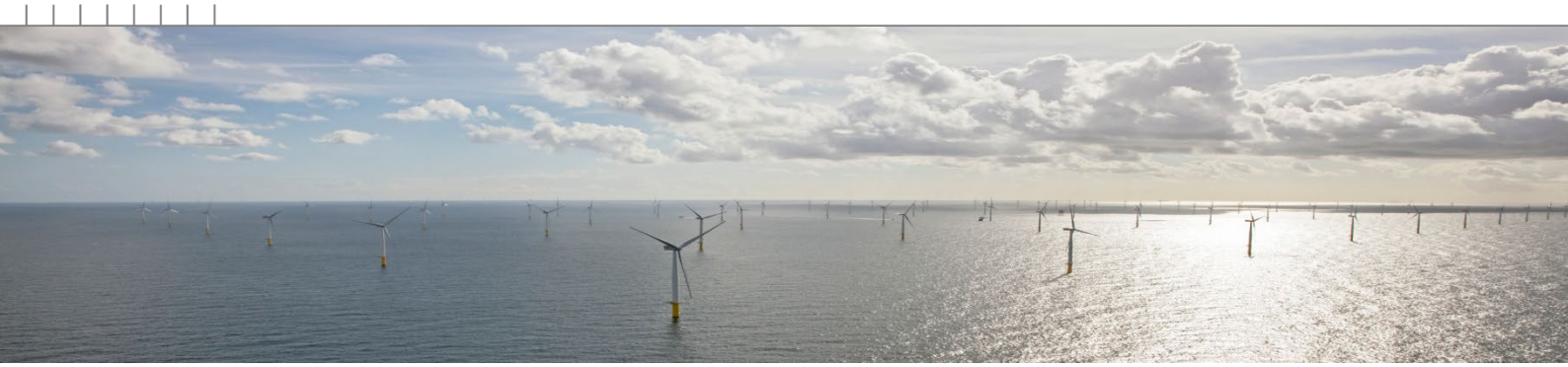
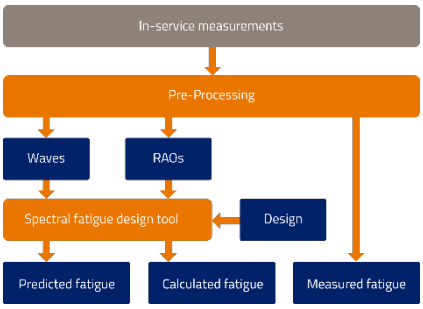


Safeguarding the structural integrity

Monitoring in combination with structural fatigue integrity management tool MONITAS increases safety, reduces inspection and maintenance costs and contributes to lifetime extension

Floating offshore wind turbines (FOWT) represent a cost-effective energy solution in deep water where bottom-fixed wind turbine becomes excessively expensive. The most common FOWT include spar, semi-submersible, tension leg platform and barge. A structural integrity assessment, which is part of the design procedure, comprises multiple calculations, which requires different input data such as the environmental conditions including waves and wind. The uncertainties associated with these calculations make a structural integrity assessment difficult and is the reason why so many offshore structures used in the oil and gas industry are suffering from fatigue damage. As the renewable energy market is relatively young, the associated FOWT structures may face new challenges, which add to the uncertainties.

By monitoring the FOWT, the uncertainties are reduced and the fatigue integrity is improved for both the present structure and future designs. Knowing the actual state of the FOWT plays a key role for ensuring a safe performance of the FOWT and contributes to lifetime extension of the floater. In order to efficiently use this monitoring data, automated analysis of this data through a specialized structural assessment tool is required. The MONITAS digital twin helps the FOWT owner to safeguard the structural integrity of the floater.



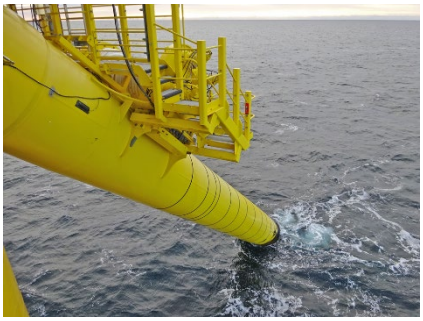
GUI Monitas

MONITAS digital twin description

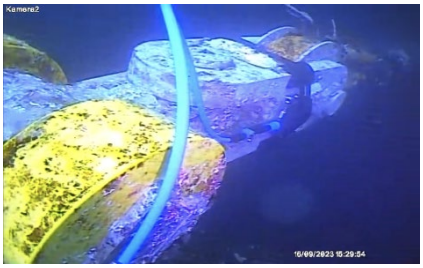
MONITAS is a dedicated software of an advanced structural monitoring system, which assesses the integrity of a floating wind turbine (floater and tower). It helps the owner to understand the real age of the floater by monitoring fatigue loading and integration with design tools. MONITAS not only measures the fatigue using dedicated sensors but also explains why the measured fatigue deviates from design predictions. Differences may originate from different conditions (environmental and loading) assumed during the design process or from simplifications in the fatigue design tool. For this reason, the floater design tool is part of the MONITAS software.

Prediction and tool accuracy factors define the effect of assumed conditions and tool performance on the overall lifetime. These factors provide insight in the different sources of uncertainty in the design process and thereby increasing the overall reliability.

TetraSpar Demonstrator, METCentre Test Site, Norway



Structural load measurements



Mooring line angle measurements

Wave measurements

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Hardware of a structural integrity management system

An advanced structural monitoring system for a floating wind turbine comprises typically strain sensors on the floater (tower, supporting structure) to monitor the structural loads, an MRU (Motion Reference Unit) to monitor the wave frequency motions, a DPGS system to monitor the floater position and low frequency motions and accelerometers to monitor the floater vibrations. To be able to relate above responses to the environmental conditions, wave and wind measurements are required as well.

To monitor the mooring line loads vibrating wire gauges, in-line load cells and/or inclinometers can be used. Vibrating wire gauges have a proven track record in the Geotechnical Industry. The main benefit of this type of sensor is the ease of retrofitting in an offshore environment. A cost effective alternative to obtain the mooring line tensions is to use the high accuracy floater position and motion measurements in combination with a numerical model.

Information of the waves can be obtained with a directional wave rider buoy. A drawback of the buoy are the costs, as it requires a boat to perform maintenance. An alternative method to measure the waves is to use a motion compensated wave elevation radar mounted on the FOWT access platform. Three radars provides in addition to the wave statistics also the wave direction.

A Motion Reference Unit (MRU) measures the 6 DOF wave frequency rigid body motions of the FOWT. The MRU sensor from SMC uses solid-state gyros and accelerometers to provide real time motion measurements with high dynamic accuracy.

MARIN was contracted in 2023 to provide an advanced structural monitoring services for the TetraSpar floating wind project. The TetraSpar Demonstrator Project is the world's first full-scale demonstration of an industrialised offshore floating wind turbine and was carried out in a partnership between Shell, RWE, TEPCO Renewable Power and Stiesdal Offshore. Pictures on page 2 courtesy of TetraSpar Demonstrator ApS.

Software as a service

The MONITAS analysis system is currently available as a dedicated windows-based software. A new version of the software will be available in 2024, enabling to operate in the cloud or a data centre and facilitating remote data access

Structural monitoring with MONITAS

- Understanding of actual lifetime consumption of floating structures
- Prevention of unexpected failures resulting in reduction of uptime
- Increased safety
- Rational lifetime extension
- Improved design of future Floating offshore wind turbines