

Measurements at Alpha Ventus

April 2nd 2025

Sixth International RAVE Workshop

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02 April 2025

1. FINO 1 + Alpha Ventus

2. Measurements at AV04 and AV05

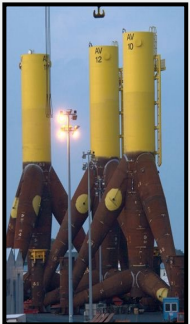
1. Continuous measurements
2. Research Archiv
 - a) Installation Documentation
 - b) Data quality control
 - c) Data-Consulting
3. Oceanographic Measurements

3. Outlook / Potential of lifetime database

2003 - FINO 1



2009 / 2010 - Alpha Ventus

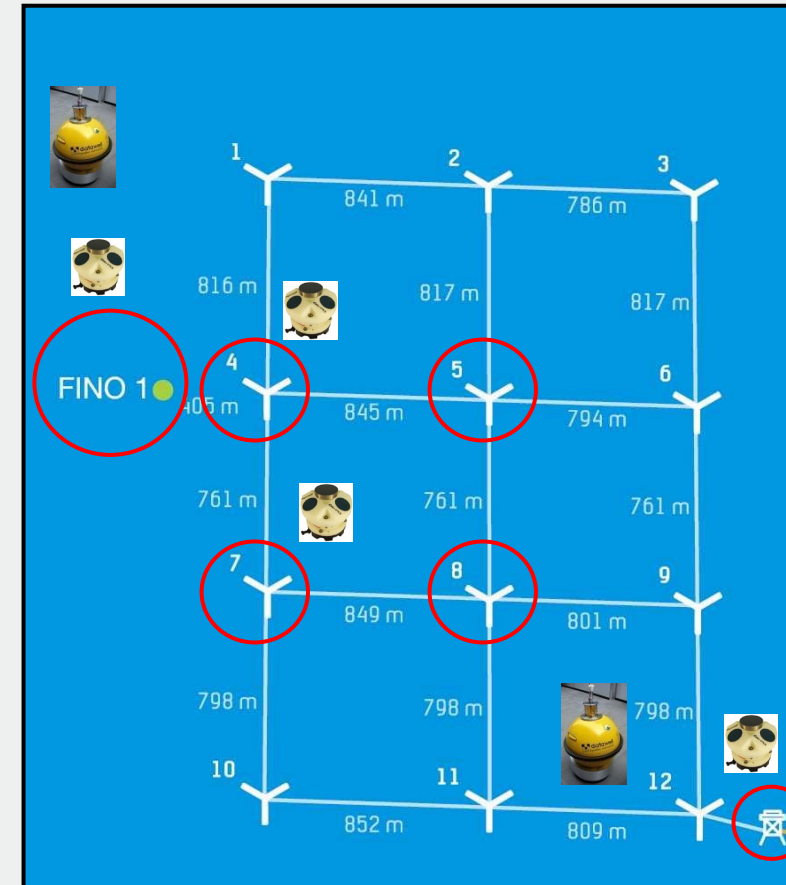


2010

Alpha Ventus

Measurements completed

- Oceanographic Measures
 - See State, Current, water level,
 - Temperature, Salinity, Oxygen
- Struktural dynamics
 - Strain, Acceleration
- Meteorology
 - temperature, air pressure, humidity
- Operational data
 - power performance, pitch angle, wind speed, generator-rpm, azimuth-angle



