Damage Detection and Quantification in the Mooring Lines of Floating Offshore Wind Turbines through Statistical Methods

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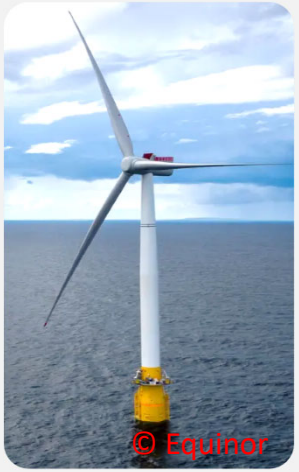


Science Meets Industry - SMIBergen2022:
Analytics for Asset Integrity Management in Wind farms (AIMWind)

Analytics for Asset Integrity Management of Windfarms (AIMWind) project

Project information:

- Collaboration of the University of Agder (UiA), the Norwegian Research Centre – NORCE AS and the Technical University of Delft (TUDelft)
- Develop technologies towards accurate remaining useful life assessment and lifetime extension of floating offshore wind turbines (FOWTs) using SCADA, condition monitoring and meteorological data
- Develop health-aware control methodologies that adapt FOWT operation for efficiency as well as reduced degradation
- Program: RCN IKTPLUSS
- Budget: 16 443 kNOK
- Project period: 2021 – 2024

UiA NORCE TUDelft

Importance of Damage Detection

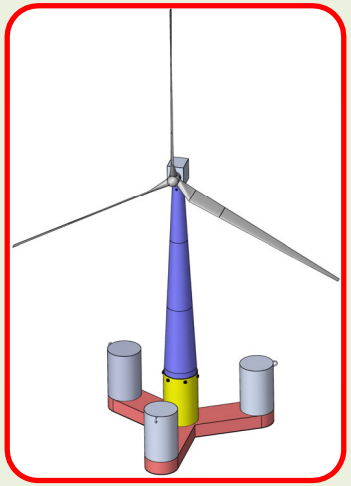
Damage in the mooring lines' → increase of tension → loss of stability, high maintenance cost → Floating Offshore Wind Turbine (FOWT) collapse and endangerment of human safety → Early damage detection being important

Goal of our part in the AIMWind project

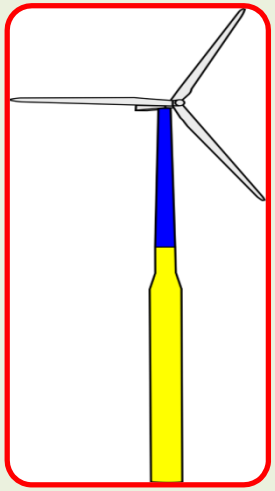
Damage Detection & Quantification in the Mooring Lines of Floating Offshore Wind Turbines (FOWTs) under Varying Environmental Conditions (wind speed and wave height)

Semi-Submersible FOWT: The examined part of the mooring line is fiber rope

Spar FOWT: The examined part of the mooring line is chain



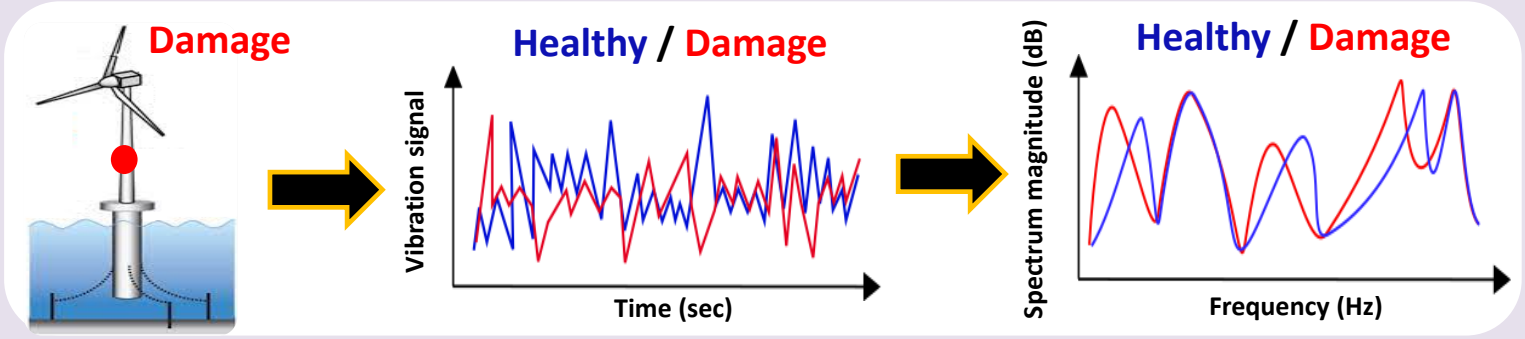
Semi-Submersible FOWT



Spar FOWT

Fundamental principle of damage detection methods based on vibration signals

Presence of damage → Change in the structural dynamics → Change in the vibration response signals → Damage detection



Environmental Conditions (ECs)

