



Towards tracing a rotor surface's 3D trajectory over time

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History

02/2011 First Winterwind participation

12/2014 First system sold

09/2015 Development Start for new applications and new measurands

09/2018 First installation on railroad track switch

02/2020 > 350 icing detection systems in operation

Icing detection solution

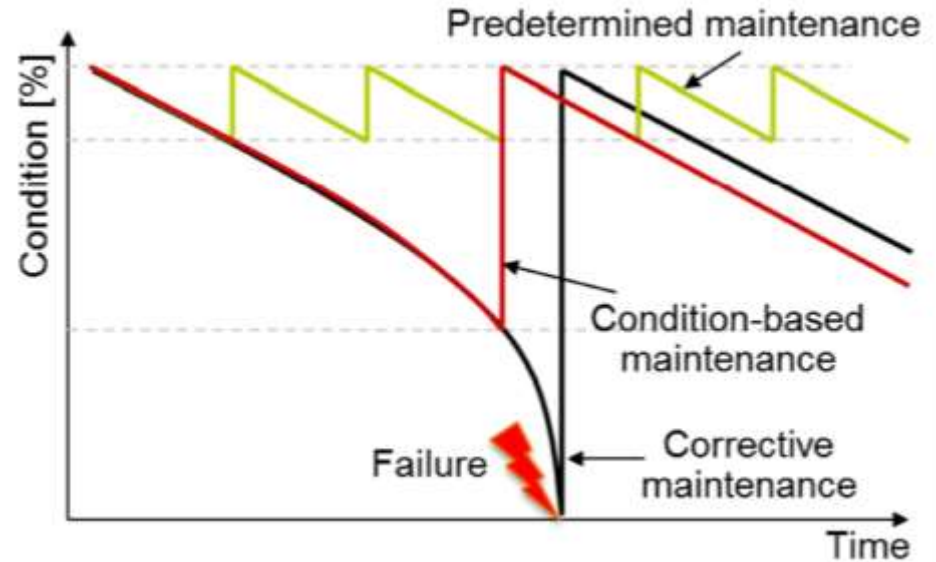
- Ice detection for rotor blades
- Flexible sensors
- Measurement at the blade surface
- Local ice thickness measurement
- Temperature measurement on each sensor position for heater control
- DNV-GL certified for automatic restart



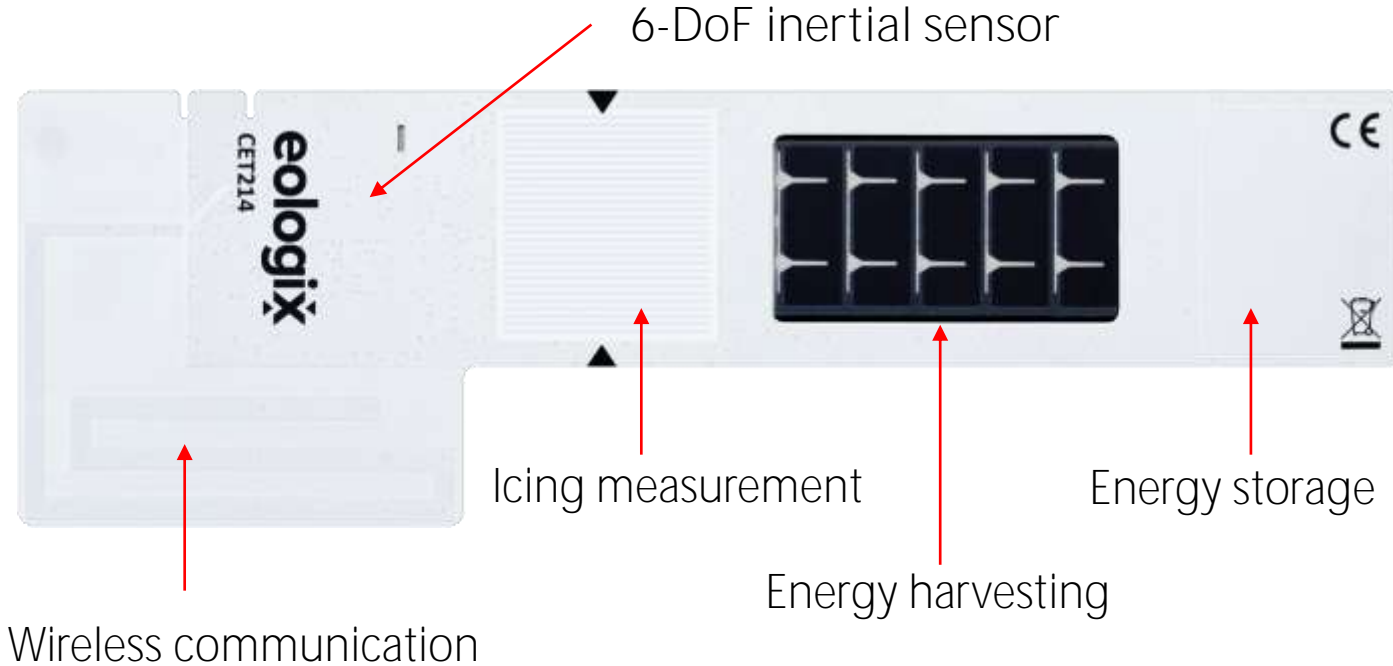
What's next?