2010

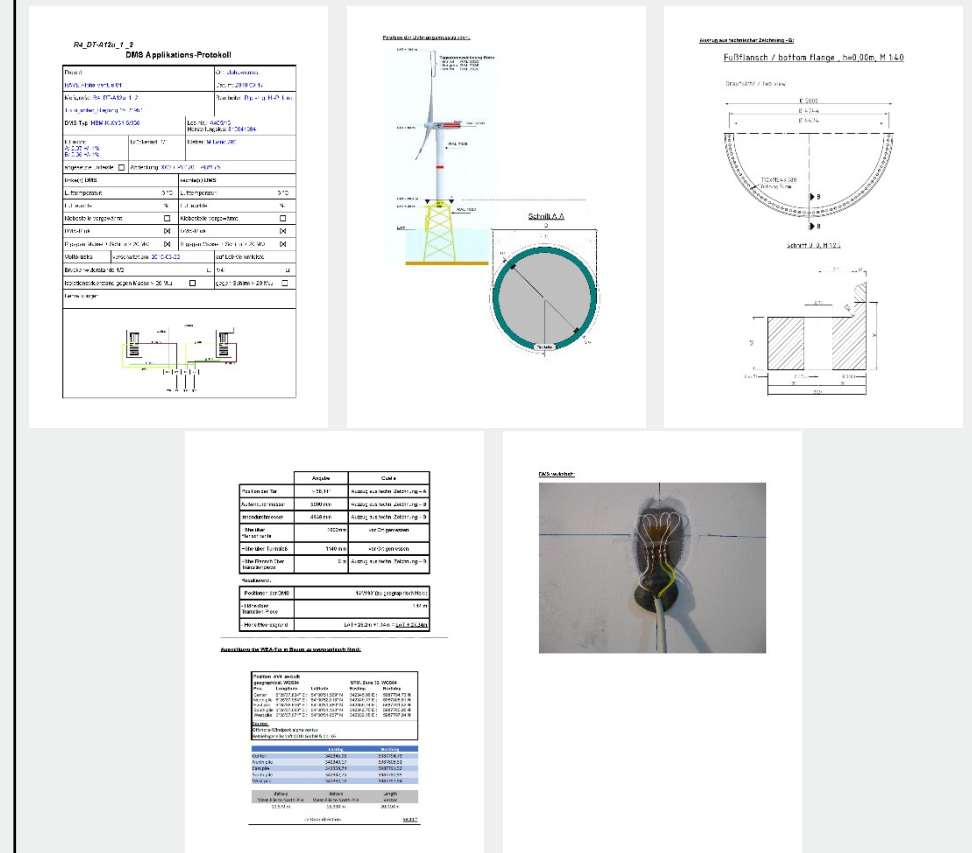
Alpha Ventus

Measurements at AV04 / AV05



**database
research archive**

1. Installations documentation



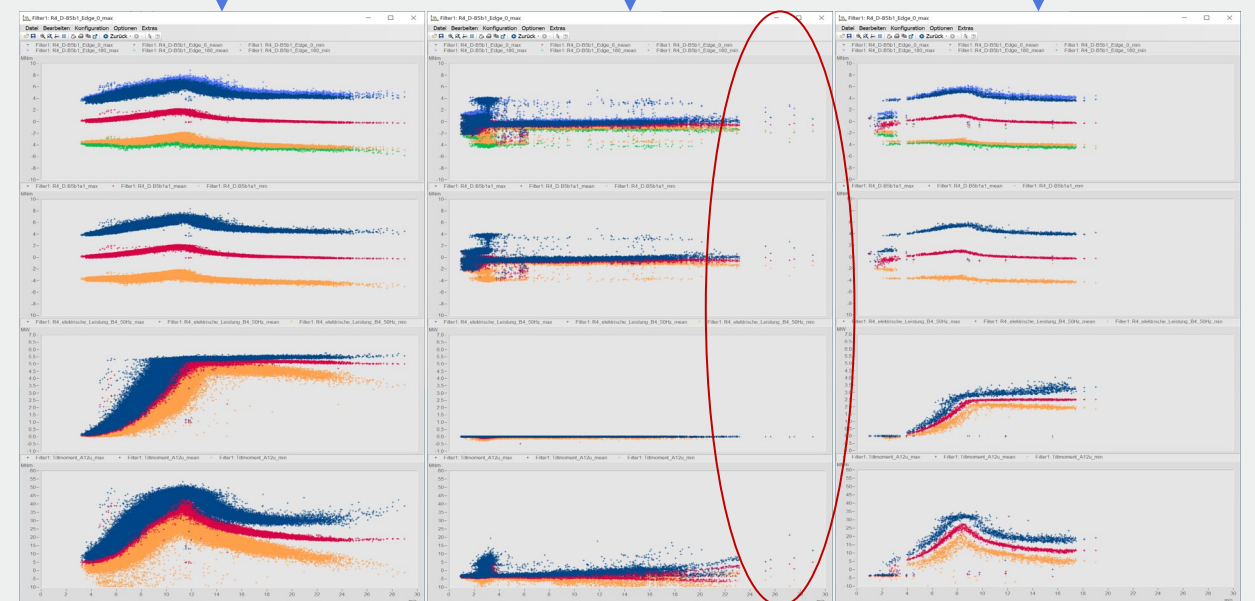
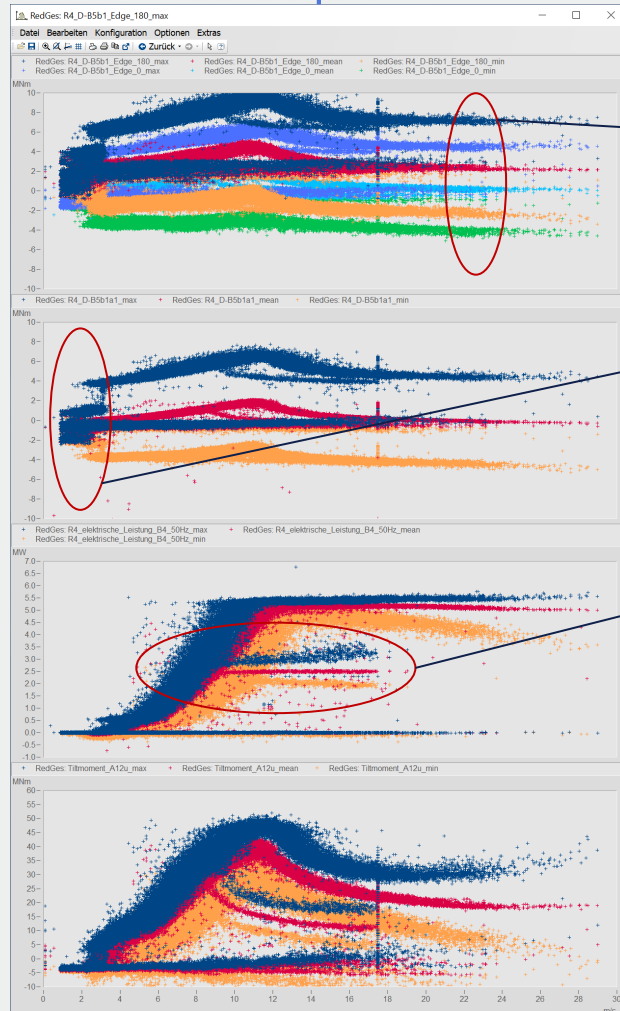
3. data consulting

2. data quality control

- a) DQC-Manually
- b) DQC-Automated
 - Flatlines_1
 - Flatlines_2
 - Length
 - Range
 - Spikes_1
 - Spikes_2
- c) (DQC-Machine Learning)
- d) **Master_Flag**



Database (e.g. 2020-11-03 to 2023-03-31)



