating structure-borne and airborne sound

Real-time data analysis
Edge computing, enhanced algorithm for deeper insights

Weidmüller

Web Visualisation



Agenda

01 **New Hardware and Functionalities**
Unique System Features, Architecture, Global Deployment

02 **Advanced Structural Health Monitoring**
Detectable Damage Types, Real Case Examples

Detectable Rotor Blade Damages

Split Tip (lightning strike)

Longitudinal Crack

Spar Web Debonding

Trailing Edge Crack

Leading Edge Erosion

Leading Edge Crack

Bolt / Nut Breakage

Sources:
https://www.cpmax.com/files/content/galerien/Schadensbilder/xTiefer-Riss-an-der-Blattwu.jpg
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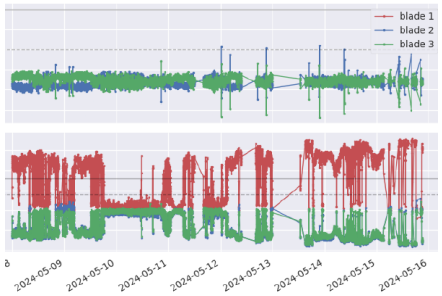
BLADEcontrol – Example Event Noti

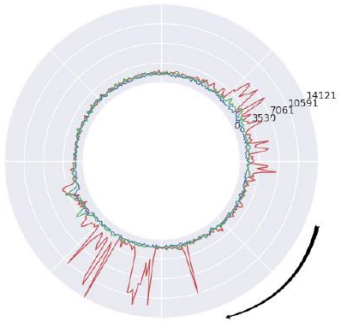
Advanced monitoring expertise is essential!

Simply stating the mathematical deviation is insufficient.

Customers want the following information:

- Where is the damage located?
- What damage type ?
- What´s the criticality?
- What kind of service steps are necessary?





BLADEcontrol® Notification Weidmüller

2024-05-16, *WMS-Employee*

WTG ID (wind farm)

Blade #		1		2		3	
Blade ID		*Blade ID No.*		*Blade ID No.*		*Blade ID No.*	
sensor	1-edge	1-flap	2-edge	2-flap	3-edge	3-flap	hub
available	yes	yes	yes	yes	yes	yes	no

Time of latest available measurement: 2024-05-16 09:20 CEST

Deviation Signature

Blade: 1

	idling	0 – 0.5 MW	0.5 – 1.5 MW	1.5 – 4 MW	> 4 MW
freq. range 1 Hz	n/a	OK	OK	OK	OK
freq. range 2 Hz	n/a	alarm	alarm	OK	OK
freq. range 3 Hz	OK	n/a	n/a	n/a	n/a

Temporal form: **stroke**

Maximum amplitude: **30,000** digits

Recommendation

Possible causes:

1. **Unknown, non-critical** (likely)
2. **Delamination** (possible)
3. **Sensor fault** (less likely)

Immediate shutdown: No

Comment

A known phenomenon (strokes in blade 1) has again lead to an automatic turbine shutdown as the already increased alarm threshold (from ... to ...) was again crossed in the ... Hz band. This was, because the strokes in blade 1 have further increased amplitude, but without changing their other main characteristics. Previous inspections in March 2024 have only identified a minor delamination on the leading edge at ... m. We therefore have now further increased the alarm threshold to ... for blade 1 to avoid additional alarms, but the turbine will also soon receive a software update that will prevent alarms of this kind altogether. An alarm will then only be triggered, when there is also a moderate deviation in the ... Hz band that is not the case here.