New device with 6-DoF inertial measurement, enabling

- Condition monitoring
- Vibration measurement
- Bending / Load monitoring
- Pitch angle estimation



Technology



Mounting

- Self-adhesive device based on industry-standard erosion protection film
- Edge sealing
- New turbines: mounting during blade manufacturing or on turbine construction site
- Retrofit: mounting by rope access
- And also at the tip!



Why Condition Monitoring?

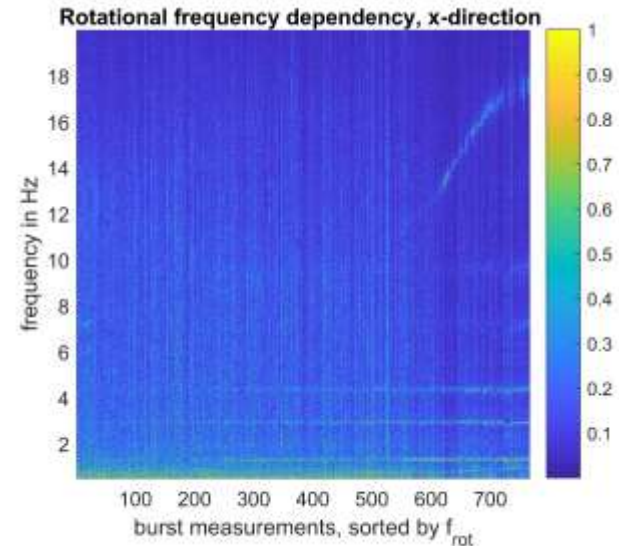


Increased production over a turbine lifetime by means of:

- Reduced down times (simpler, scheduled, shorter repairs)
- Minimized safety risks
- Increased life time (based on information collected by long-term monitoring)

