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

Post-doctoral Research Fellow Christos S. Sakaris, WP 2 Leader \ Deputy Director Rune Schlanbusch

Smart Instrumentation and Industrial Testing research group, NORCE Norwegian Research Centre, 4879 Grimstad, Norway

{csak,rusc}@norceresearch.no

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

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**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
Damage detection & quantification in the mooring lines of FOWTs

**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

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