Example 1 – Large Debris

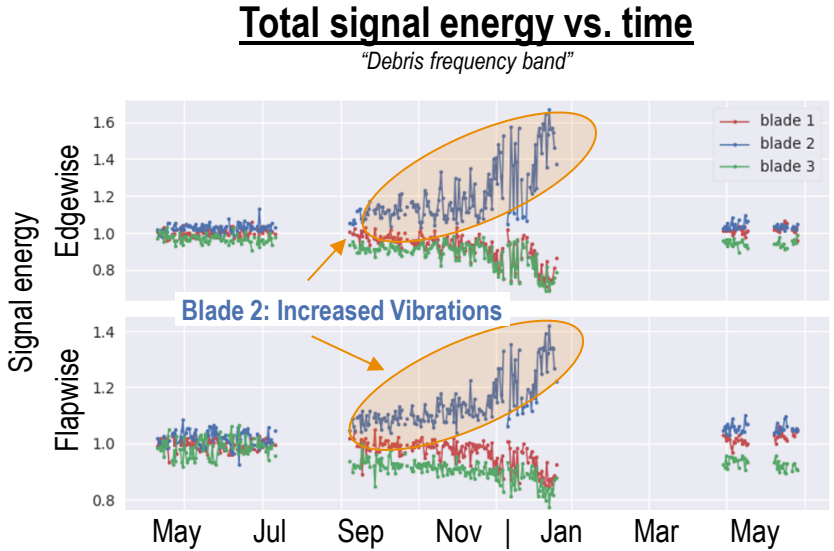


Fig 1. Large increase in vibration response in blade 2 detected over 2-3 months

Fig 2 & 3. Large chunk removed from tip of blade. Smaller debris also present

Example 2 – Large Internal Crack

Internal laminate cracking detected *before* external presentation

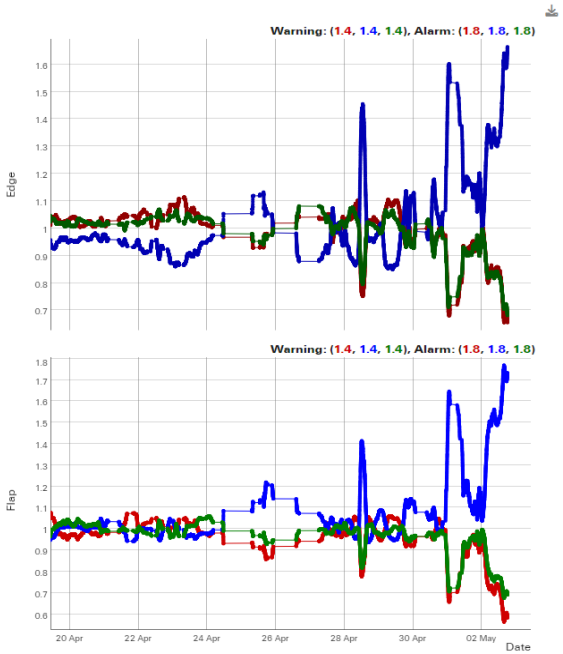


Fig 1. Detected late April, even at low wind speed

Fig 2. Confirmed with internal inspection

Example 3 – Large External Crack

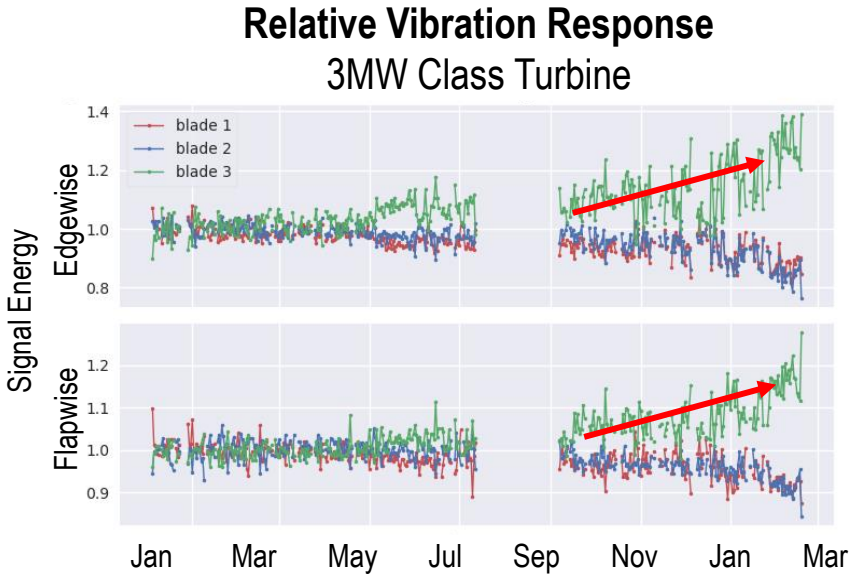


Fig 1. The turbine was shut down from drivetrain repairs, and blade issues presented on restart over the winter months

