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Jornada Análisis Operativo
de Parques Eólicos 2022

A shock detection and trend analysis
tool

October 2022

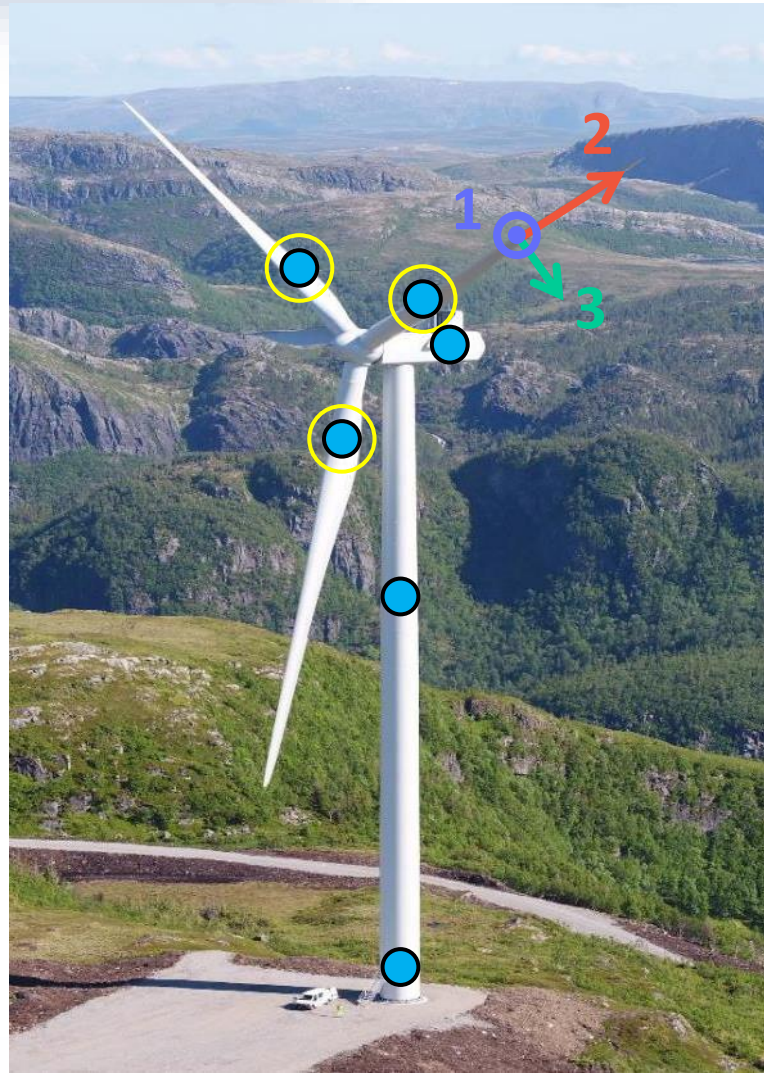
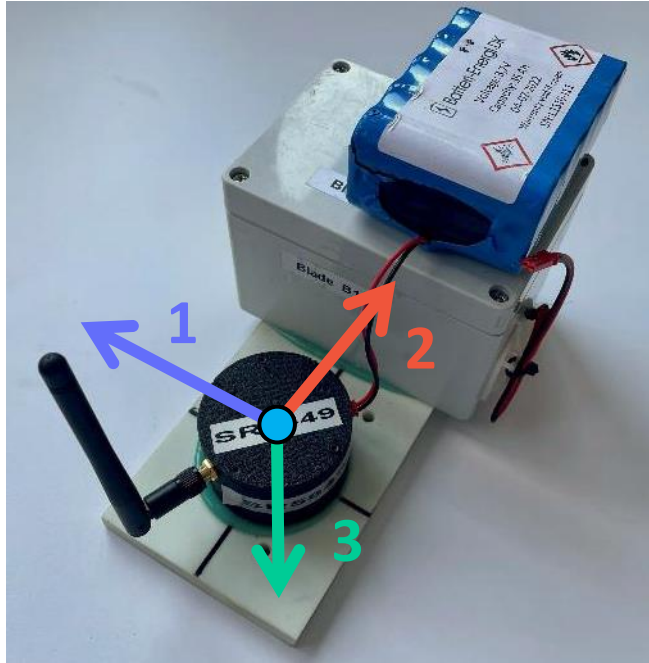
Overview

- The Ventus TripleCMAS system
- Shock detection
- Trend analysis & case studies
- Future outlook



Critical Components Condition Monitoring and Alarms System

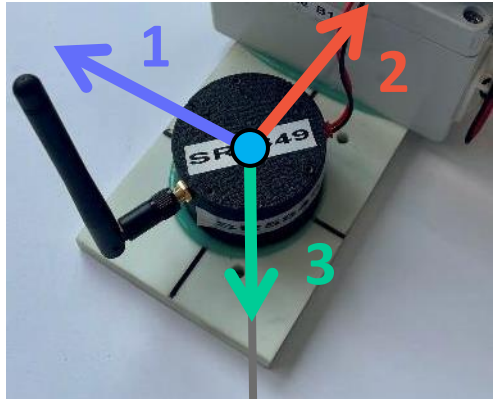
Three-axis accelerometers



- Turns the rotor and swept area into a condition monitoring instrument for the WTG
- Data driven condition monitoring:
 - Diagnostics
 - Alarms
 - Forecasting
 - Predictive service management
- Independent of wind turbine type
- Wind turbine optimization within type approval envelope
- Future: LEDS, atmospheric sensors, wind farm optimization
- Present focus: A specific algorithm, 'shock detection'



