Damage Detection and Quantification in the Mooring Lines of Floating Offshore Wind Turbines though 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

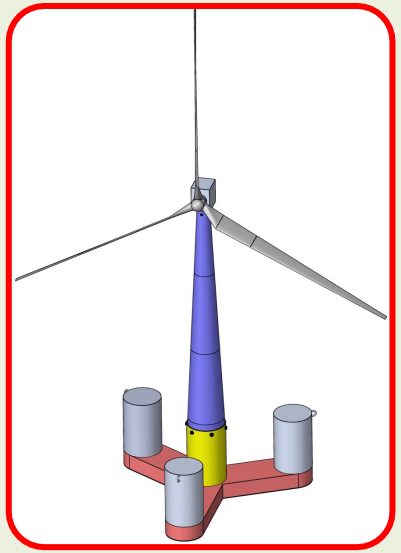
Damage in the mooring lines' → increase of tension → loss of stability, high maintenance cost → Floating Offshore Wind Turbine (FOWT) collapse and endangerment of human safety → Early damage detection being important

Goal of our part in the AIMWind project

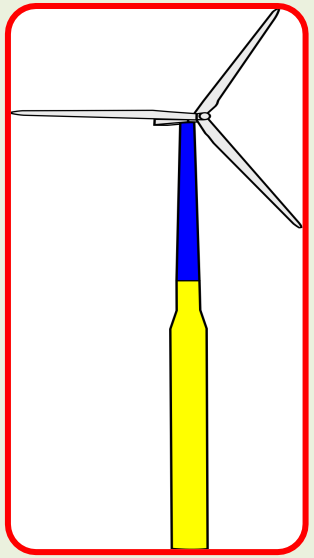
Damage Detection & Quantification in the Mooring Lines of Floating Offshore Wind Turbines (FOWTs) under Varying Environmental Conditions (wind speed and wave height)