A – WEC in Operation at 5 MW rated power

B – WEC out of Operation and idling

C – WEC at 2.5 MW rated power

Small Database at high ws

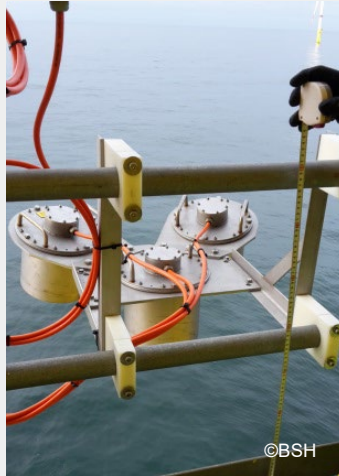
Lifetime Database

- Is foundation for high quality development and verification of ML-Models
- will be unique and will give opportunities for future developments (e.g. AI-Models)
- Stand Still data are opportunity for investigation with respect to see state impact in turbine loads

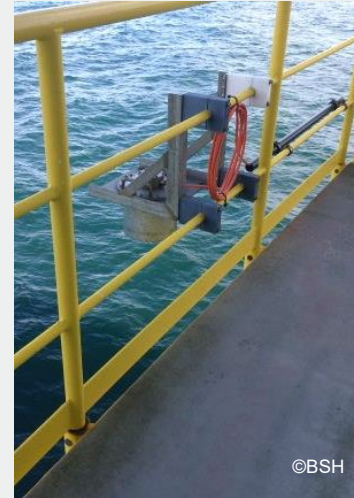
Oceanographic measures - instrumentation



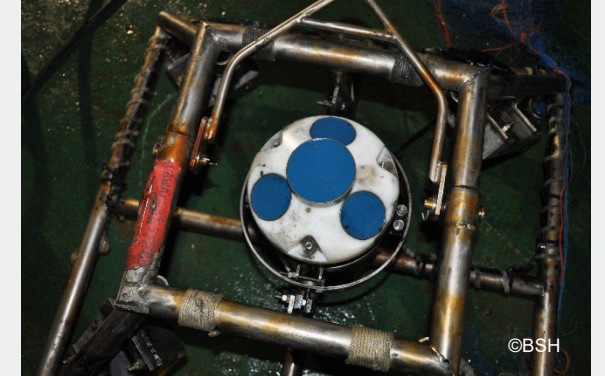
Waverider Buoy



Directional Radar



Wave Radar



Acoustic Doppler Profiler

Database – Oceanographic Measurements

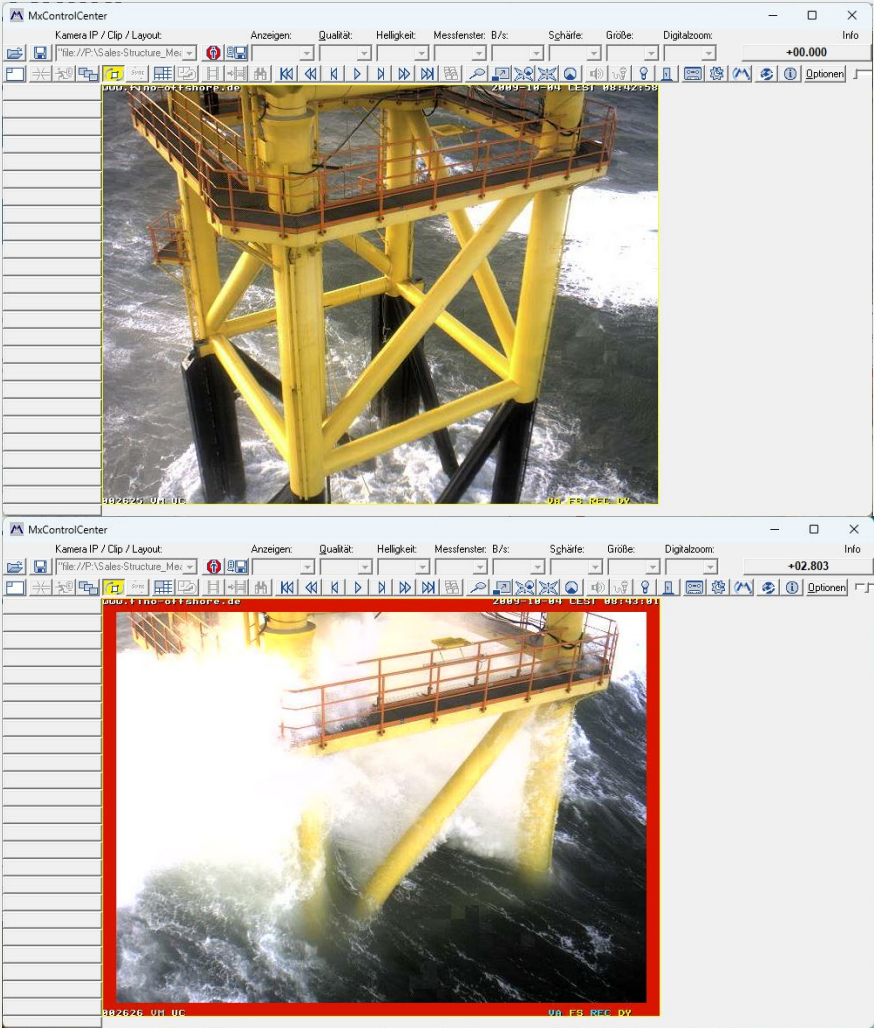
➤ See State Portal



2009-10-04
08:42:58

3 sec. later

2009-10-04
08:43:01



Outlook / Future Potential of Lifetime database

- **Oceanographic data**
 - **Impact to WEC (Mechanical Loads vs. Oceanographic data)**
 - **Optimization of Offshore-deployments**
- **Monitoring until decommissioning**
 - **Completion of database with unique Quality**
 - **Creates Opportunities for future Investigation with respect to End-of-Life investigations**
- **ML- and AI-applications (e.g. for damage detection)**
- **Early detection of damages**

