Offshore Structural Health Monitoring: Concept of a Global Monitoring System Based on the Structure Dynamic Behaviour

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Abstract

The civil engineering structures of offshore wind turbines and converter stations are “relatively new’ structures, although the oil & gas industry have been operating offshore for many decades. Hence the design is engineered with high partial safety factors and the manufacturing process is subject to extensive quality controls, both to take the unknown ambient offshore conditions , e.g. harsh environment & subsea soil, into account. As a result the structures are robust.

Cost effective monitoring of offshore wind turbines and transformer stations decreases the uncertainties involved with these ‘new’ structures. Most monitoring systems for offshore structures implemented in the past are ‘local’ monitoring systems which focus on hotspots. In contrast, the concept of a ‘global’ monitoring system based on ambient vibration monitoring techniques, which is already implemented in five offshore wind farms, is presented in this poster.

Objectives

The assessment of offshore structure components, especially under water, is a challenge for the wind industry. Therefore, permanent monitoring systems help to reduce both the life cycle costs and the risks involved with ‘conventional’ structure inspections by experts and divers.

The main objectives of a Permanent Monitoring System are to

- identify changes in structure performance and characteristic in real-time
- determine residual service life time
- complement periodic inspections
- assess life cycle management

The monitoring system has to be integrated into the existing asset management systems.

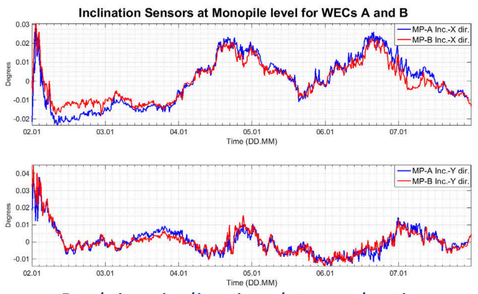
Monitoring and data evaluation Techniques

Global monitoring technique focuses on the identification of key structure performance parameters, which are sensitive to structural changes. The data evaluation strategy is generally performed in three stages direct, advanced and model based.

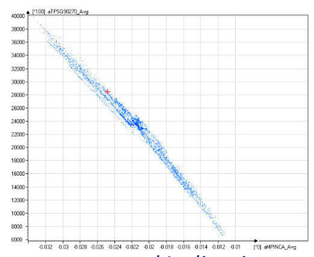
The direct data evaluation (stage-I) is a real time evaluation of the time history plots. Responses from sensors of similar wind turbines are compared against a threshold and among each other. It also uses operational/environmental data as an input.

The advanced data evaluation (stage-II) technique is capable of detecting changes in the structure’s dynamic properties even at higher order Eigen frequencies to identify local anomalies.

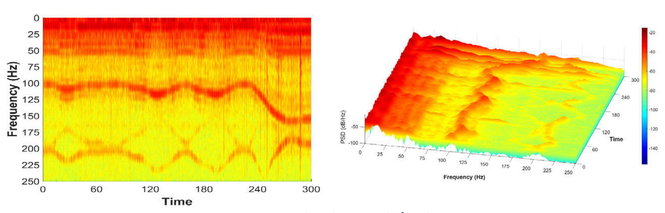
In case any anomalies occur, the model based data evaluation (stage-III) is applied, in which a calibrated FE model of the structure is updated with all SHM information to locate possible structure anomalies.



Real time inclination data evaluation

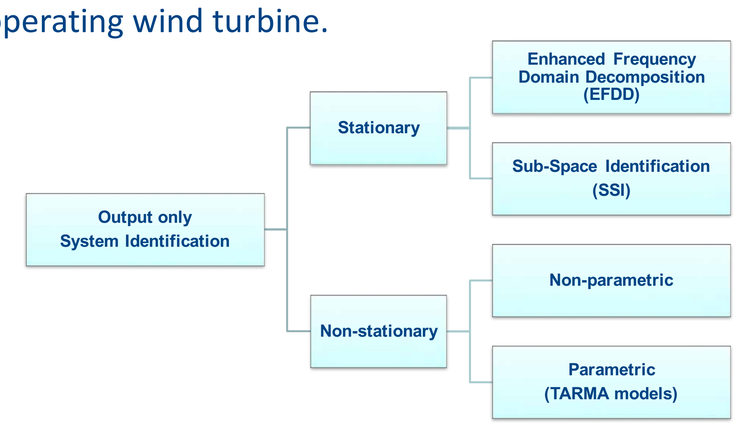


Bending moment and Inclination correlation



PSD variation with time

System Identification (SI) from Ambient Vibration Monitoring is a well established global monitoring technique that got matured in the last few decades. Recent trends include the application of non stationary random vibration analysis, which accommodates the time varying characteristics of an operating wind turbine.



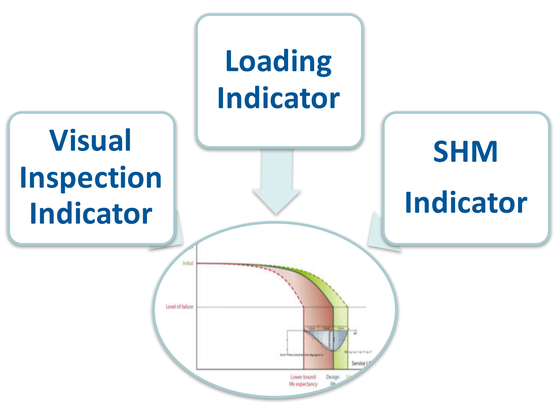
Trends of output only system identifications techniques

In stage-II data evaluation, other parameters are also evaluated such as vibration intensity, energy dissipation and rain flow fatigue analysis.

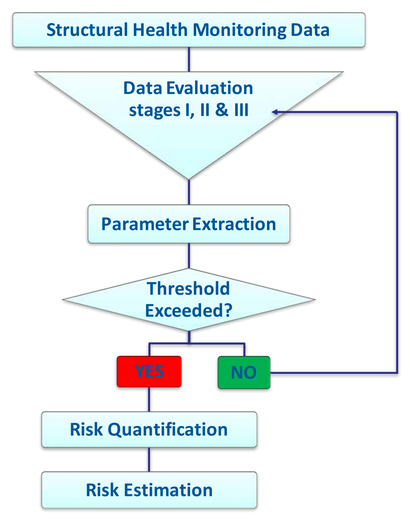
Risk Based Approach and Asset Management

In the past, monitoring systems most often were implemented as isolated measurement systems. To take full advantage of structure monitoring, the system need to be incorporated with asset management systems. To this end a risk based approach to the monitoring and to data presentation needs to be followed consequently. Asset management – as all management systems – are based on risk management.

The European Collaborative Research Project IRIS (CP-IP 213968-2) defined an approach for risk estimation suitable for various industries.



Inputs for calculating the condition index for Life cycle analysis [1]



IRIS Risk Assessment Tool implementation for SHM data

Conclusions

Other industries have successfully integrated monitoring systems into asset management systems in the past. The secret is to focus on risk as the central control parameter of all management systems. For further information please refer to www.shmanager.org

The advantages of the concept are:

- can be integrated into any asset management system
- only few, strategically positioned and reliable sensors are needed
- sensors can be placed in accessible positions to decrease maintenance costs
- the method focuses on loads and the load bearing characteristics of the structure

References

1. H. Wenzel [Coord.] (2013), Industrial Safety and Life Cycle Engineering, IRIS project, VCE