Condition Monitoring von Windenergieanlagen

Brauchen wir heute noch Schwingungsmessungen?

Dr. Lisa Ziegler
Spreewindtage
06.11.2019

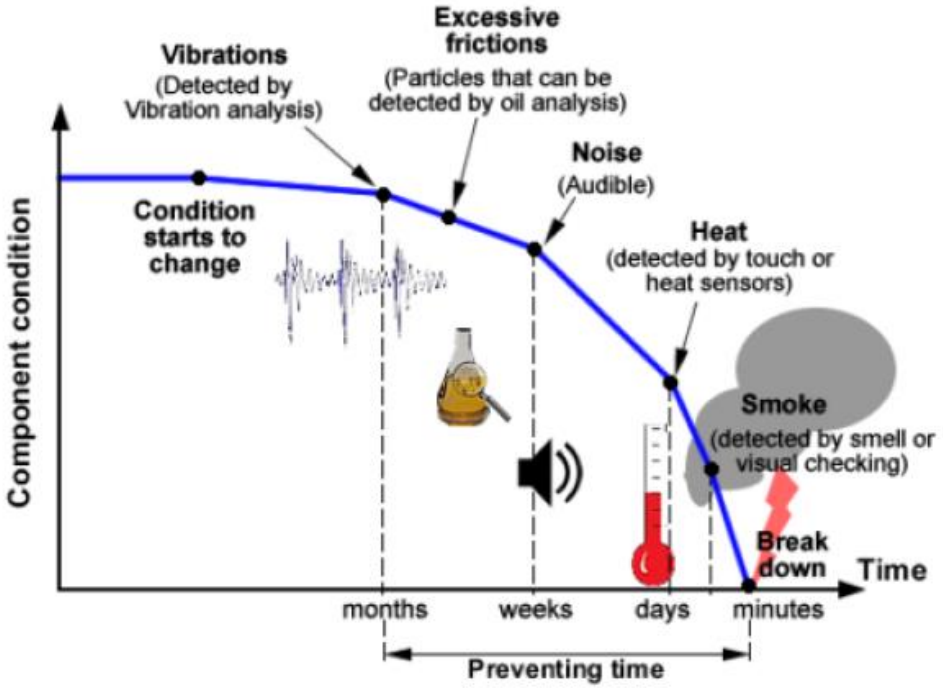
EnBW

Agenda

1. **Introduction to condition monitoring**
2. **Vibration versus SCADA data**
3. **Example 1: Bearing damage**
4. **Example 2: Generator short circuit**
5. **Damage database**
6. **Conclusion**