Lifetime Database ➡ A Data Treasure

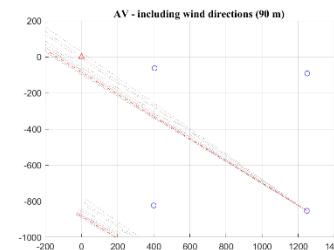
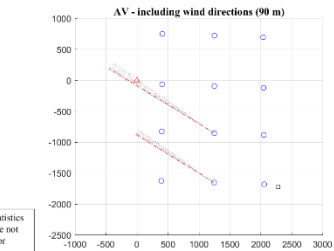
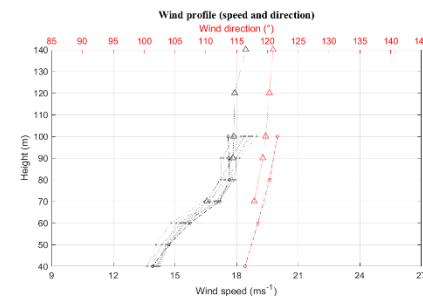
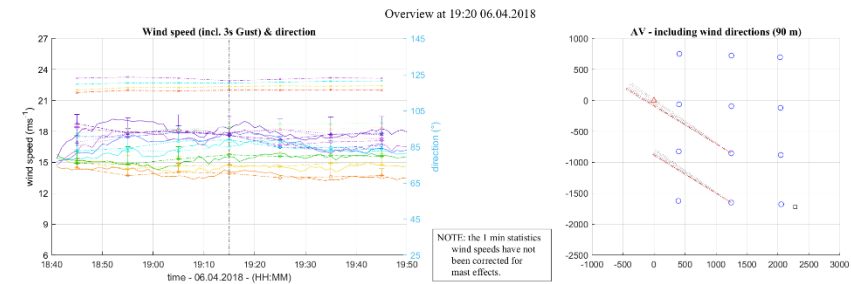
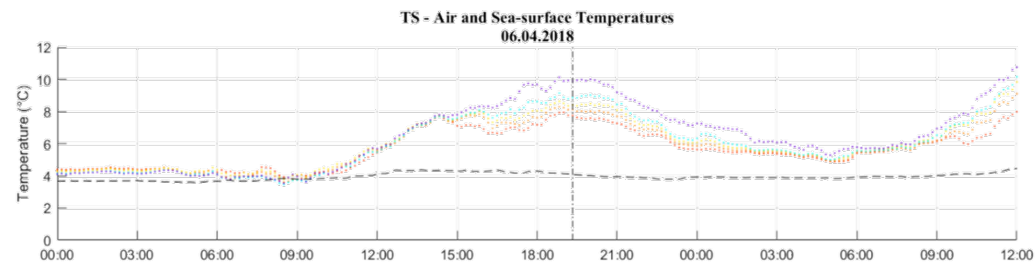
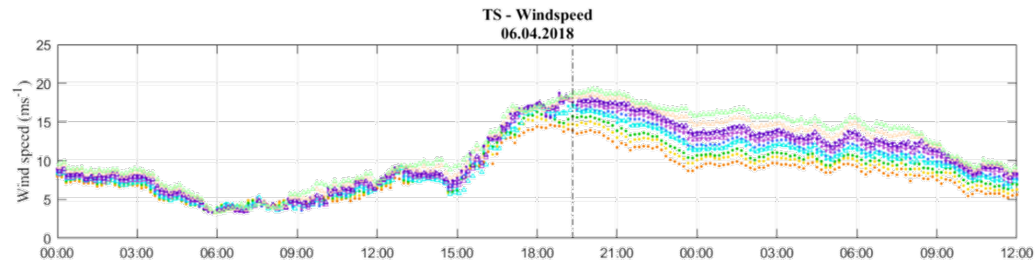
Special Events

- Regular boat landings
- Storms
- Multiple wake situation
- Historically growing turbulence intensity
→ successively growing neighbouring wind farms
- Standstill periods of different turbine types and parks
- Major accident → **AV07 04.2018**

Nacalle Accident 2018 : A Multilayer Problem

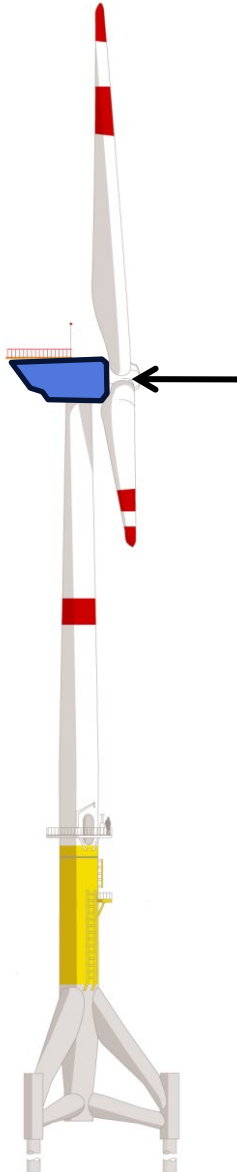
Conditions measured at FINO1:

- Wind direction south-east
- Stable atmosphere
- Strong wind shear 13 – 19 m/s @ lower rotor
- No direct wake on that day

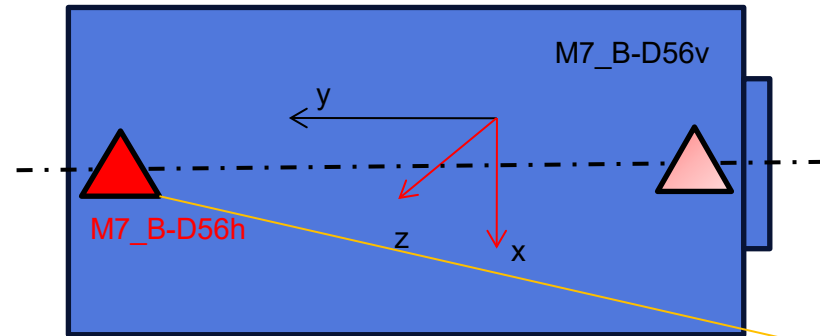


What can we analyze?