Characterization of vibration

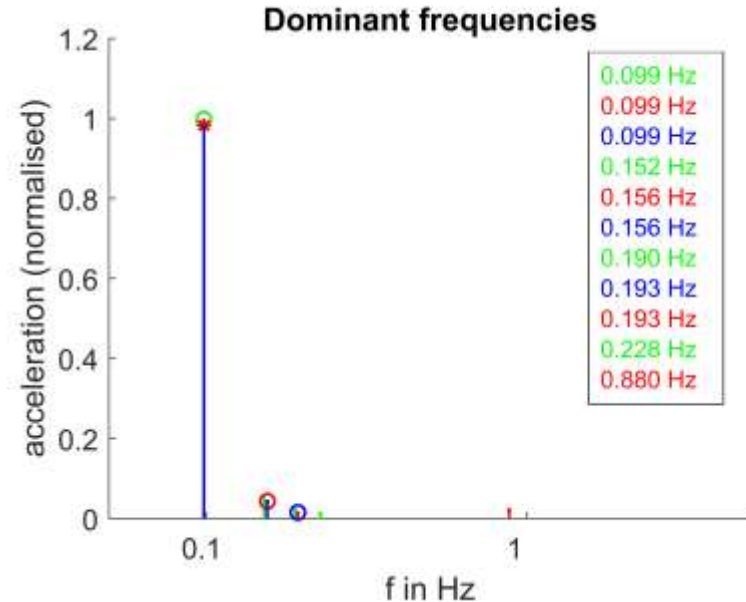
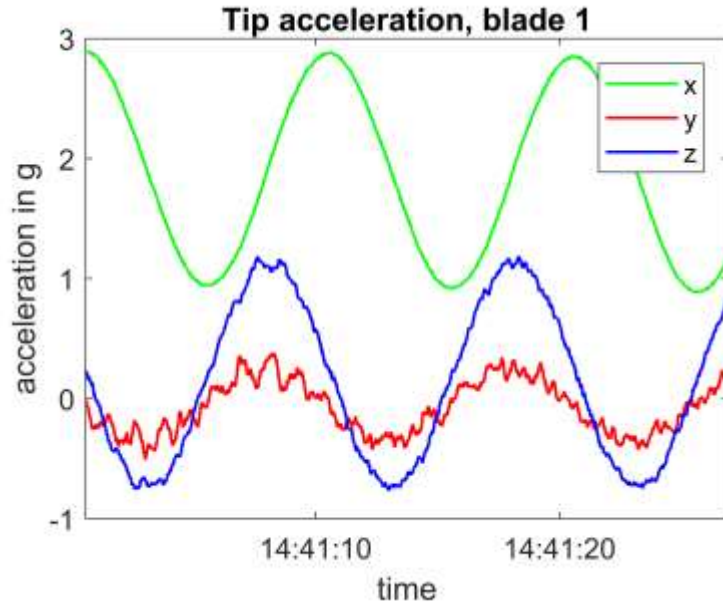
- Detection of increased vibration amplitudes (especially at the tip)
- Correlation with factors such as rotational frequency, temperature, ice load (based on a single sensor), without data from the turbine
- Even more information from all sensors on a turbine



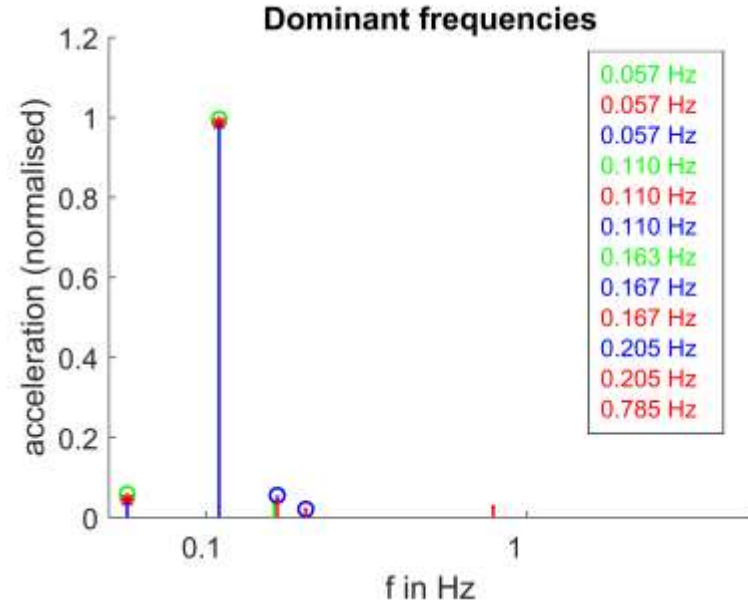
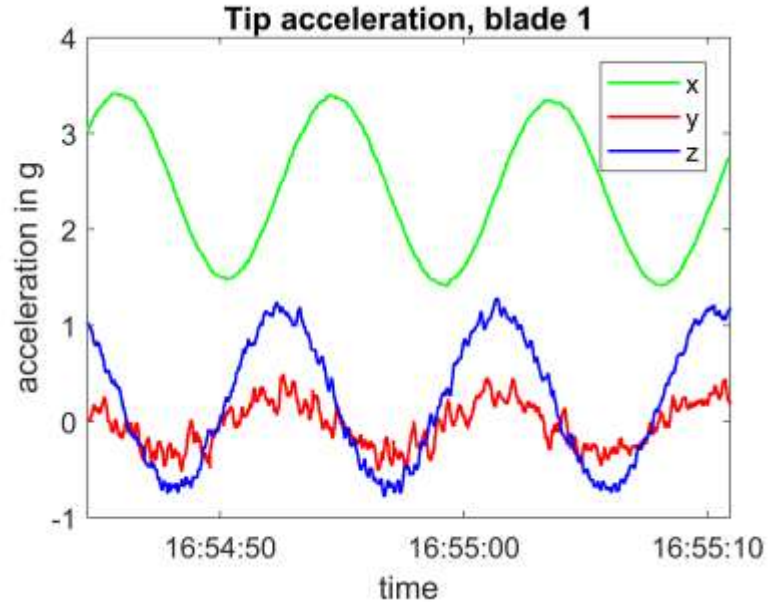
Vibrations (linear acceleration) [1]