Accelerometer placed on a table



$$\begin{aligned} X_1 &= 0 \text{ [g]} \\ Y_2 &= 0 \text{ [g]} \\ Z_3 &= -1 \text{ [g]} \end{aligned}$$

$$F_g = 1 \text{ g} \downarrow$$

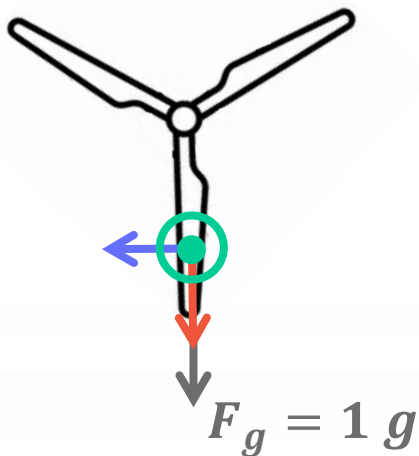
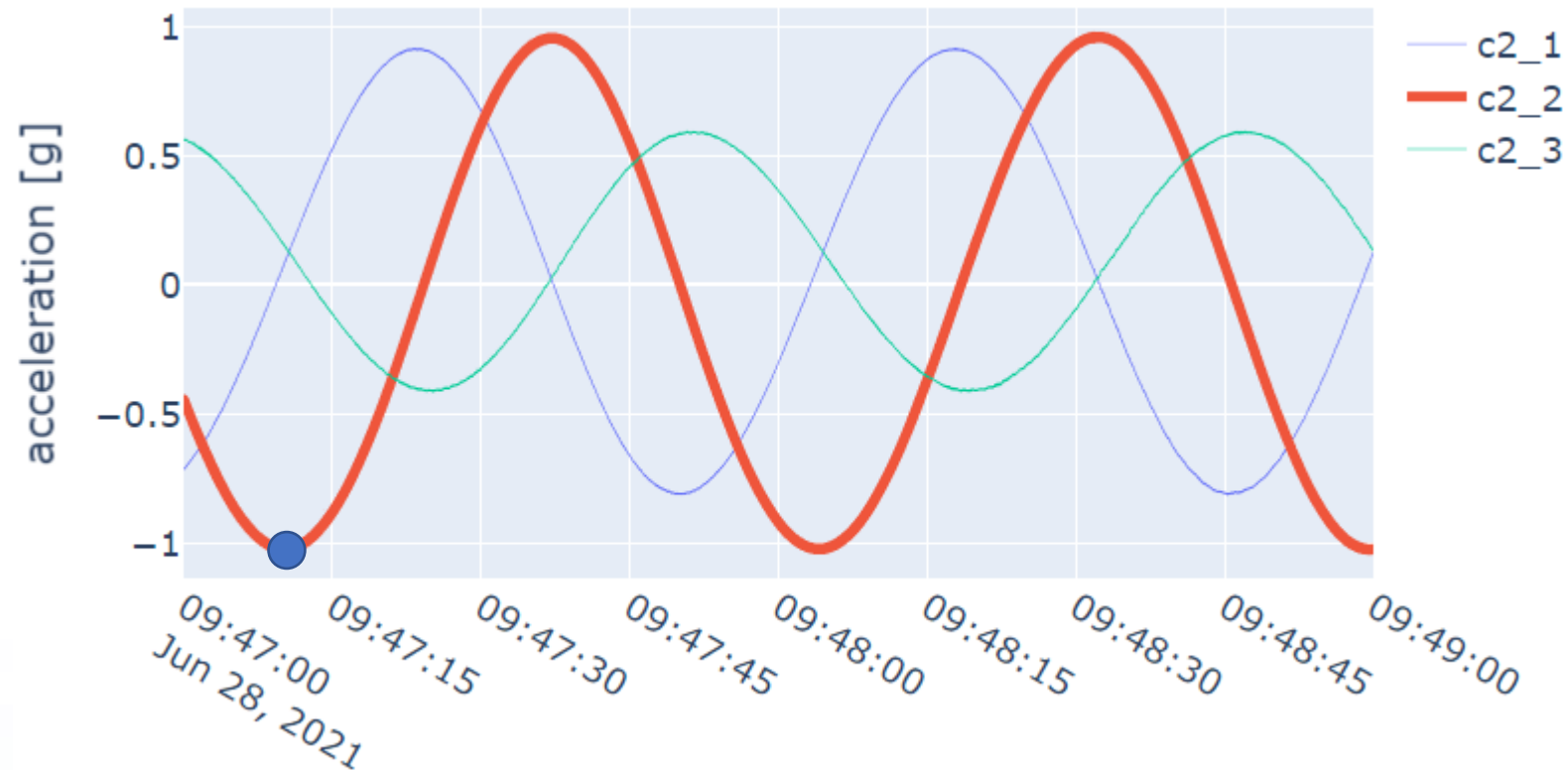
upside down

$$\begin{aligned} X_1 &= 0 \text{ [g]} \\ Y_2 &= 0 \text{ [g]} \\ Z_3 &= 1 \text{ [g]} \end{aligned}$$