Varying ECs

↓

Partially or fully "masking" the effects of damages on the structural dynamics

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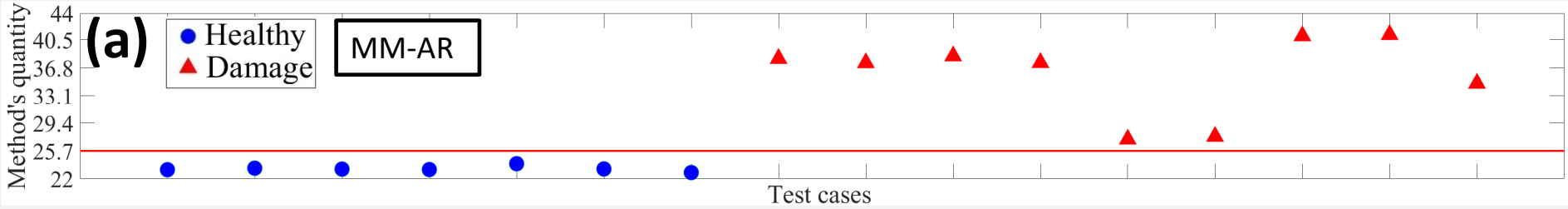
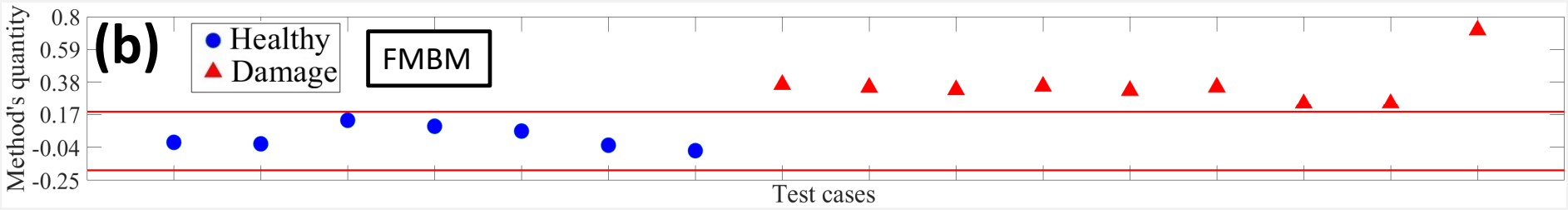
Highly challenging damage detection

Employed statistical methods for damage detection and quantification

- Multiple Model – Power Spectral Density (MM-PSD) method equipped with multiple Power Spectral Density (PSD) models
- Multiple Model – AutoRegressive (MM-AR) method equipped with multiple AutoRegressive (AR) models
- Functional Model Based Method (FMBM) equipped with a single Functional Model (FM)

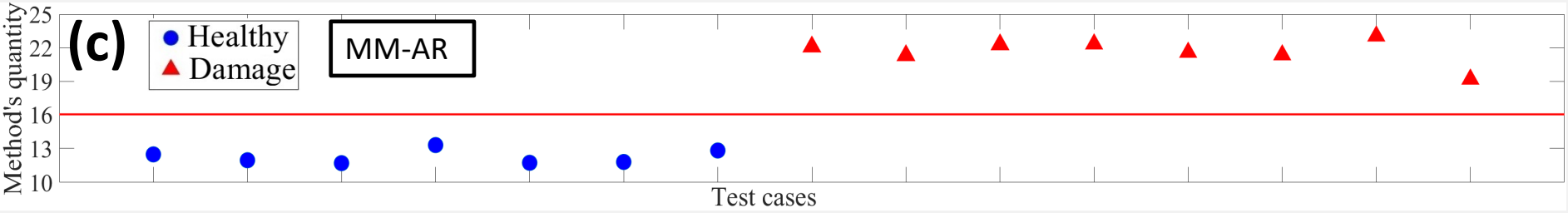
Results

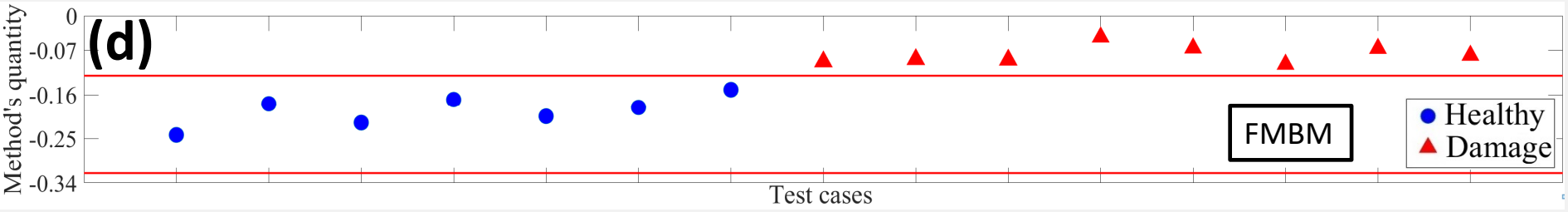




Spar FOWT

All the 7 healthy & 9 damage cases detected correctly with the MM-AR and the FMBM





Semi-Submersible FOWT

All the 7 healthy & 8 damage cases detected correctly with the MM-AR and the FMBM

Conclusions

Preliminary simulations under healthy and various damage states in the Semi-Submersible and the Spar FOWTs, have shown:

- **Damages of different weights and at different locations, have small and similar effects on the structural dynamics**
- **Successful damage detection in the FOWT mooring lines though statistical methods**