[1] Theresa Loss, Michael Moser, Alexander Bergmann: Load and Vibration Monitoring of Wind Turbine Blade Tips Using 3D Accelerometers, presented at the Eurosensors conference in Graz, Austria, 09th-12th September 2018

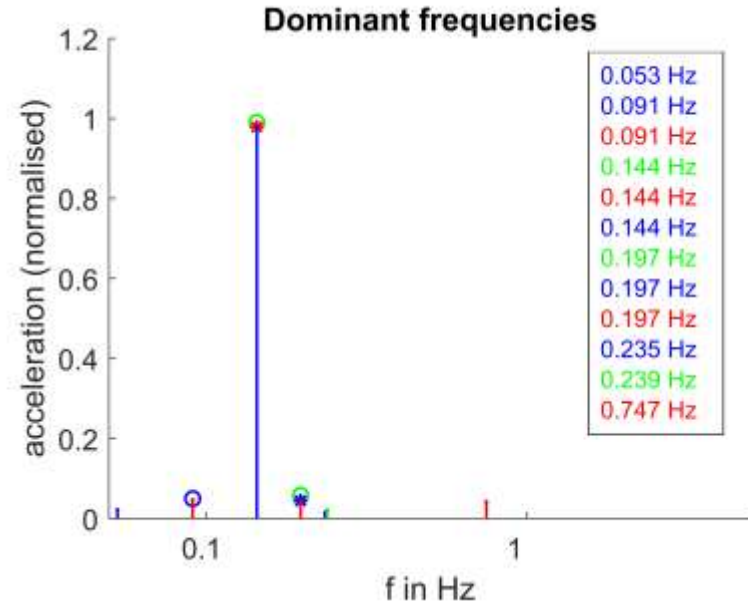
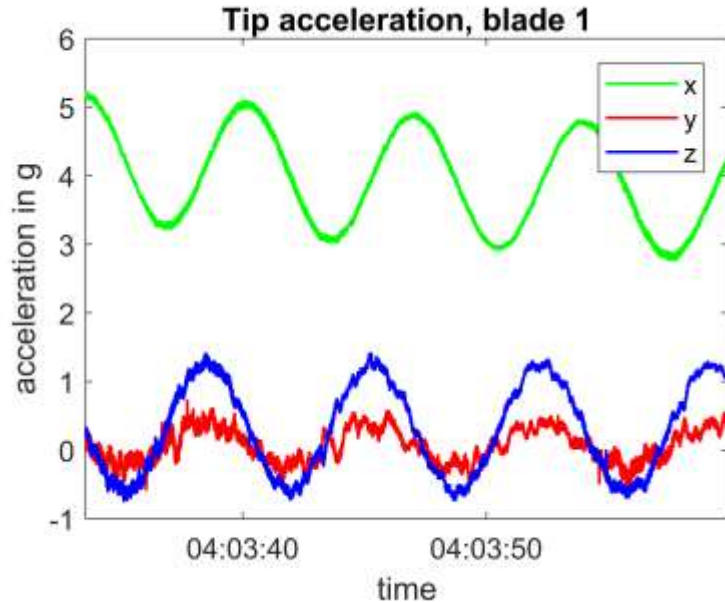
Blade tip example data (1)