real dynamic measurements

256 Hz

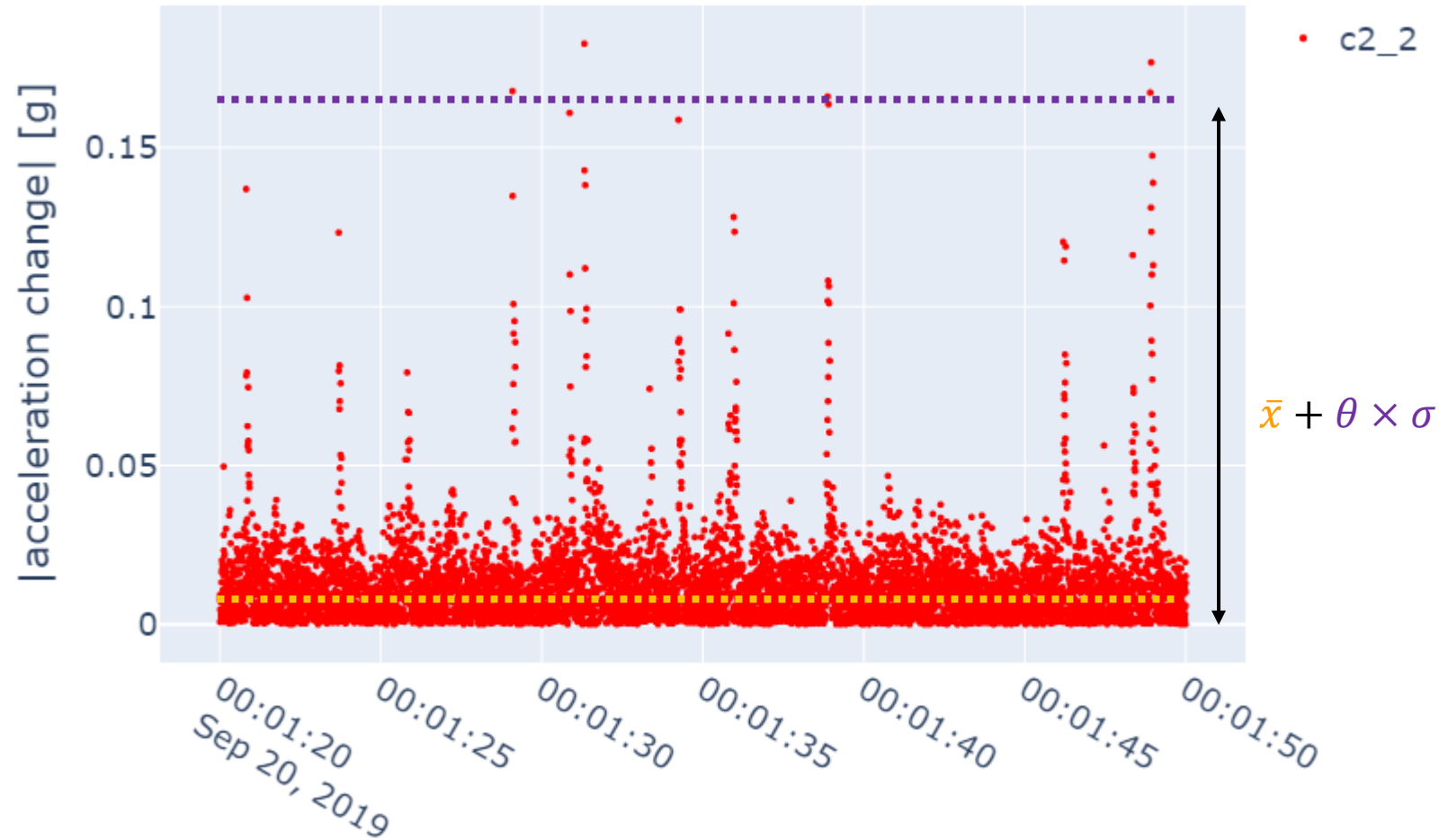
Rich with all kinds of information!



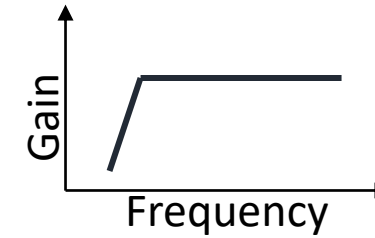
Shock detection

High-frequency information

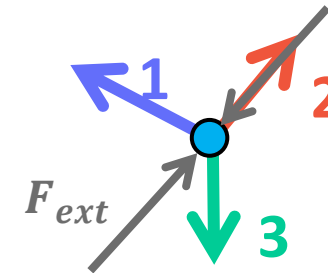
Strong sudden forces (accelerations) are dangerous for the turbines!