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

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



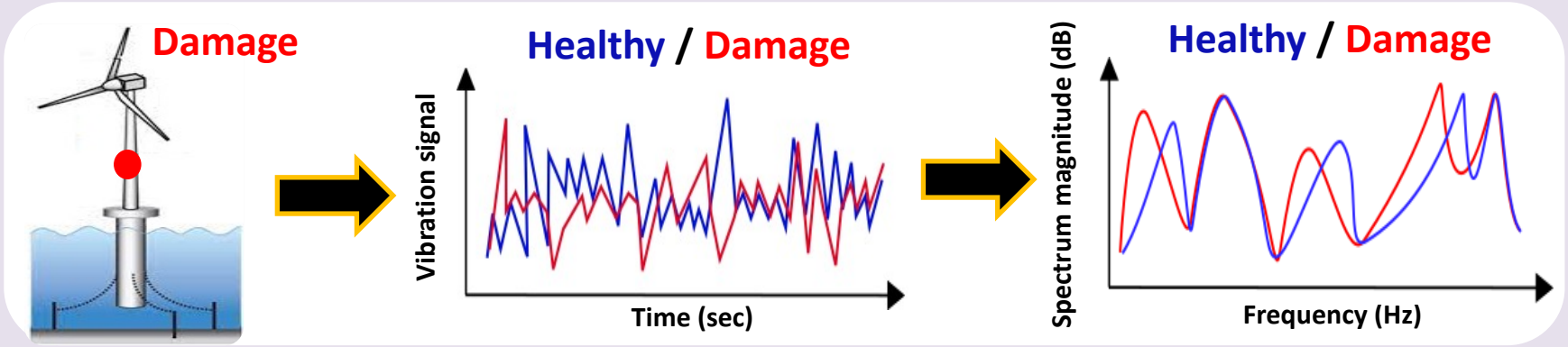
Semi-Submersible FOWT



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

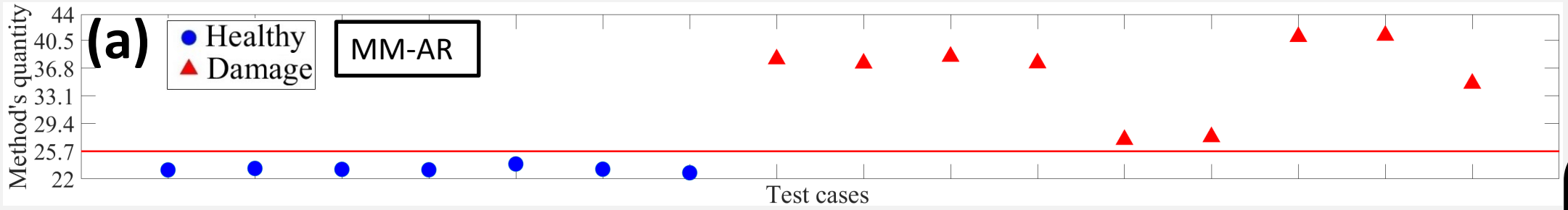
Partially or fully "masking" the effects of damages on the structural dynamics

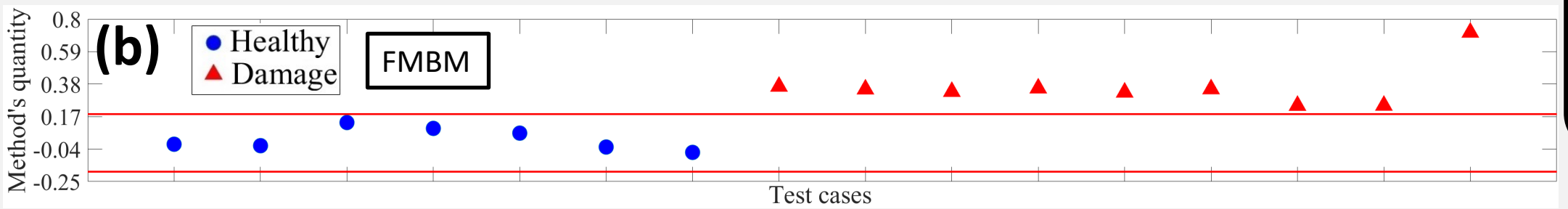
Highly challenging damage detection

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)

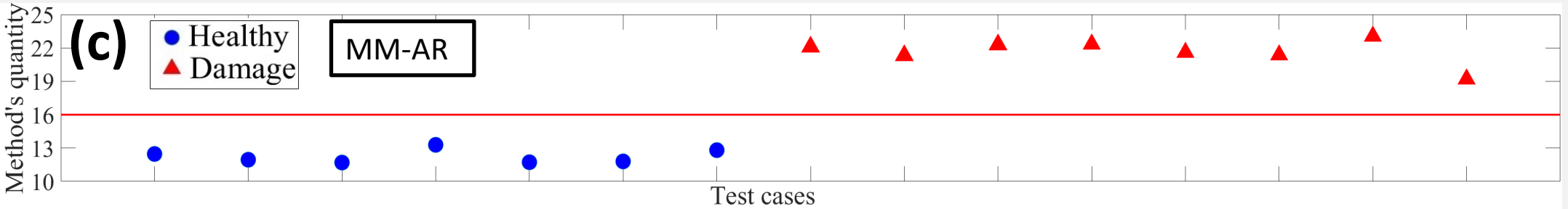
Results

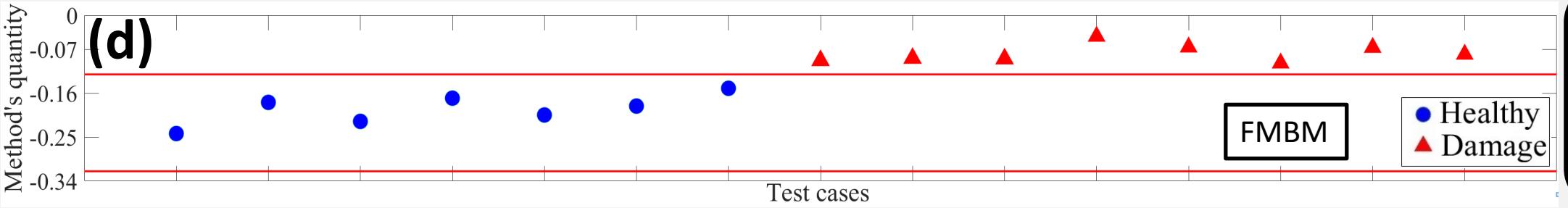




Spar FOWT

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 through statistical methods**