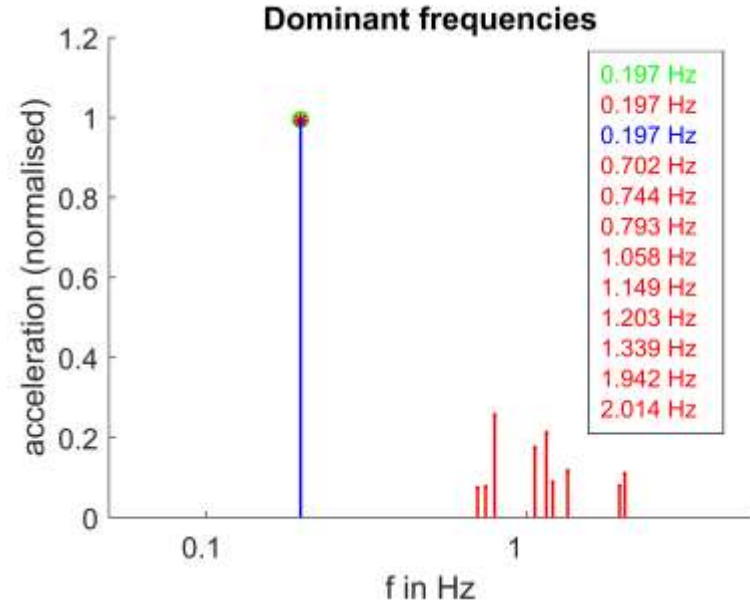
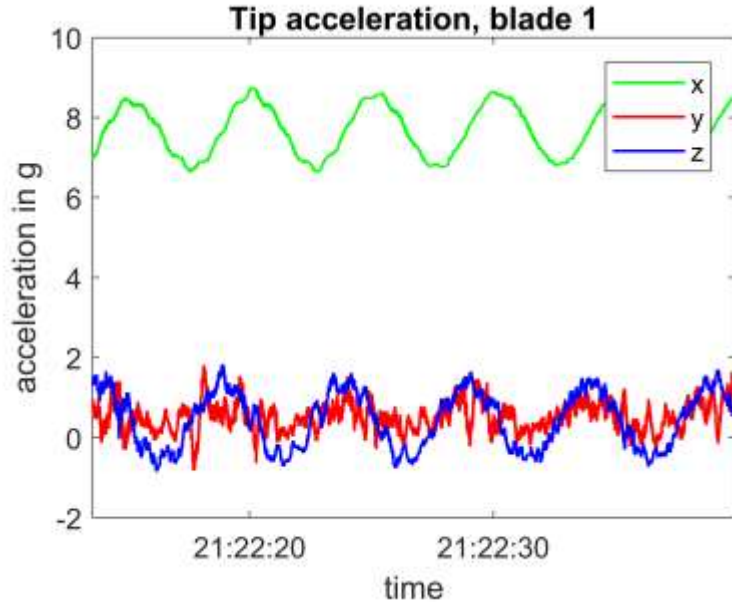
Blade tip example data (2)



Blade tip example data (3)