- High-pass filter



- Omnidirectionality



- Identify shocks

\bar{x} = mean

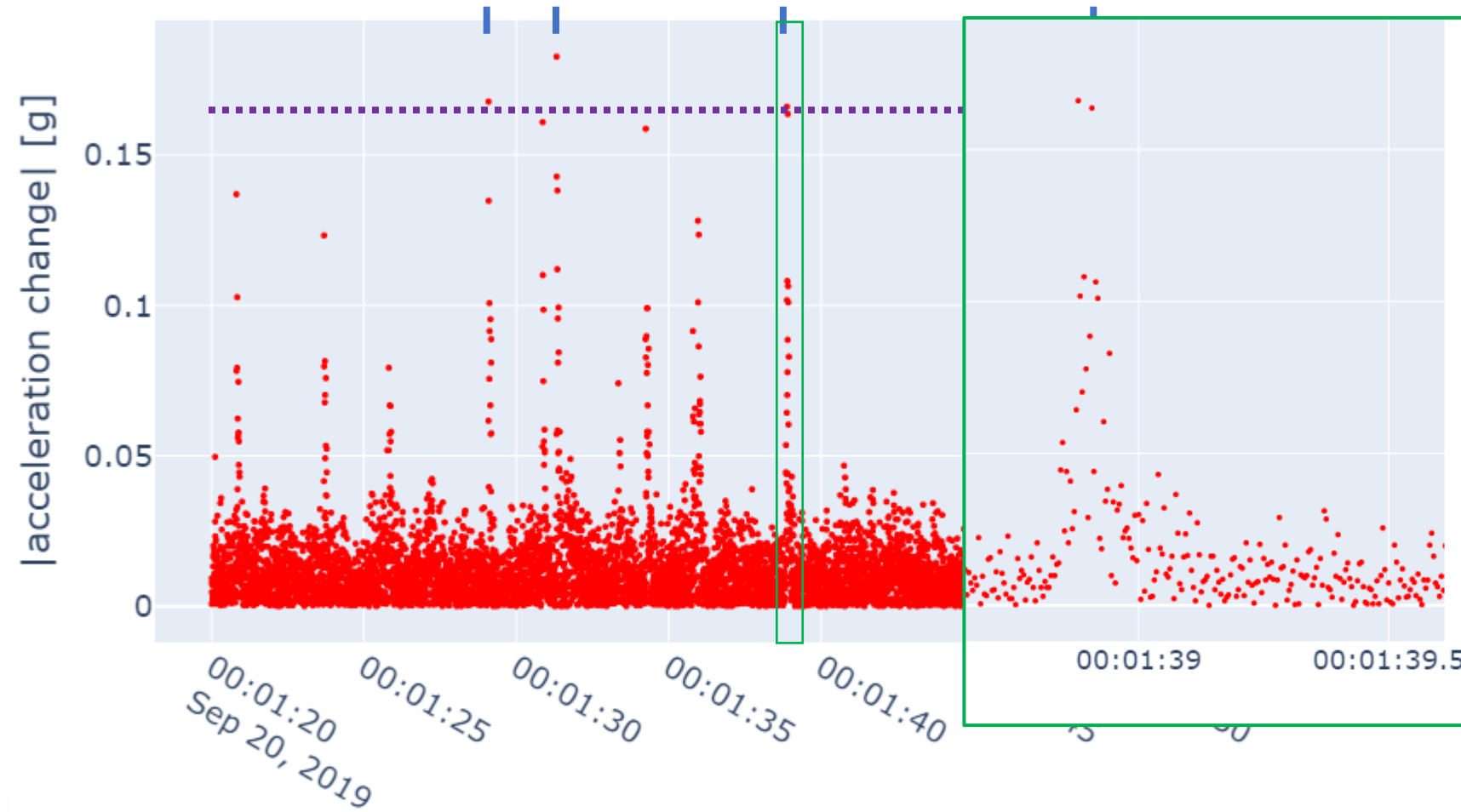
σ = standard deviation

θ = multiplier



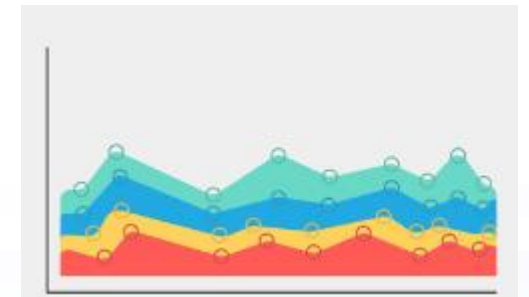
Shock detection

Shock profiling



- How many dominant shocks?
- How intense are they?
- When do they happen?
- How do they decay?