Fig 2. Confirmed with Drone inspection after recommended shutdown

Example 4 – Large External Crack

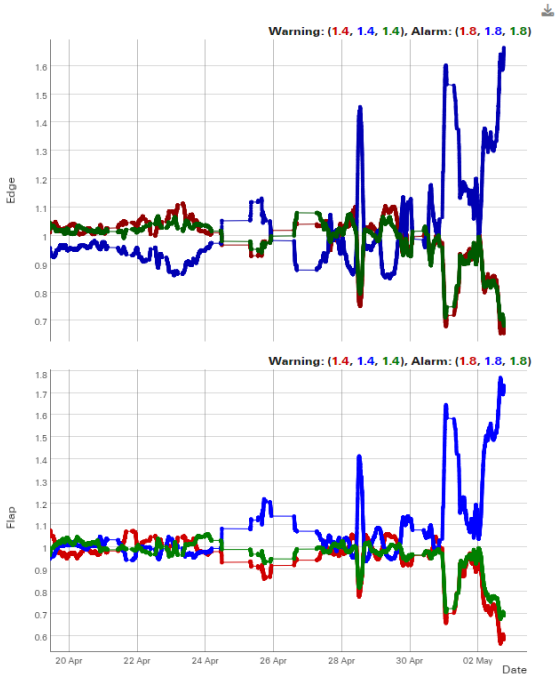


Fig 1. Significant deviation above warning level

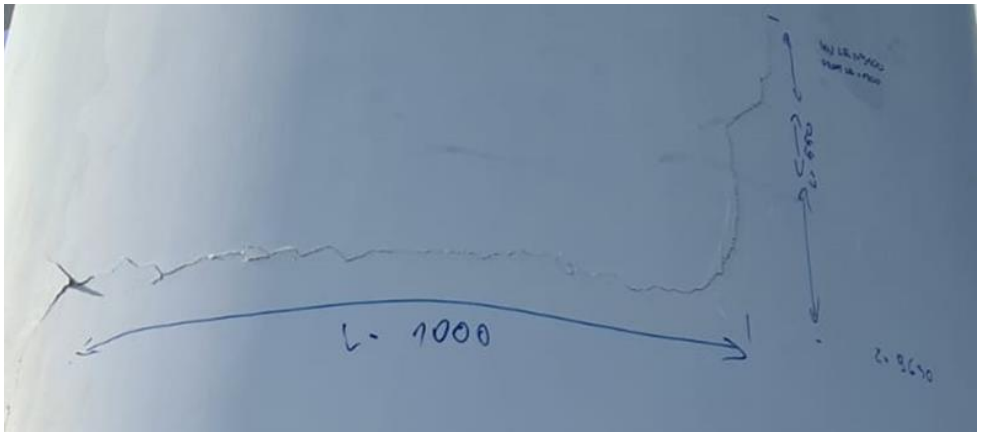


Fig 2. Confirmed with Drone inspection after recommended shutdown

Example 5 – Seam Seal

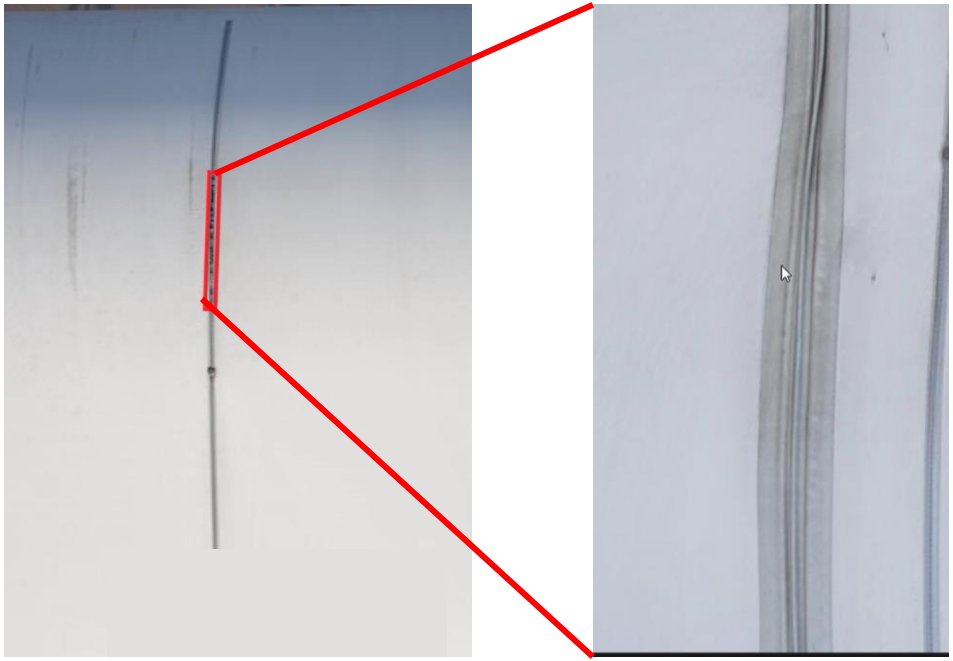


Fig 1. Area of interest on seam seal from drone inspection in March

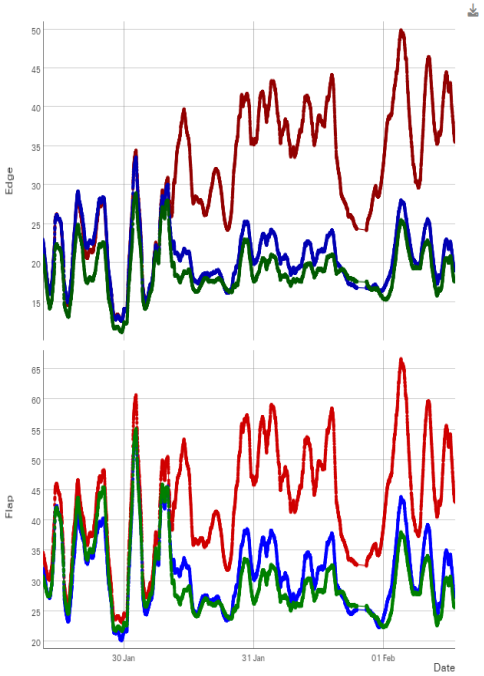


Fig 2. Initial Deviation occurred in Jan

Example 6 – Loose Production Parts