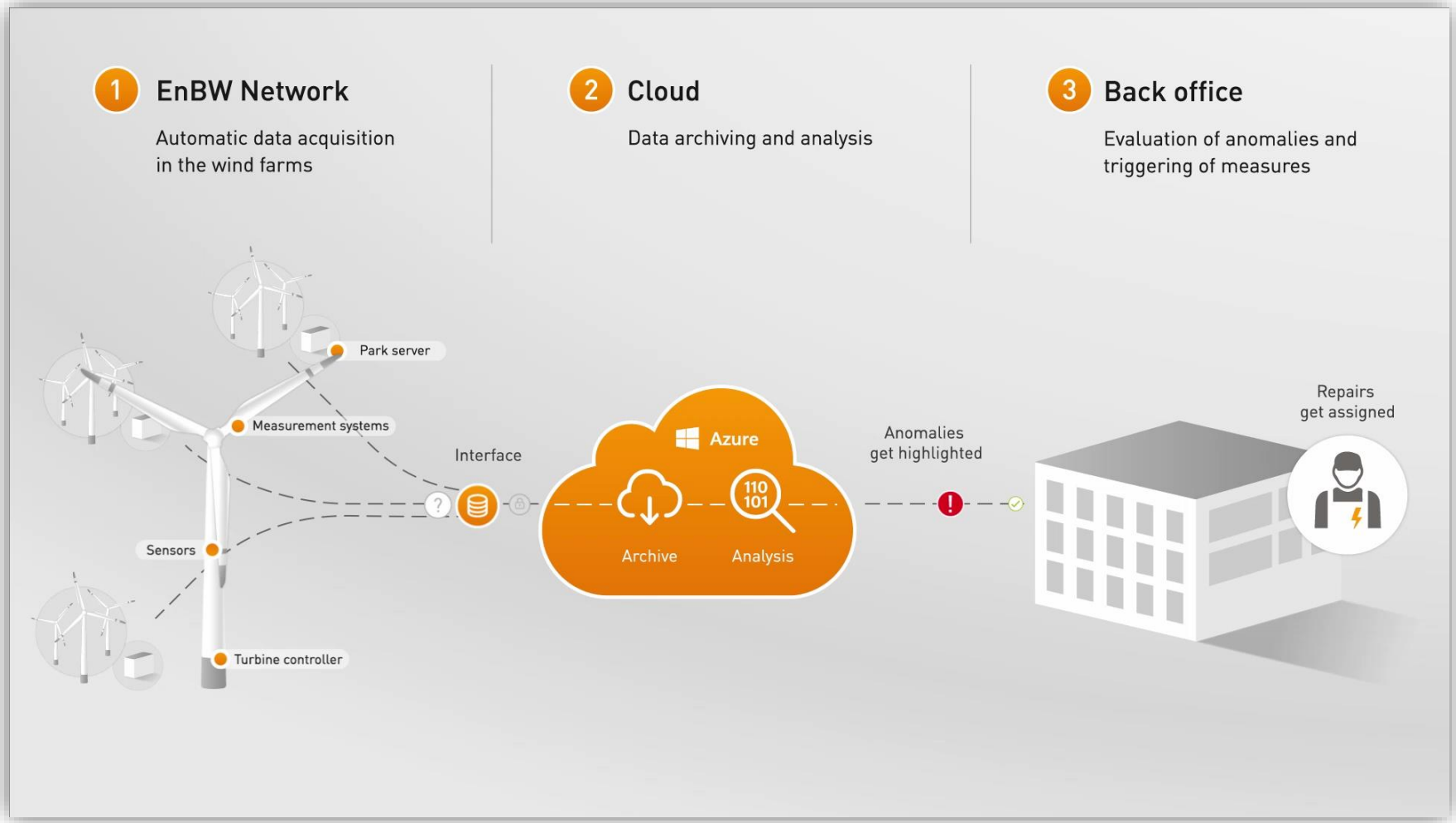
Introduction to Condition Monitoring

- Rotating machinery
- Goal: condition-based maintenance
- Online or offline
- Example of methods
  - Vibration analysis
  - SCADA data analysis
  - Oil analysis
  - ...
- SCADA = Supervisory Control and Data Acquisition system



Source: Tchakoua, P., Wamkeue, R., Ouhrouche, M., Slaoui-Hasnaoui, F., Tameghe, T., & Ekemb, G. (2014). Wind turbine condition monitoring: State-of-the-art review, new trends, and future challenges. Energies, 7(4), 2595-2630.

Condition Monitoring @ EnBW



Data services

- Import from park servers
- Data consolidation
- Storage and backup
- Data access

Analysis services

- SCADA Data analysis
- Vibration analysis
- Analyses on demand

Support services

- Root cause analysis
- Fleet optimization

Condition Monitoring @ EnBW

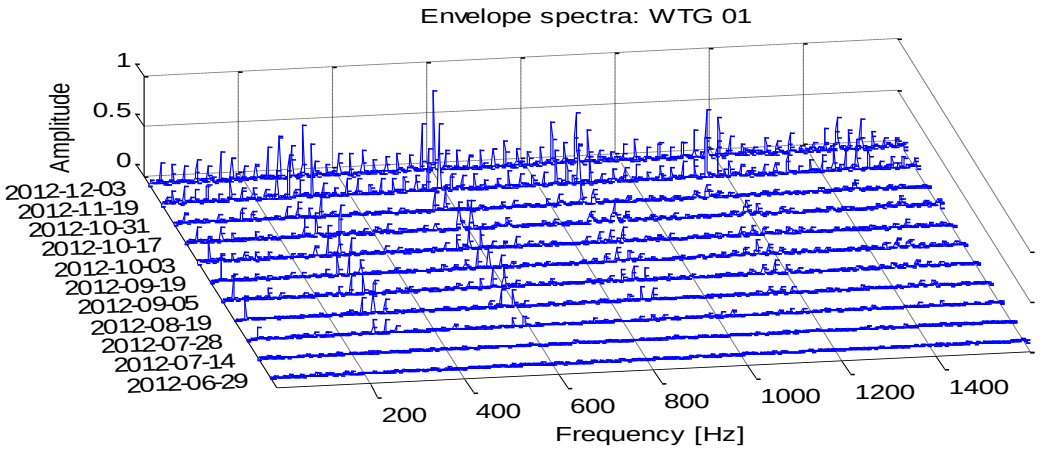
- > 600 MW / 210 WEC monitored
- Inhouse software RADAR

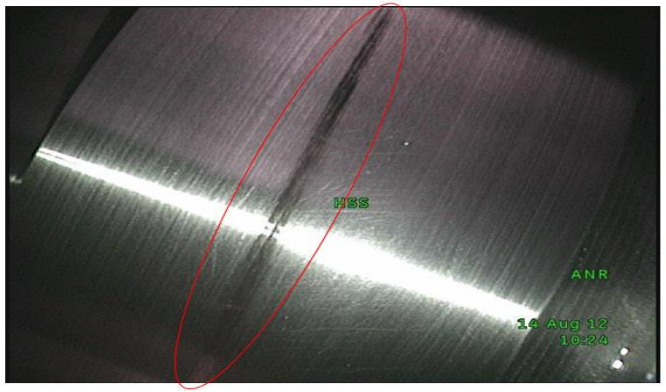
Expertise

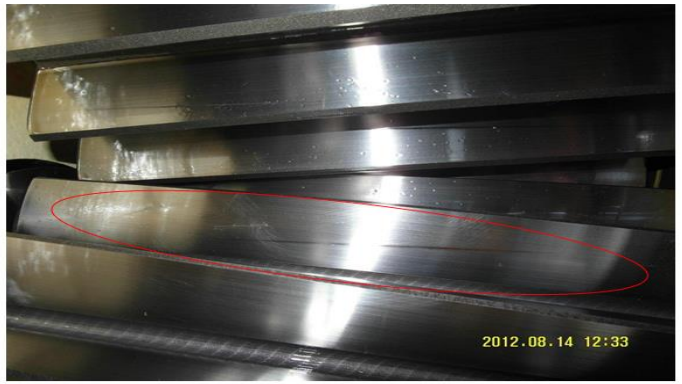
- Vibrations & SCADA
- Structural health monitoring
- Oil monitoring
- Material and root cause analysis