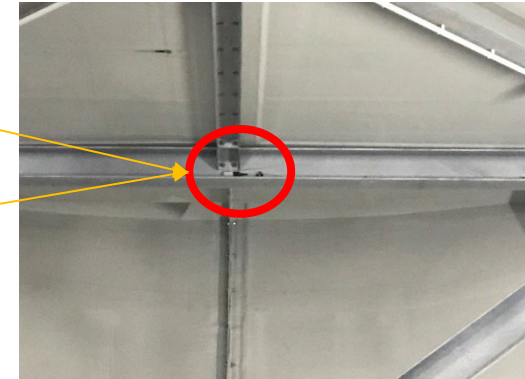
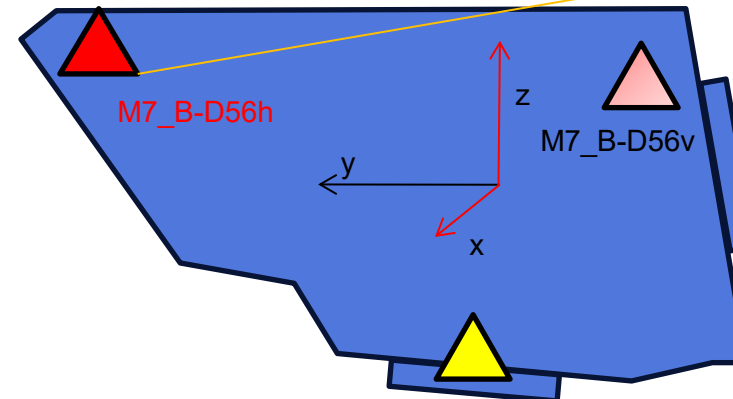
AV07 Nacelle
Sensors
M7_B-D56v
M7_B-D56h



View from above:

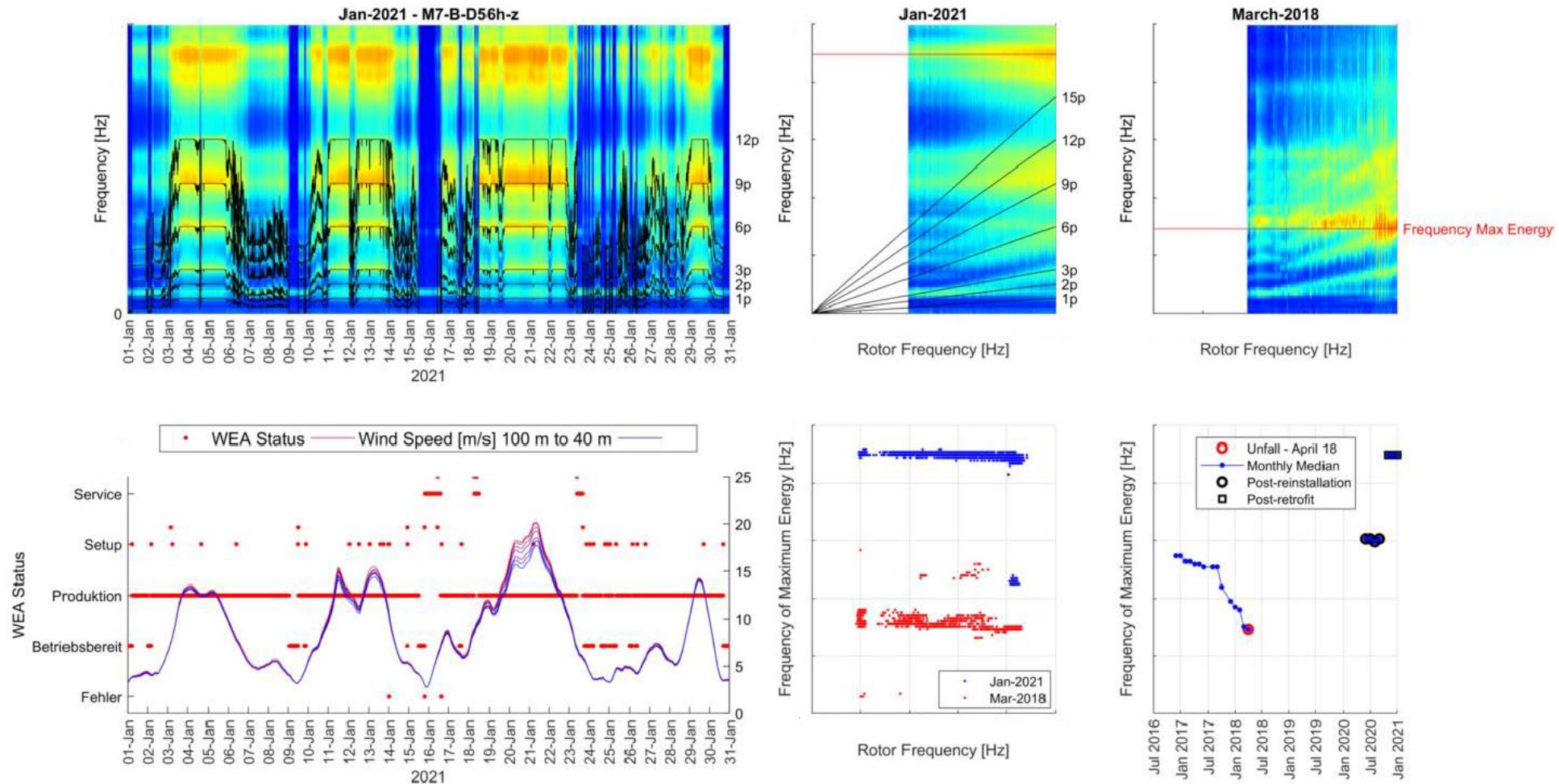


Side view:

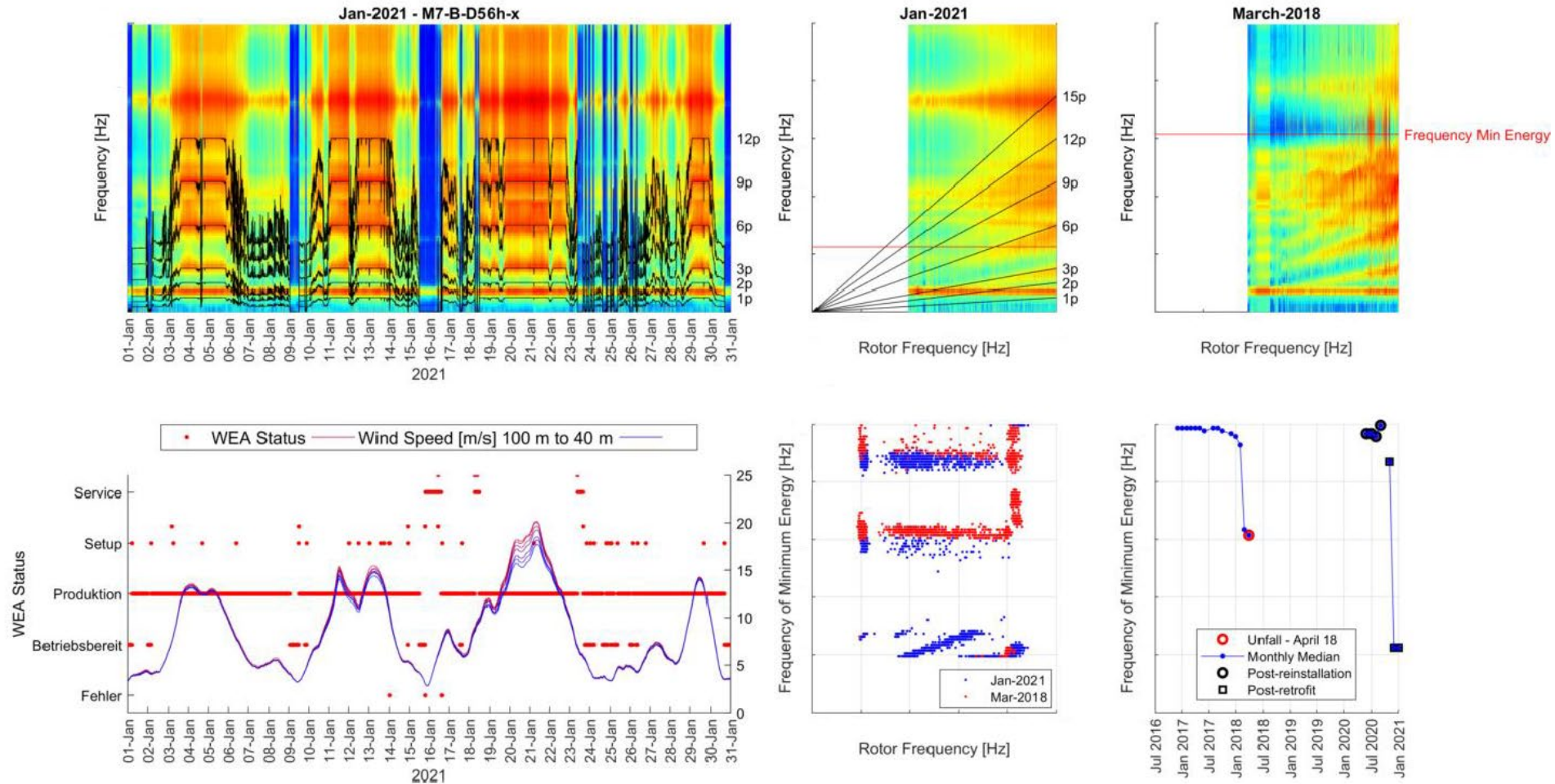


M7_B-D56h_z acceleration vertical to the nacelle direction
M7_B-D56h_x acceleration perpendicular of the nacelle direction
M7_B-D56v_x acceleration perpendicular of the nacelle direction
M7_B-D56v_y acceleration in direction of the nacelle