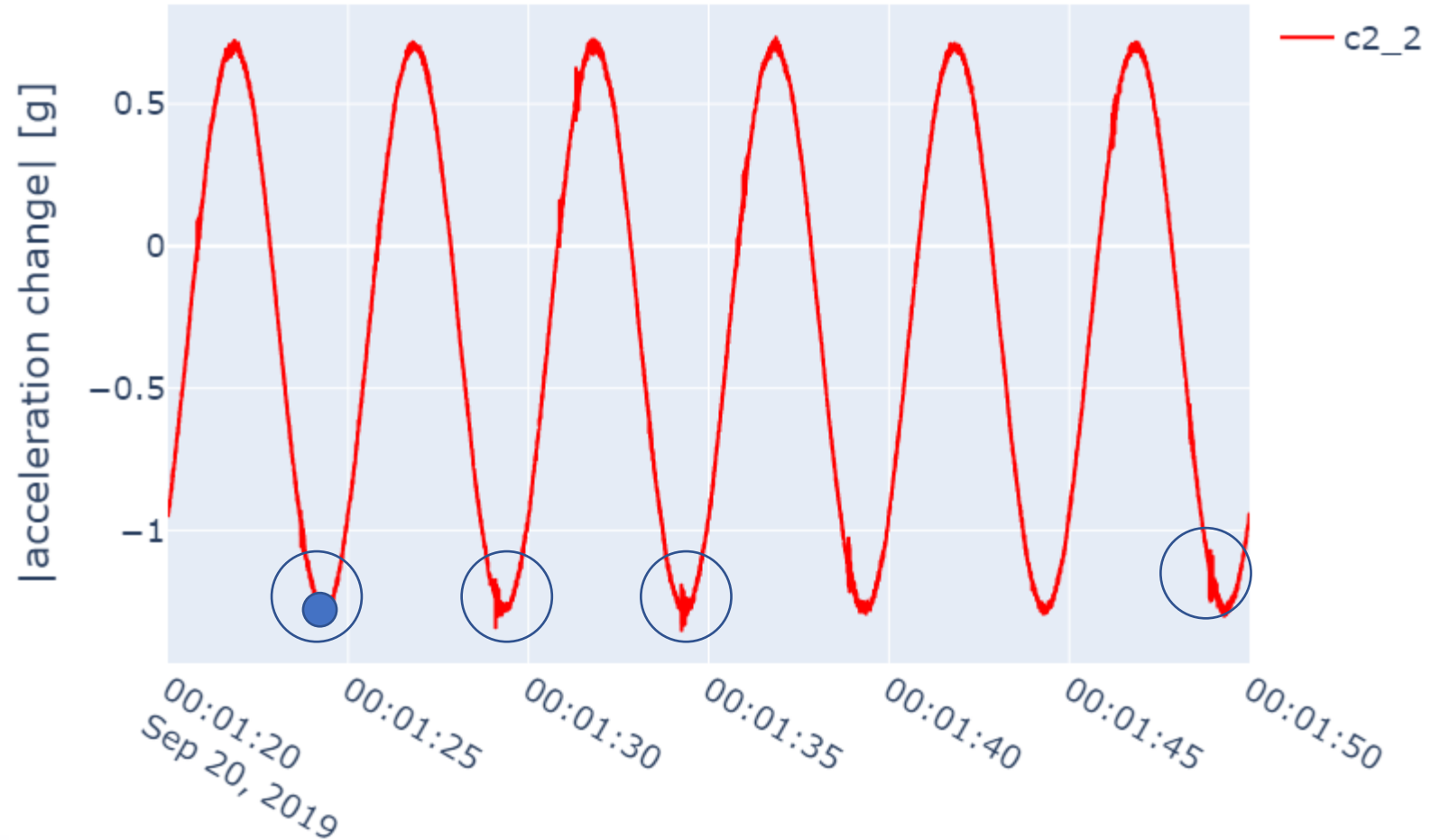
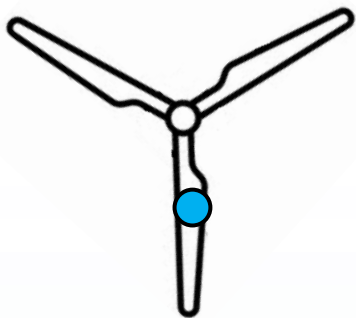
Trend analysis