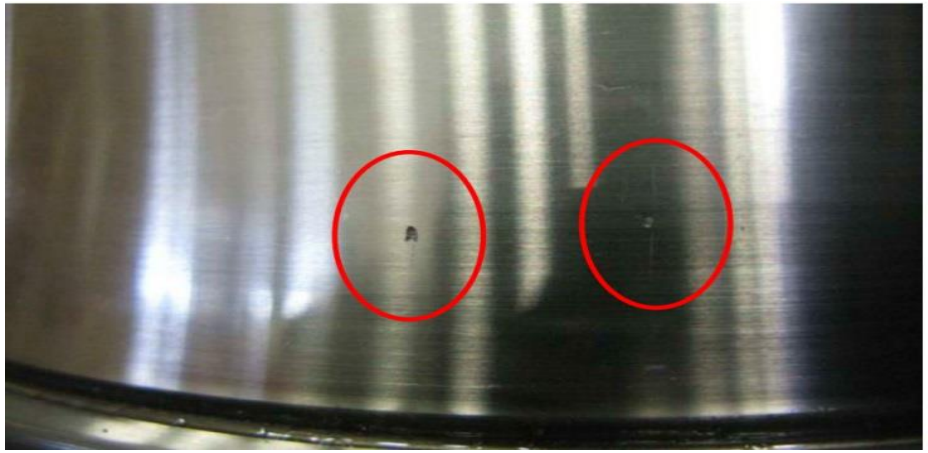
Methods for Condition Monitoring
SCADA | Vibration

- Discontinuous, high resolution acceleration measurements
- Order analysis to compensate for variable speed
- Analysis of the envelope spectra (Bearing damage)
- Time synchronous averaging process (Gearing damage)
- Kepstrum (Gearing damage)

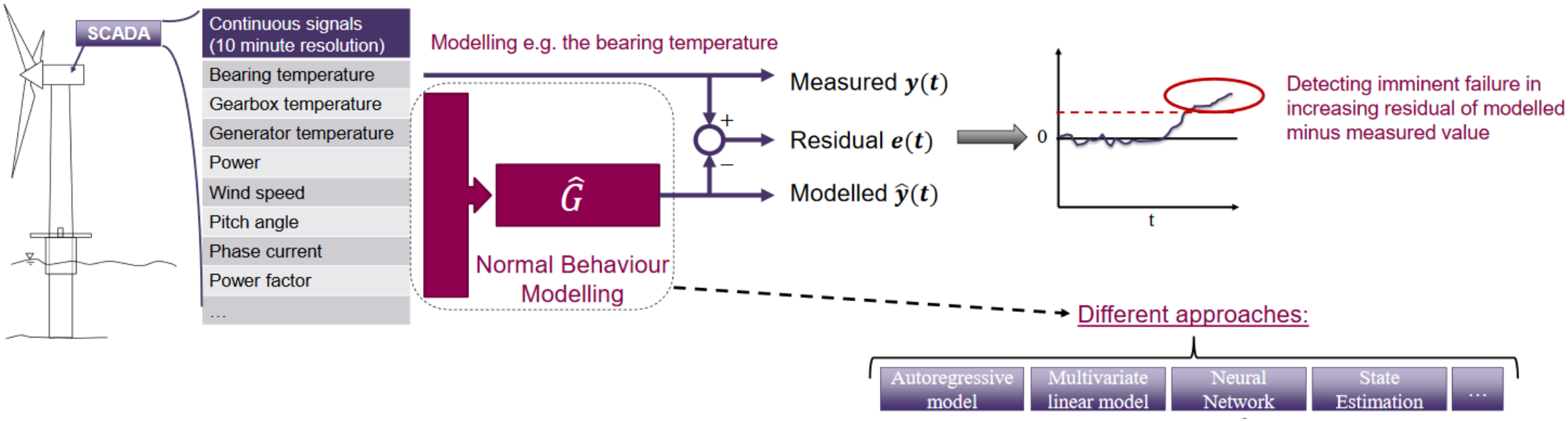








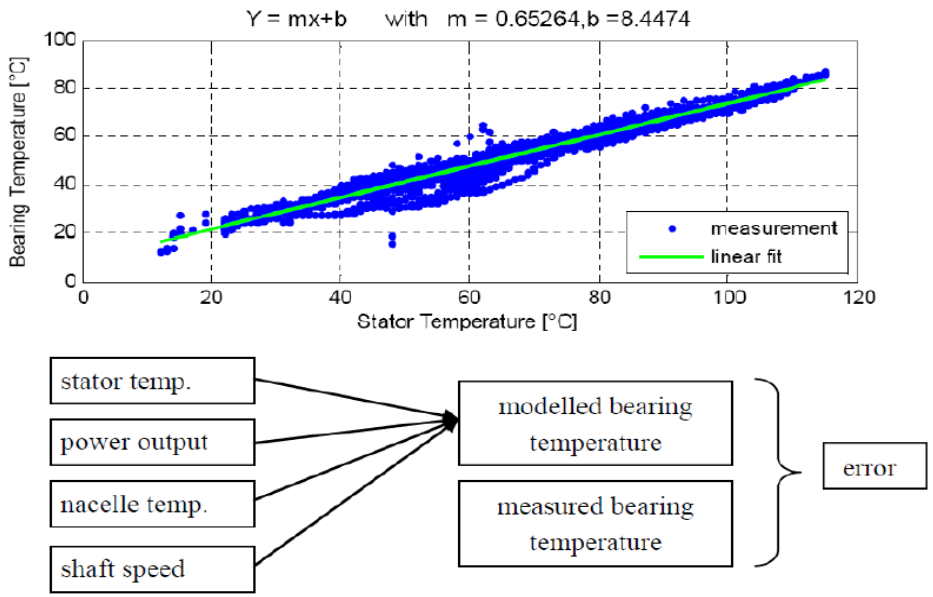
Methods for Condition Monitoring
SCADA | Vibration