Vertical nacelle acceleration : Accident AV07 vs normal state

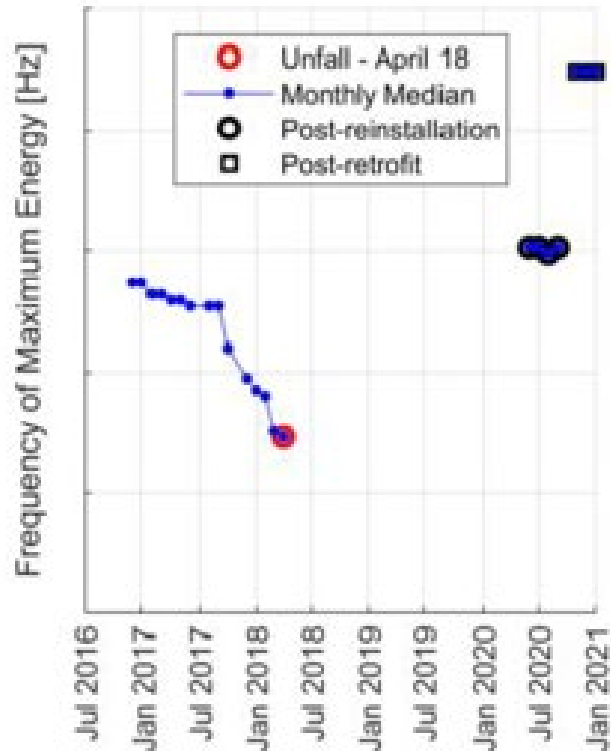


lateral nacelle acceleration : Accident AV07 vs normal state

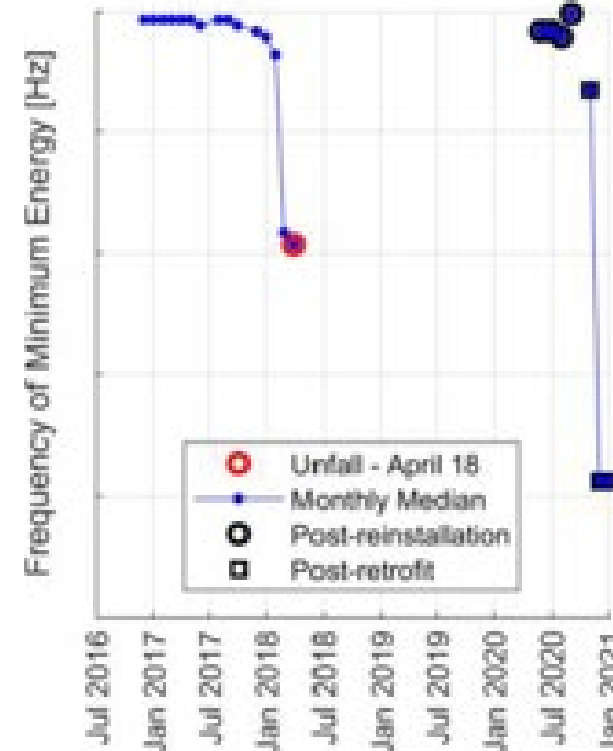


Nacelle acceleration : Early change and failure detection

Z-axis (max. energy)



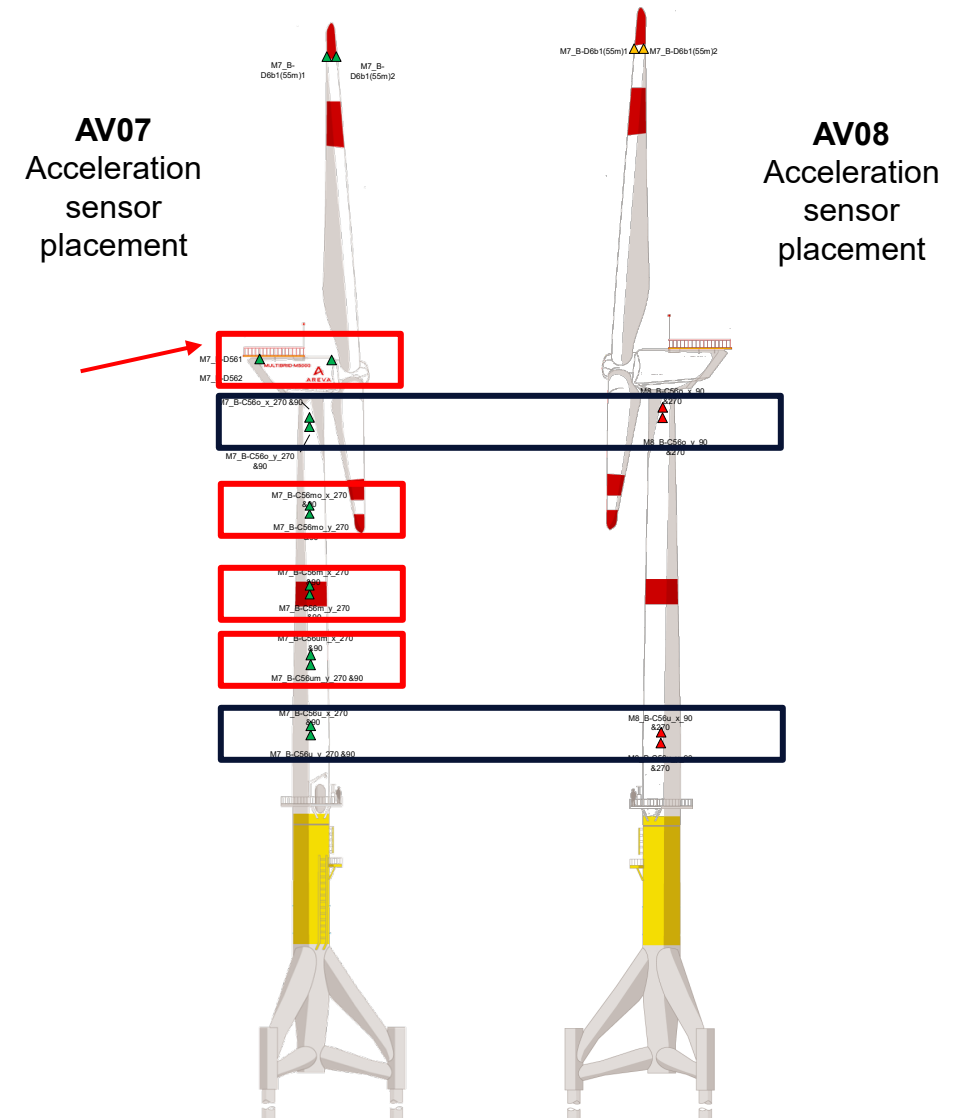
X-axis (min. energy)