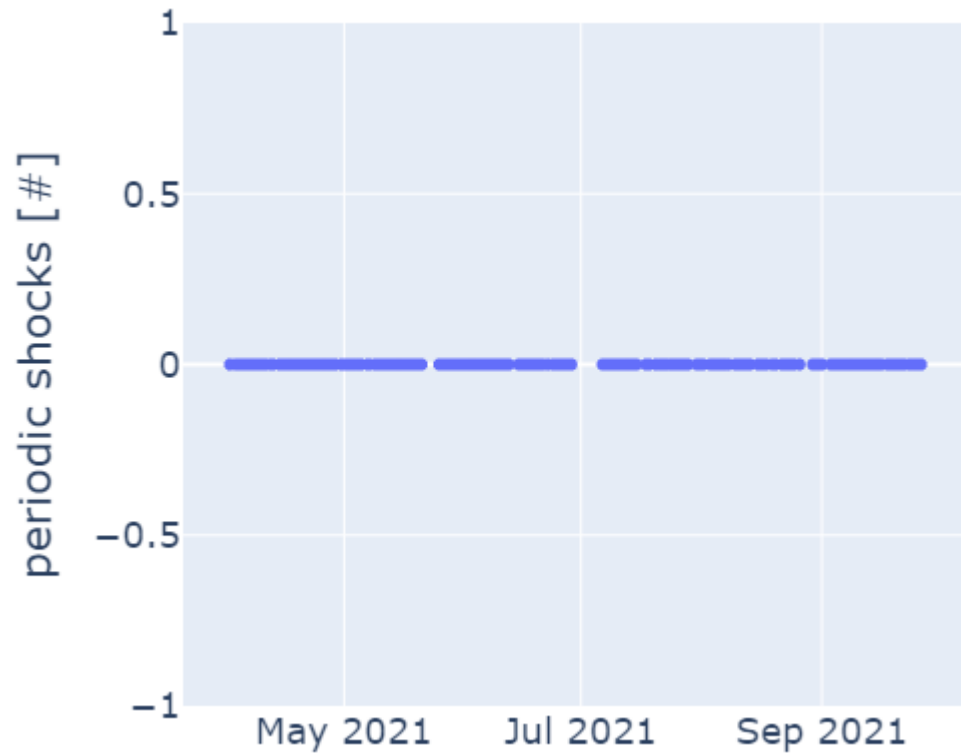
Shock detection

Towards classification

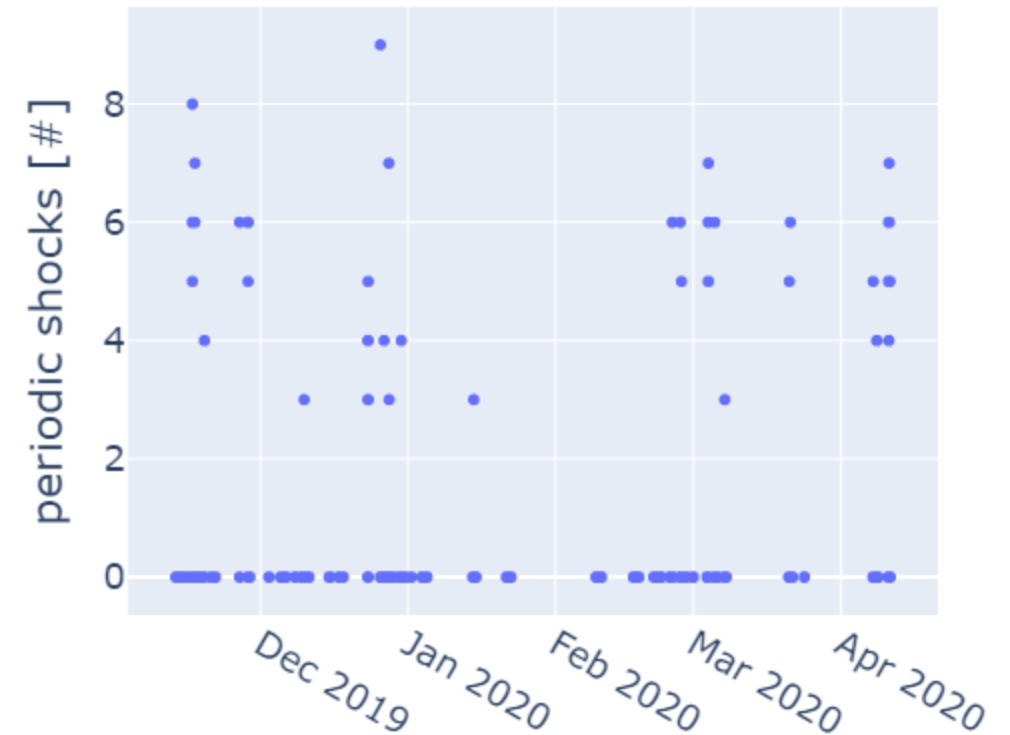
- Periodic shocks?
 - Compares time separation of shocks
- Internal source
 - Trapped objects
 - Acoustic cracking from structural alignments
- Critical component damage detection!