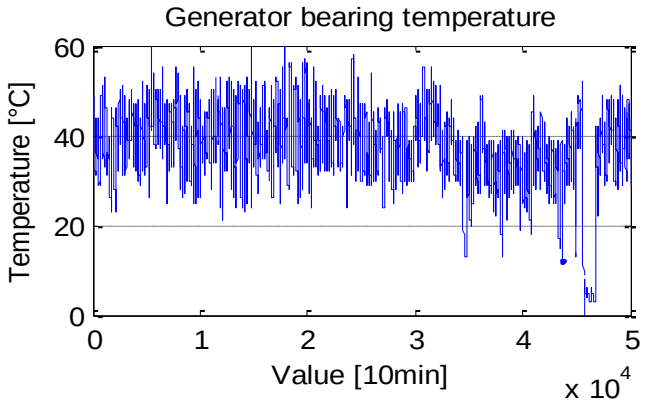


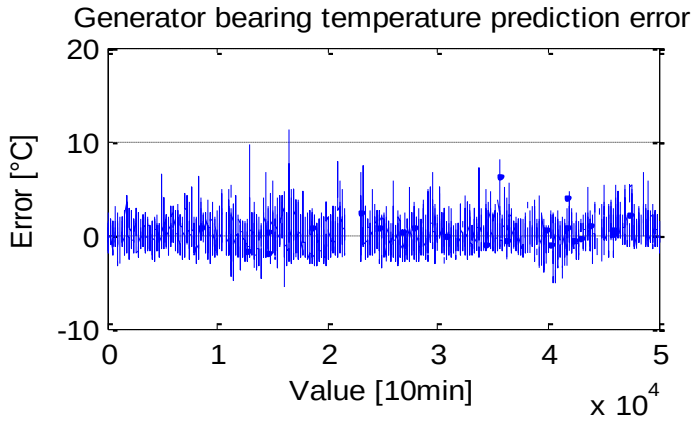
Source: Weinert, J and Watson, SJ (2015) Wind Turbine Fault Detection by Normal Behaviour Modelling, Midlands Energy Consortium Postgraduate Student Conference. Full text: https://dspace.lboro.ac.uk/2134/22532

Methods for Condition Monitoring
SCADA | Vibration

- Machine learning
- Input chosen based on physics and cross-correlation
- Representative set of training data