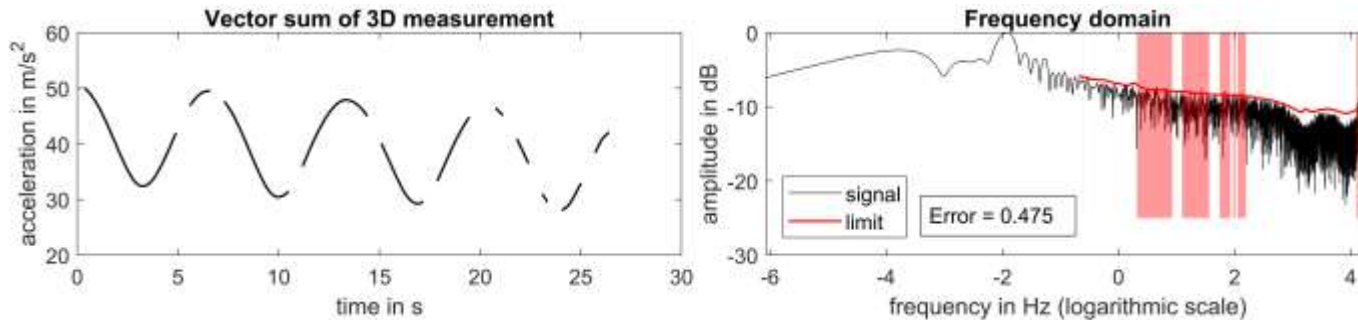


Blade tip example data (4)



Turbine condition monitoring

- Analysis of characteristics
- Detection of changes over time
- Correlation with turbine parameters

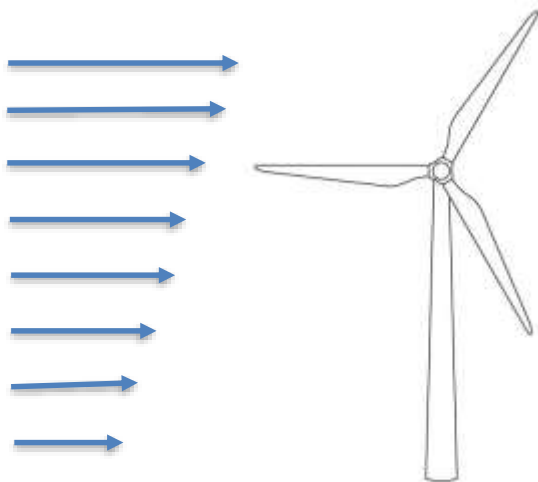


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Talking about (blade) loads

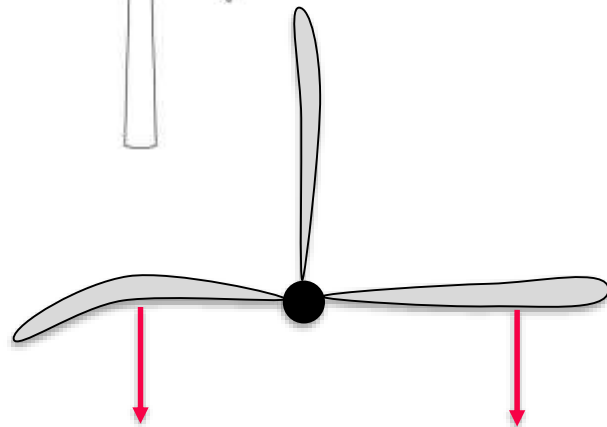
Increasing blade lengths:

- Higher typical loads
- Shear winds
- Gravity
- Risk of undetected damages

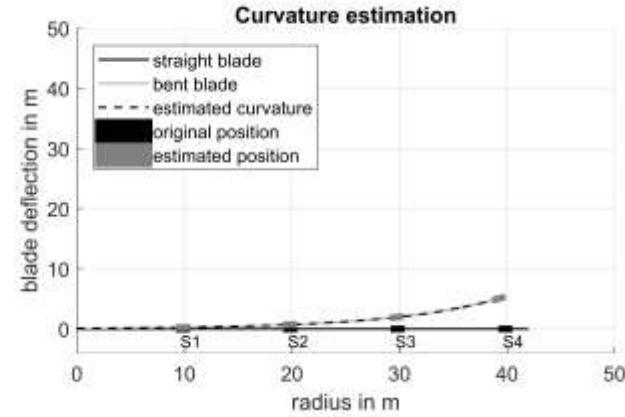
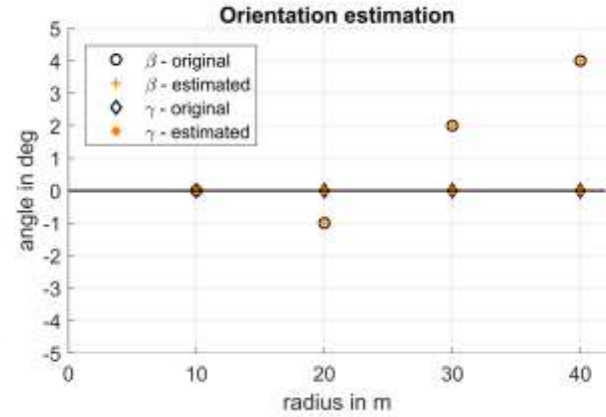
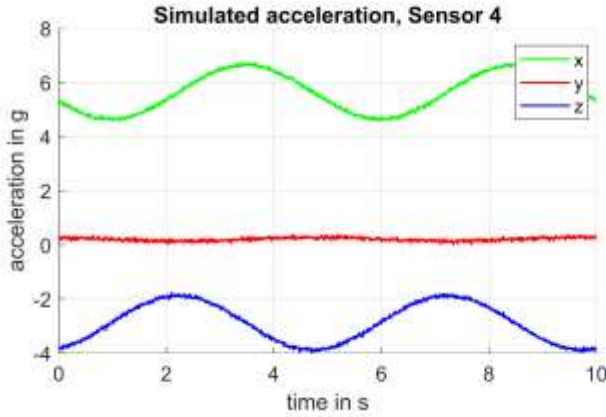


Tower effects

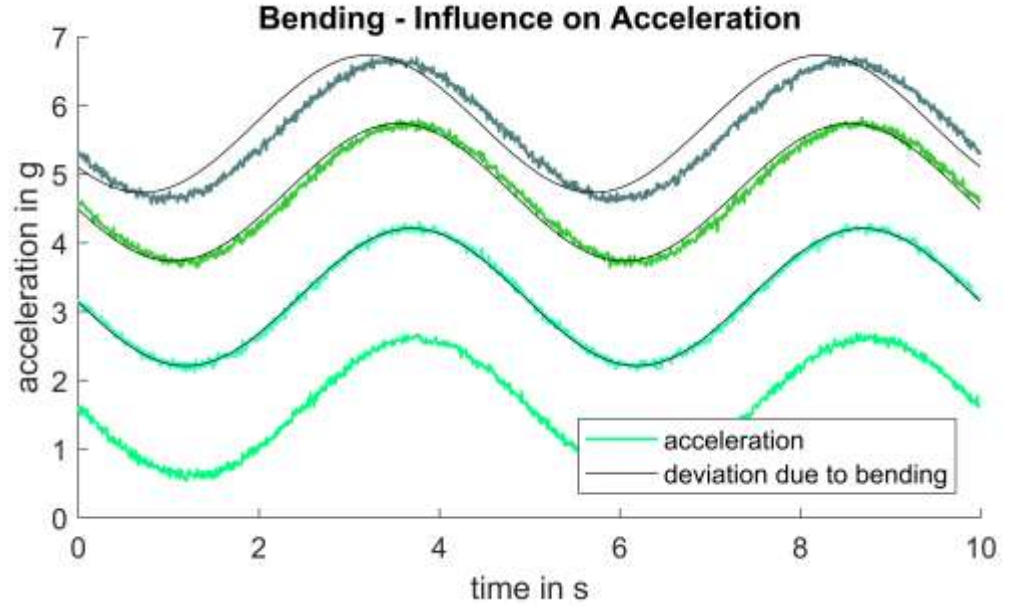
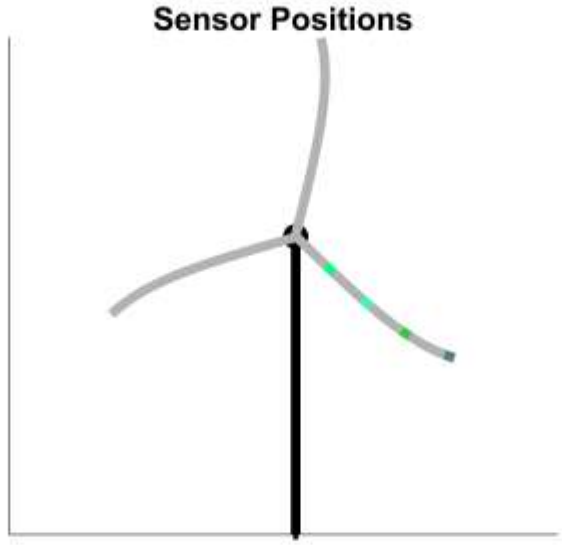
Yaw misalignment