Healthy turbine

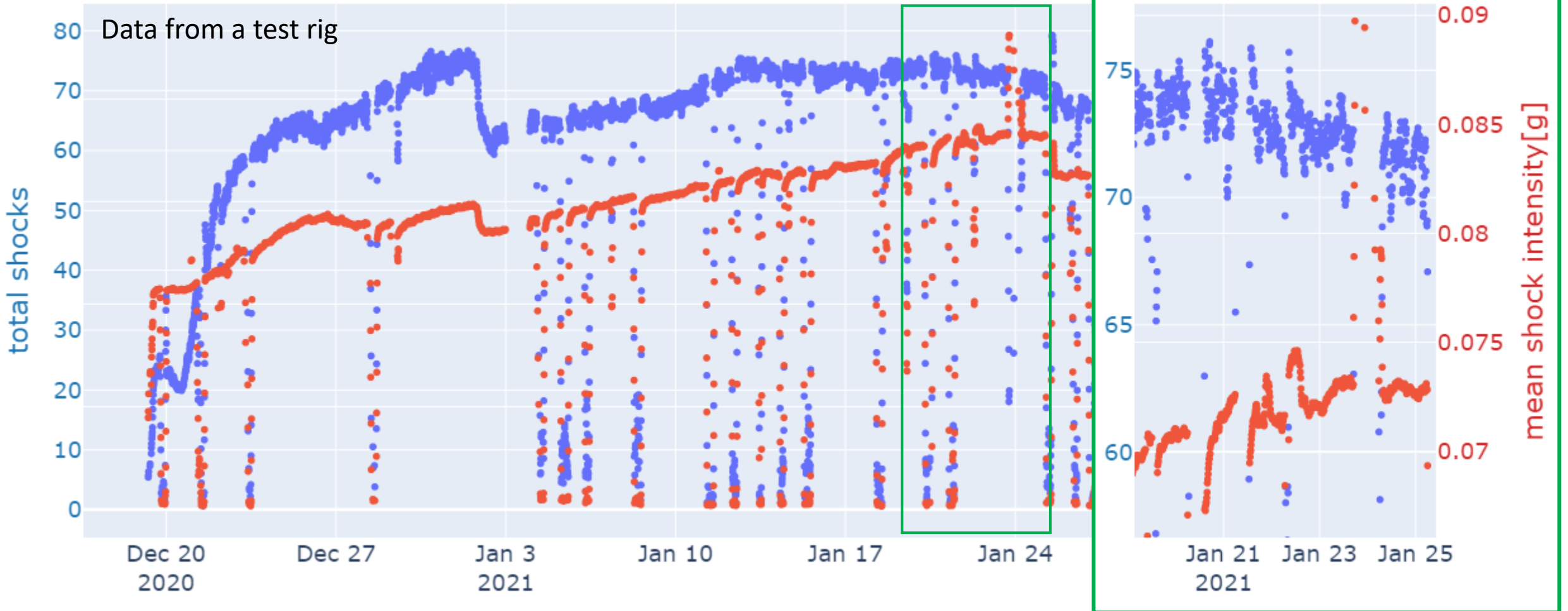


Turbine with trapped objects inside a blade



Cross fleet comparisons

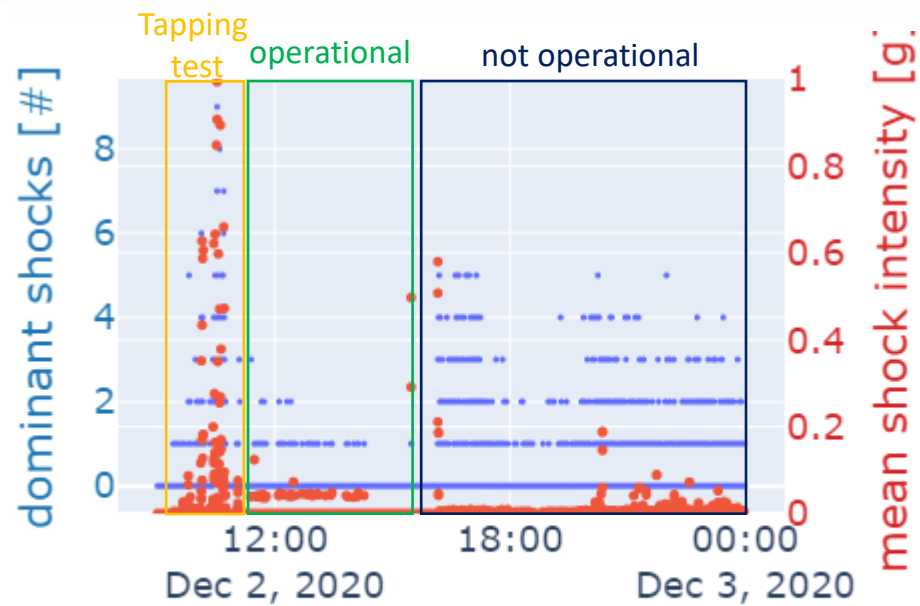




Decreasing shock count, increased intensity -> inspection recommended!

Predictive maintenance





Time domain data used in tandem with some of the other TripleCMAS algorithms:

- RPM
- Swept area segmentation
- Rotor imbalance



Ground truth test for this specific shock algorithm in progress:

- movement in blade studs
- damaged blade bearings
- lightning detection

Hardware improvements –
Frequency domain classification



V1 Ventus sensor

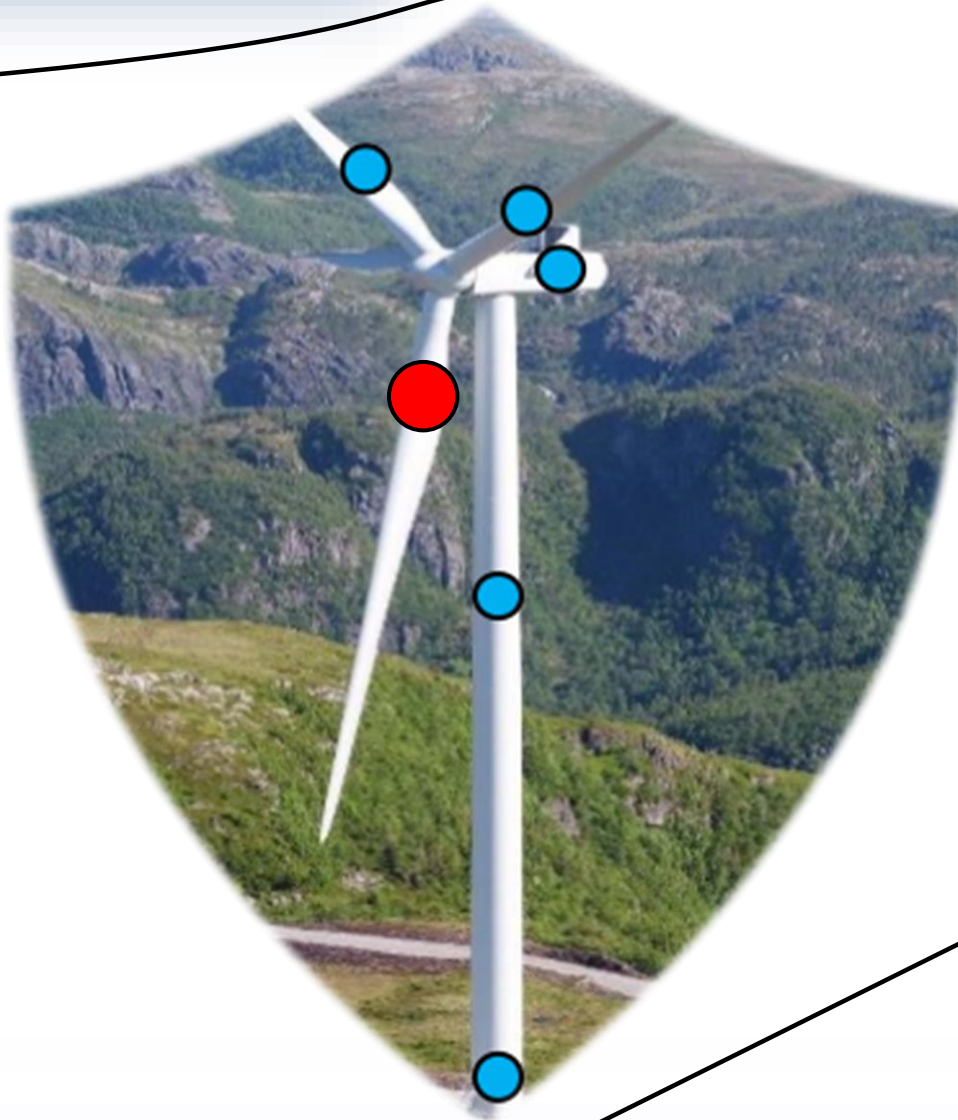
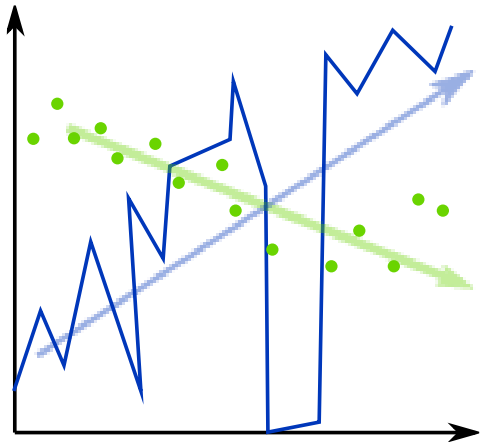