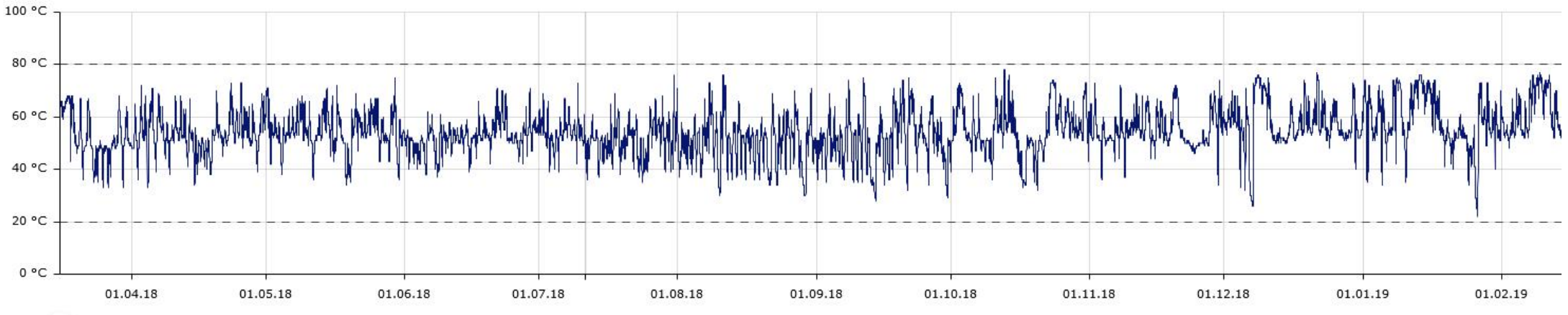






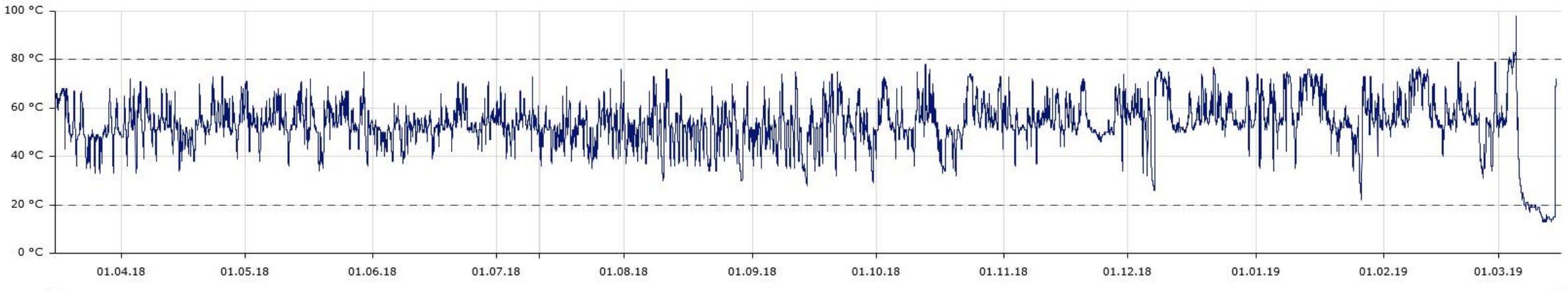
Example 1: bearing damage

- Temperature of a bearing in the generator
- 10-minute average values

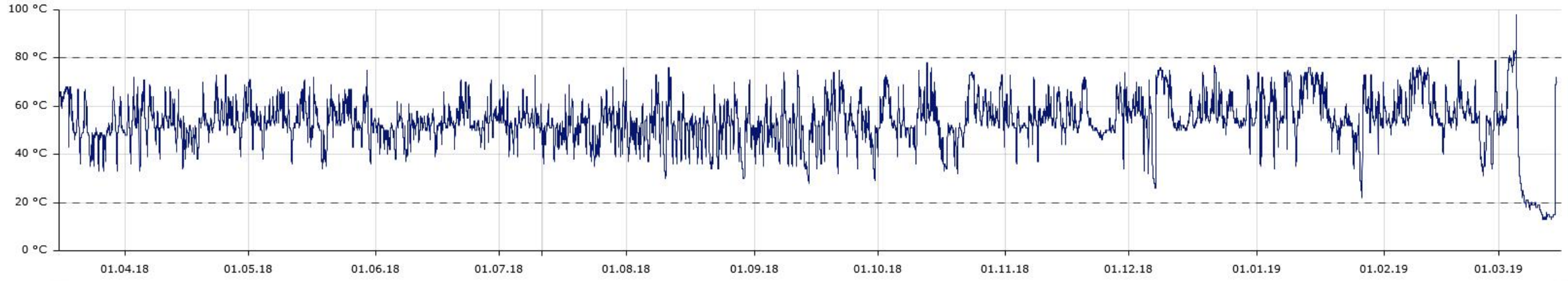


Example 1: bearing damage

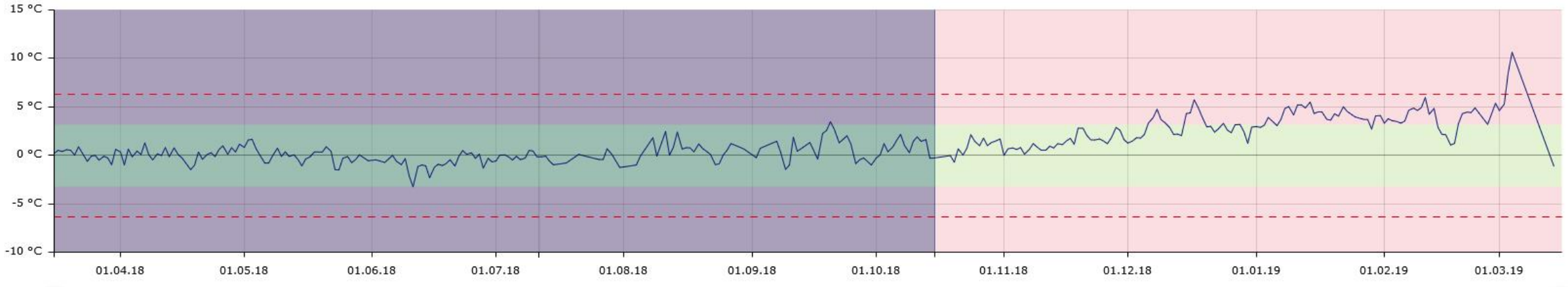
- Temperature of a bearing in the generator
- 10-minute average values