Fig 1. Clips used in the production layup were left in the blade

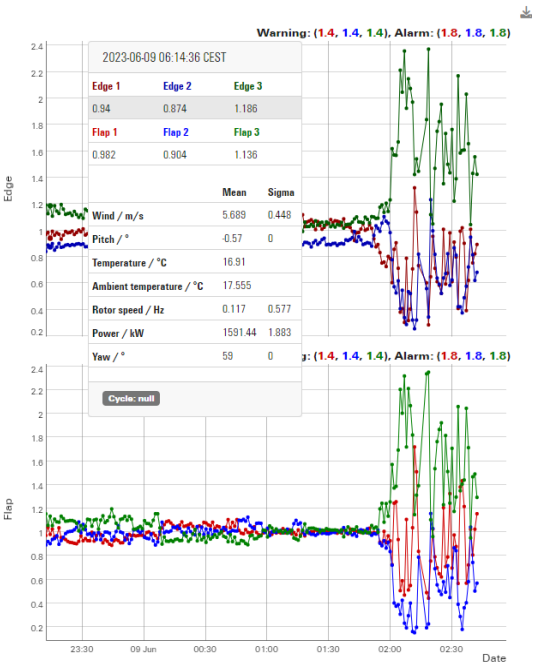


Fig 2. Sudden increase in flap/edge energies when parts became dislodged

Transforming Data to Value

✓ **Less unplanned downtime and safer operation**
- Early detection of turbine health risks
- Alarms, shutdown triggers, auto-restart

✓ **More efficient planned downtime**
- Data driven maintenance and service

✓ **Optimized performance**
- Increased productivity
- Higher profitability

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