V2 Ventus sensor

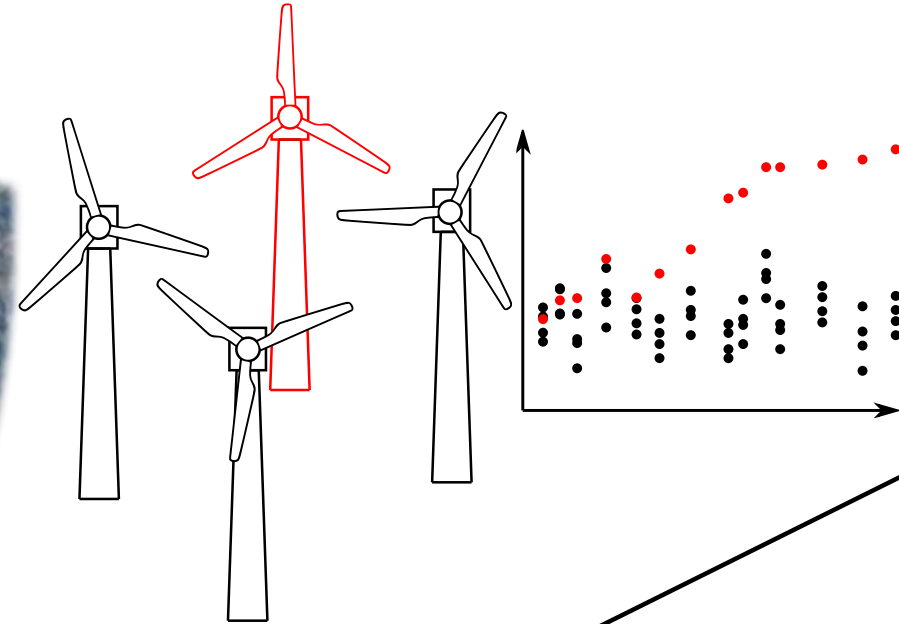
Conclusion

Critical component damage detection

Trend analysis



Cross fleet comparison



Predictive maintenance



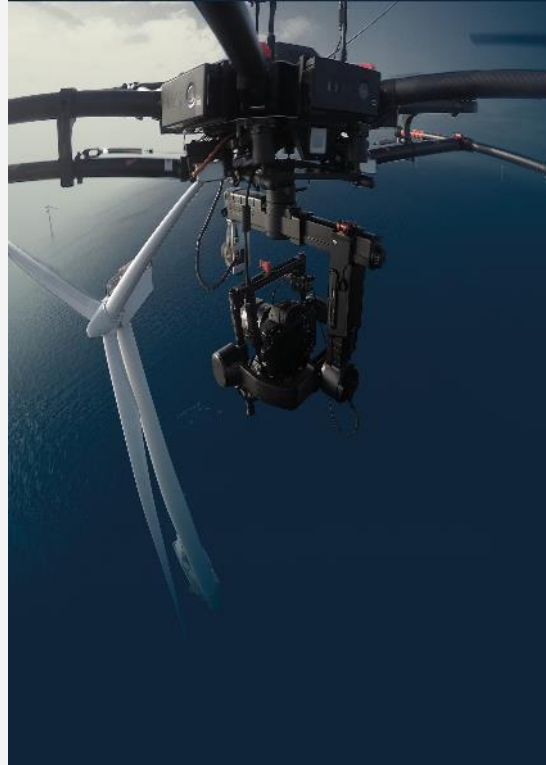
THANK YOU FOR YOUR ATTENTION!



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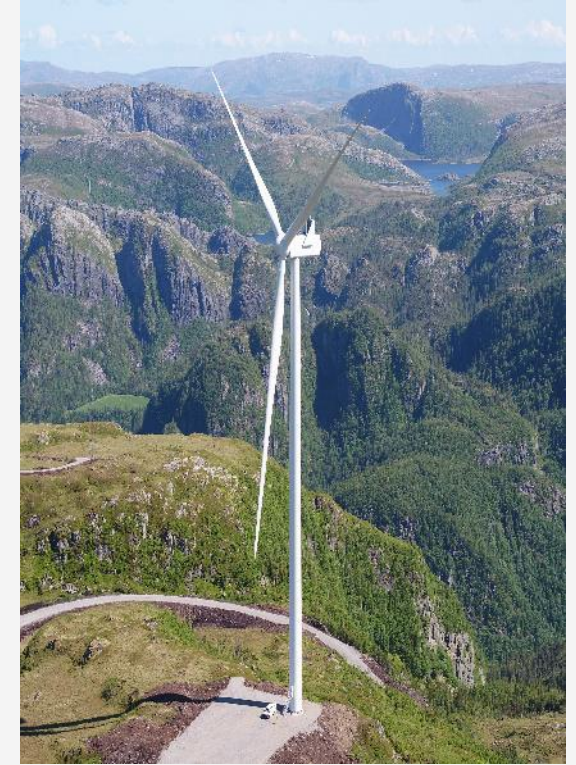
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