Example 1: bearing damage

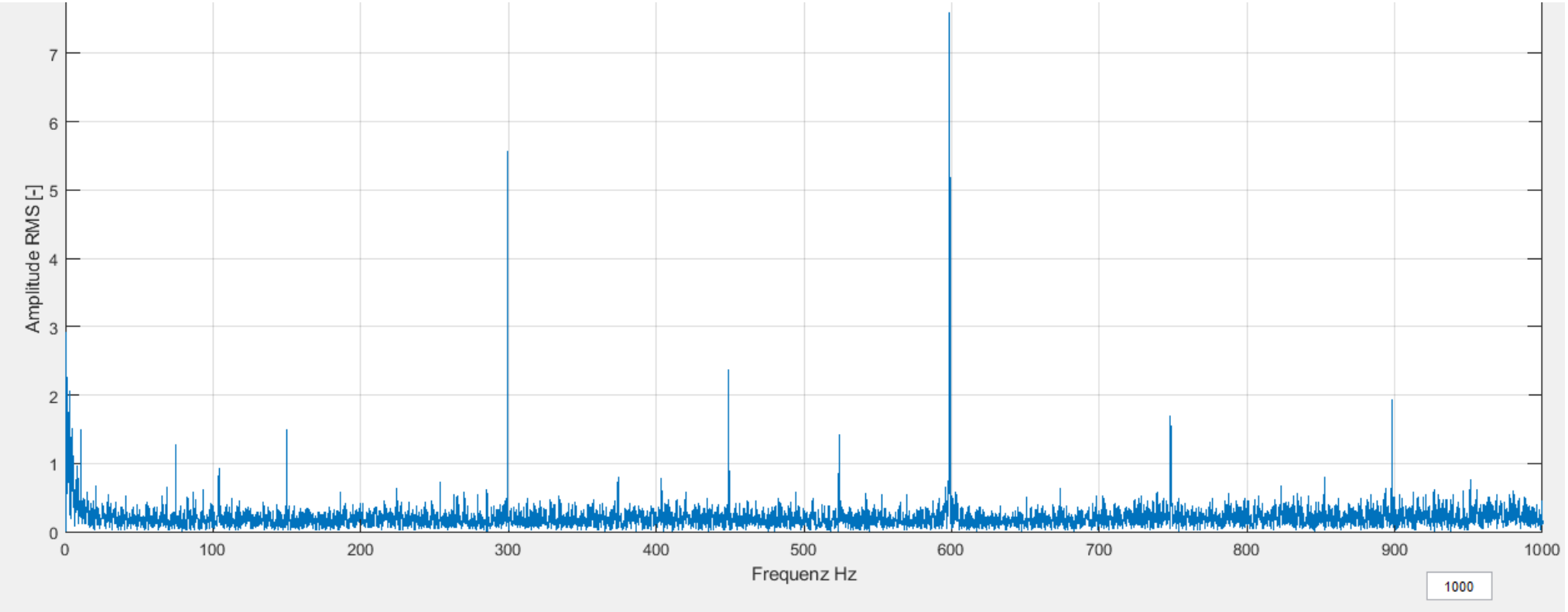


Derivation of measurement data from normal behavior model (daily average):



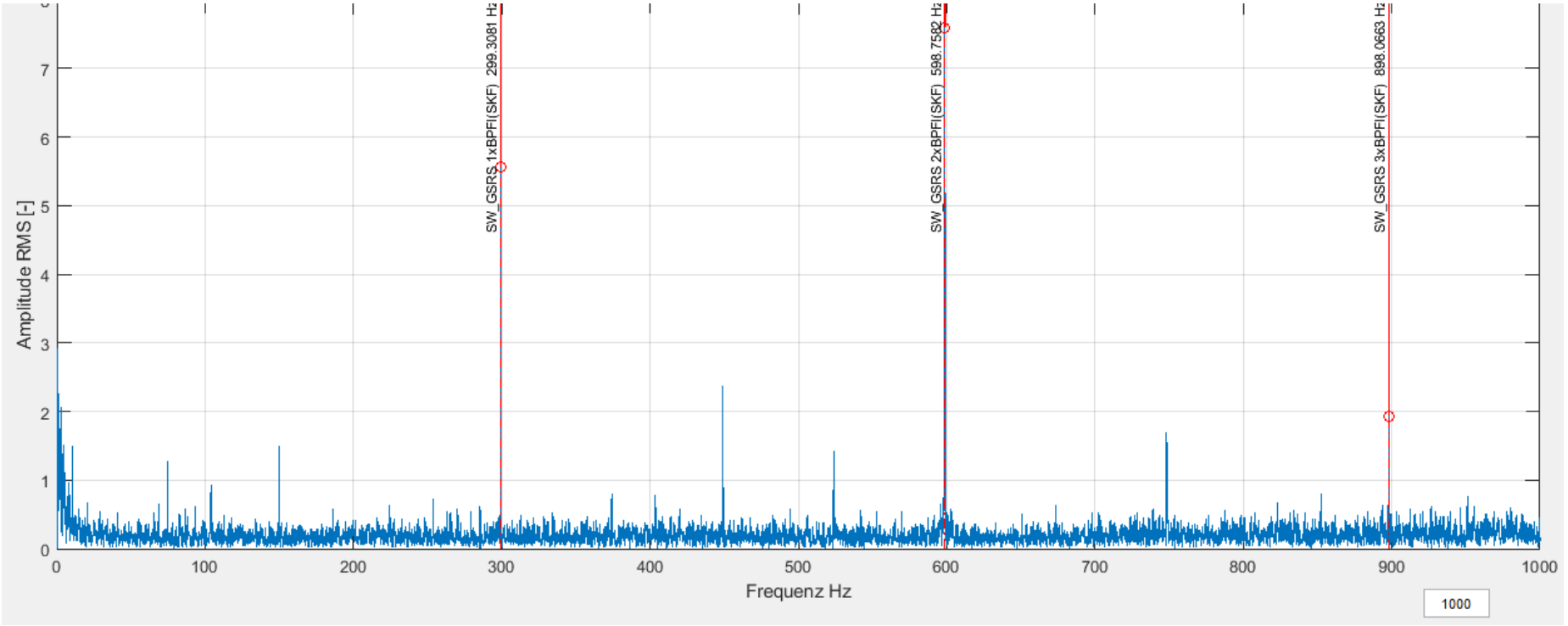
Example 1: bearing damage

- Discontinuous acceleration measurements (50kHz, 10s, rpm constraints)
- Envelope spectra of acceleration measurements