Blade bending & Load measurement

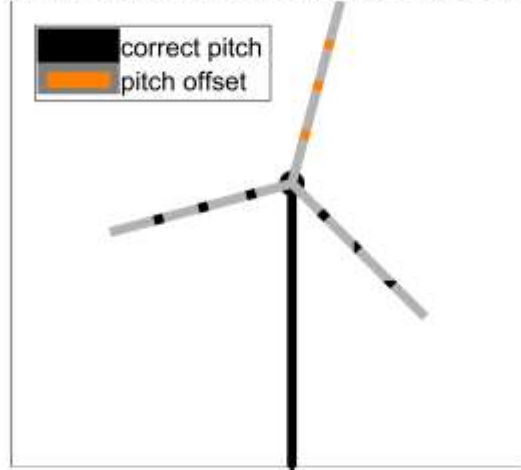


Blade bending & Load measurement

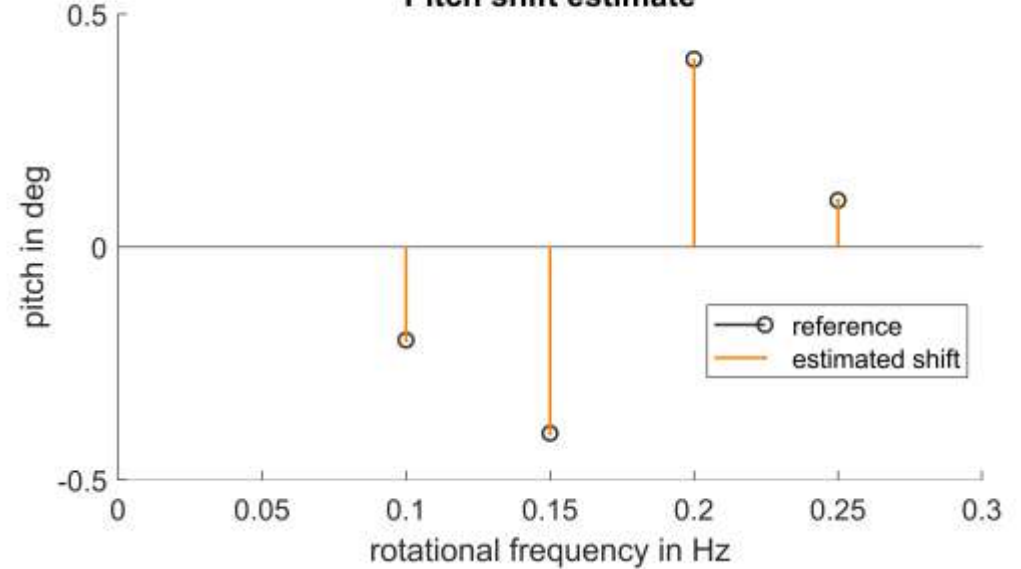


Continuous pitch angle measurement

Pitch estimation with root sensors



Pitch shift estimate



Conclusion & Outlook

- Vibration monitoring and characterization can be achieved by wireless sensors
- Blade status information is collected over time to determine load and fatigue status information over time
- Blade damage detection allows for early repairs, reduced downtime and costs
- Critical operational modes are recognized and allow for optimization
- Continuous pitch angle measurement allows for early detection of deviations

Thank you for your attention!