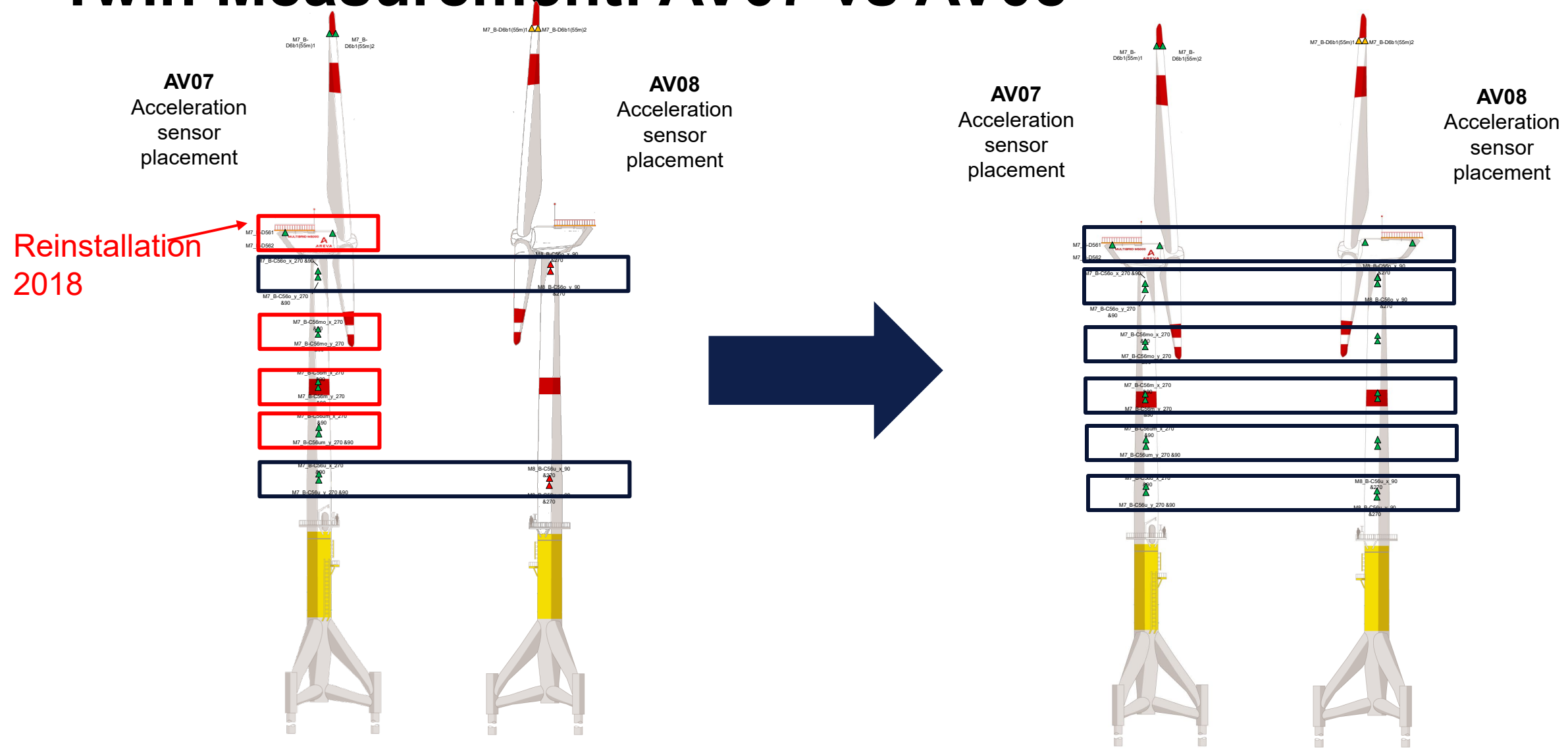
No standard structural health monitoring and influence in standard sensor hardly distinguishable!

Twin Measurement: AV07 vs AV08

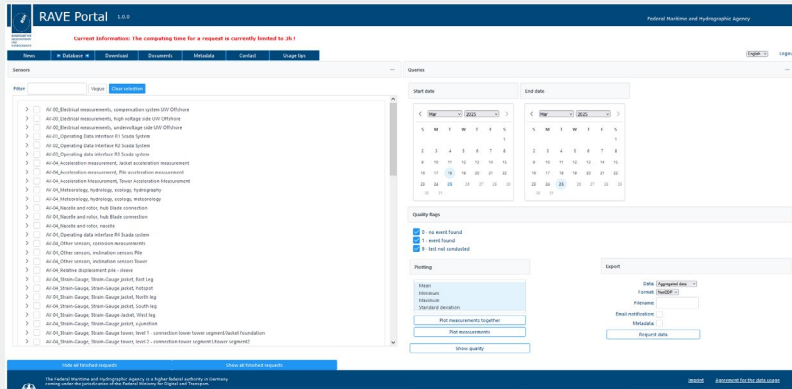
- The basic idea:
- Increase availability of broad scope of accelerometers
- Increase database for machine learning applications
- Extend possibilities for validation of ML models by validation data for prediction



Twin Measurement: AV07 vs AV08



RAVE research archive – user view & access



Step 1

To access the RAVE research archive, a Data Usage Agreement must be completed, signed and send to rave-forschungsarchiv@bsh.de

Step 2

To apply for online access,
please register here:
<https://login.bsh.de/fachverfahren/registrierung>

After login, please apply for the RAVE special procedure

Please register here:

Agreement for the data usage

between _____

_____ hereinafter referred to as »Data User«.

and

the Federal Republic of Germany, represented by the Federal Ministry of Transport and Digital Infrastructure, the latter represented by Bundesamt für Seeschifffahrt und Hydrographie (BSH), represented by the President Dr. Karin Kammann-Klippstein, Bernhard-Noch-Strasse 78, 20359 Hamburg, Germany.

_____ hereinafter referred to as »BSH«.

Information given by the Data User

Name of responsible person: _____

Title of research project or internal research: _____

https://rave-offshore.de/files/images/Datenarchiv/20190909_RAVE-KOV_Anlage_3-final.pdf





Thank you

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