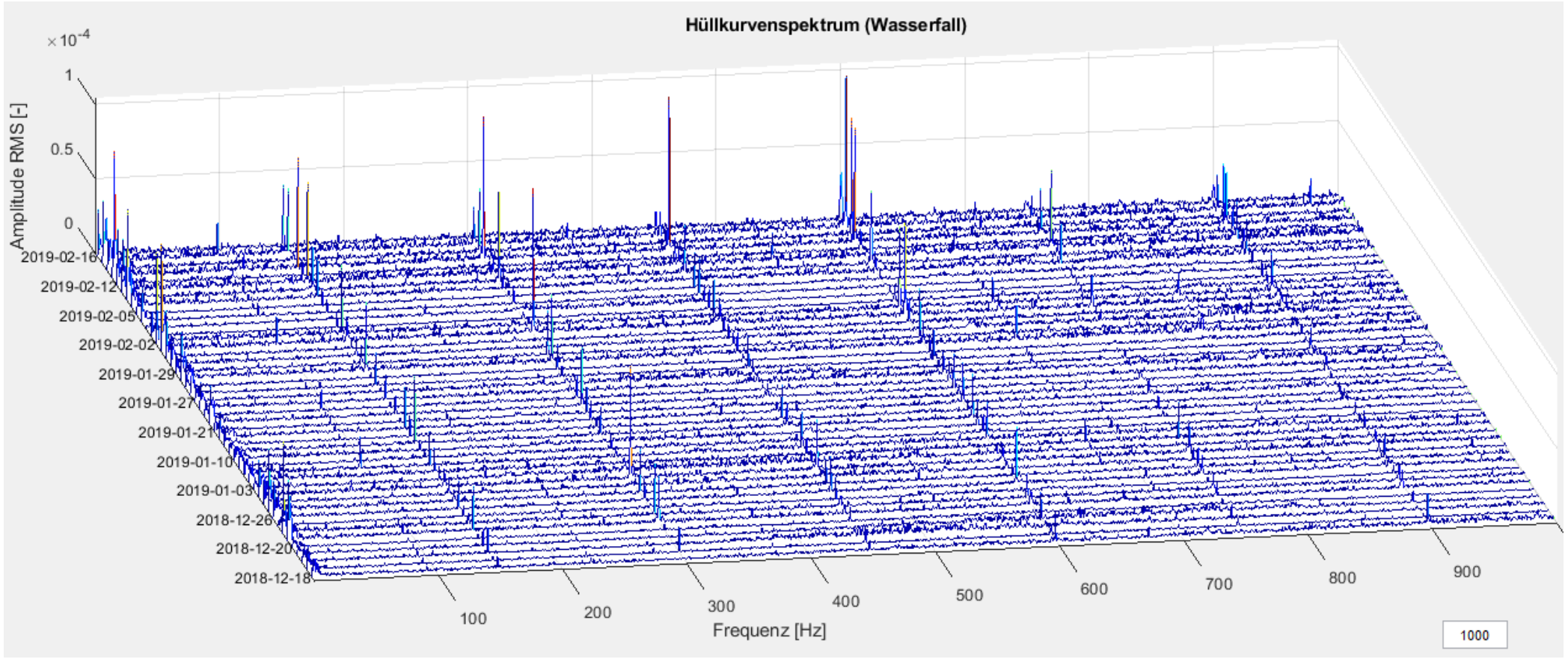
Example 1: bearing damage

- Identification with kinematic data
- Characteristic frequencies, harmonics, sidebands

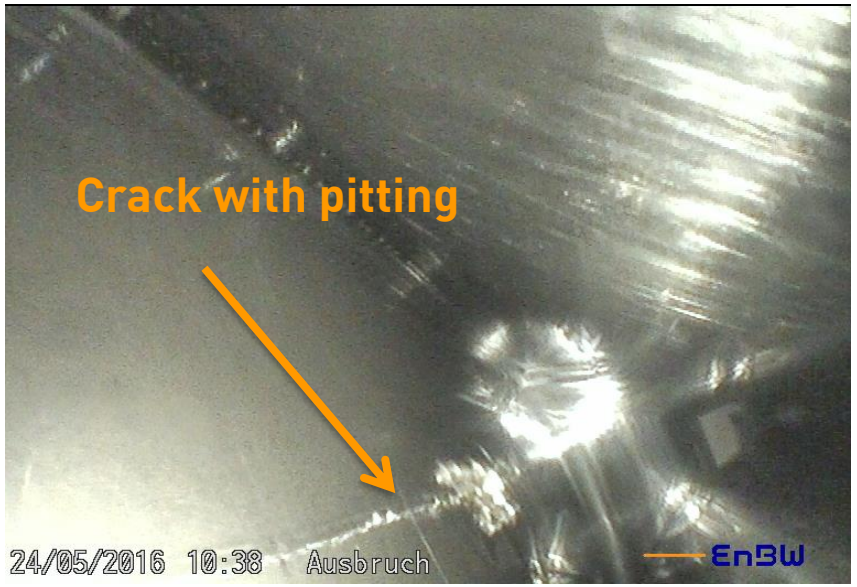


Example 1: bearing damage

- Spectrogram / waterfall diagram

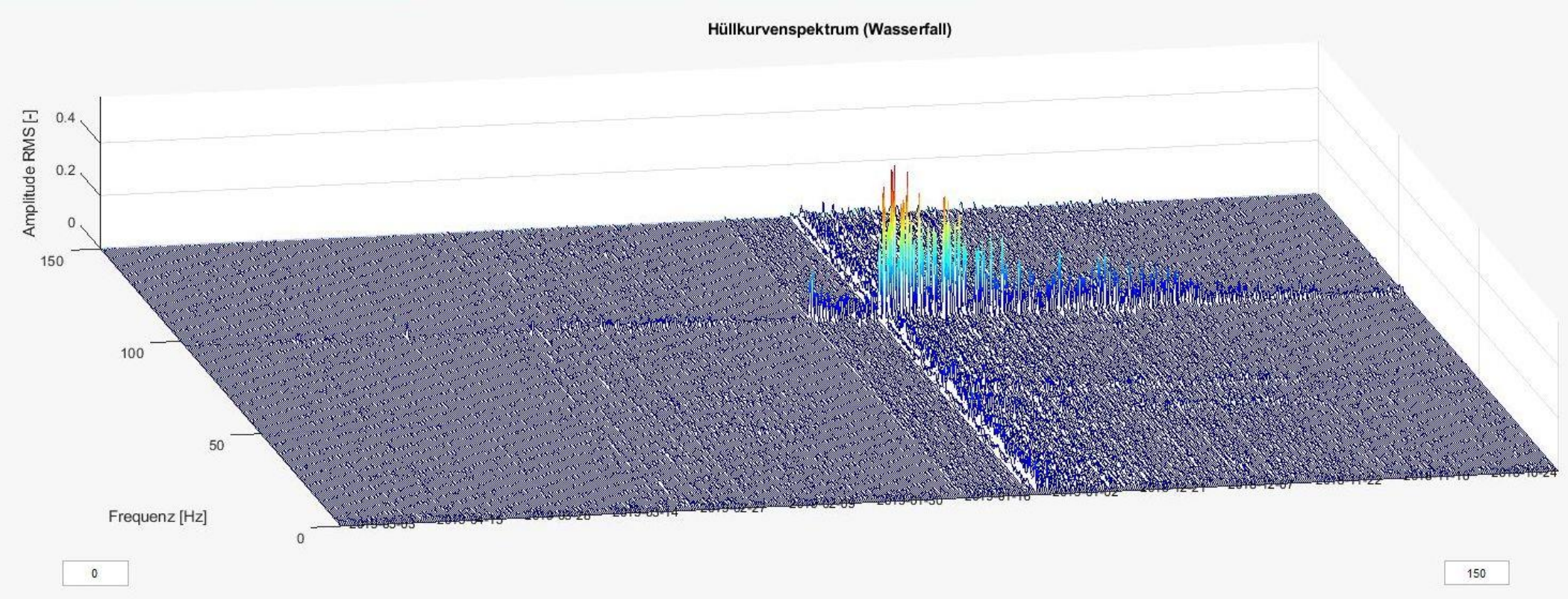


Later: Endoscopy confirming CMS diagnosis

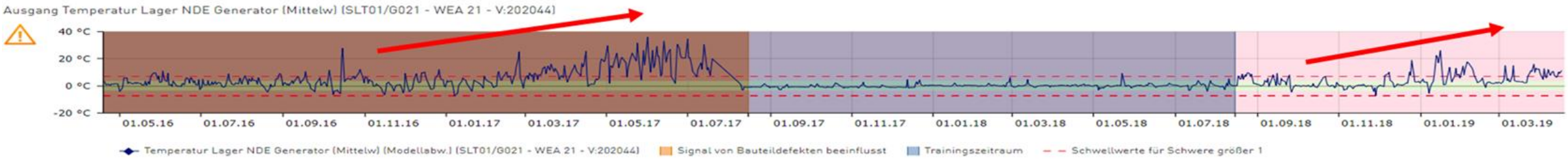


Example 2: Generator short circuit

- Loss of slot wedge in generator
- Visible 4 months before short circuit



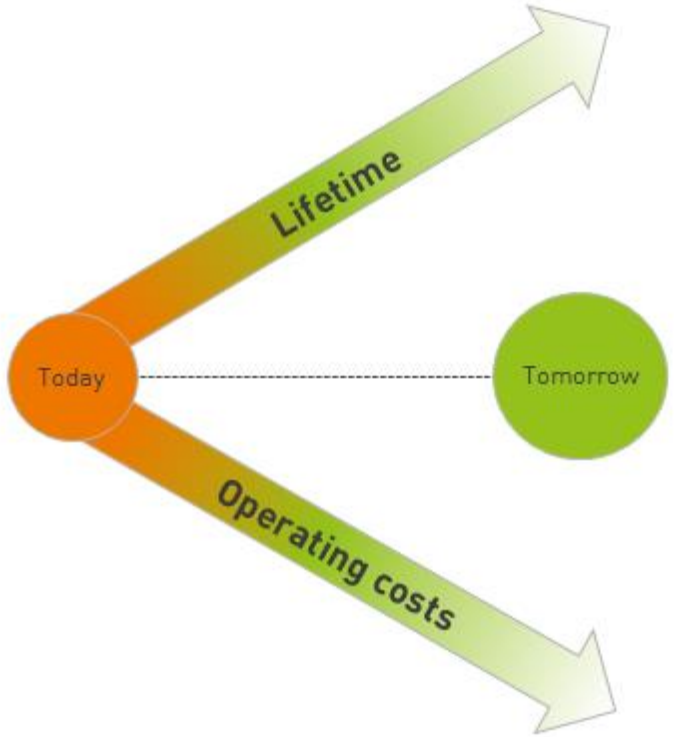
Damage database



- Optimization of operation and maintenance
- Improvement of monitoring characteristics
- Machine learning
- Automatization of diagnosis

Summary

- Condition monitoring is crucial to reduce operational costs and extend the lifetime of our assets
- Successful forecast of bearing damages with SCADA data is possible
- Vibration analysis necessary for in-depth analysis
- Importance of damage database required to fully utilize benefits of machine learning



Contact

Dr. Lisa Ziegler
Fischertwiete 1
20095 Hamburg
l.ziegler@enbw.com
+49 40 533 268-353