# Wind Turbine structural monitoring with Osmos Technologies

## Summary

**Designed to produce electricity from the force of the wind, wind turbines generators are increasingly efficient machines that must be able to operate with maximum efficiency and availability for a minimum period of 20 years.**

Wind Turbines are made up of moving parts (blades, rotor and nacelle), and fixed parts (mast and foundation). Despite the care taken by manufacturers during the design phase, many factors can alter the expected performance and cause premature aging of components. WTGs are indeed highly stressed structures, even in normal operation, and are also very sensitive to fatigue and vibration phenomena.

**As far as the mast and foundation are concerned, the visual inspections and assembly control campaigns usually carried out are not sufficient to know their structural health with precision. This information is essential in the following cases:**

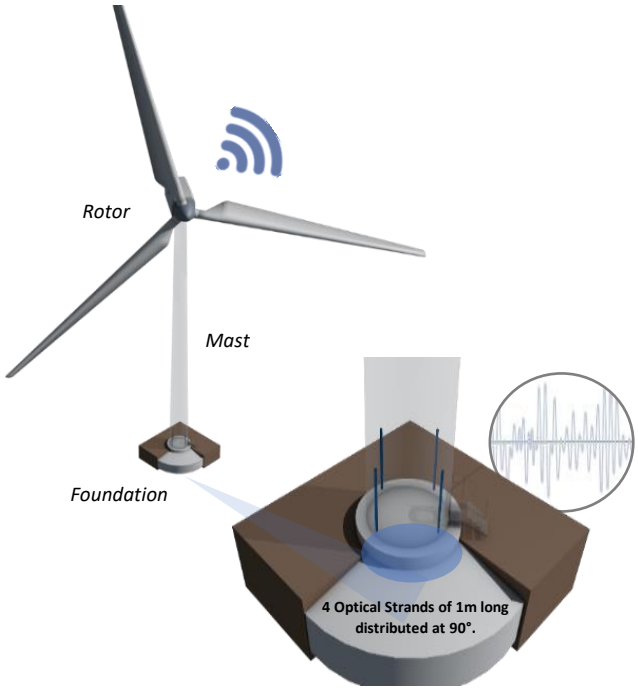
- *Appearance of disorders*
- *Request for extension of the machine's operating time*
- *Repowering studies*
- *Restart after accident or natural disaster*
- *Litigation with the supplier or construction companies*

**COMMISSIONING**

**EXPLOITATION**

**DEVELOPMENT**

**It is to provide that information that OSMOS has designed a new monitoring solution especially dedicated to the WTGs.** The device consists of **4 Optical Strands sensors**, a **monitoring station** and a **data visualization interface**.




**Optical Strands** are long base strain sensors. Both accurate and robust, their micrometric resolution and 100Hz acquisition frequency make them particularly well suited for monitoring structures under continuous load.

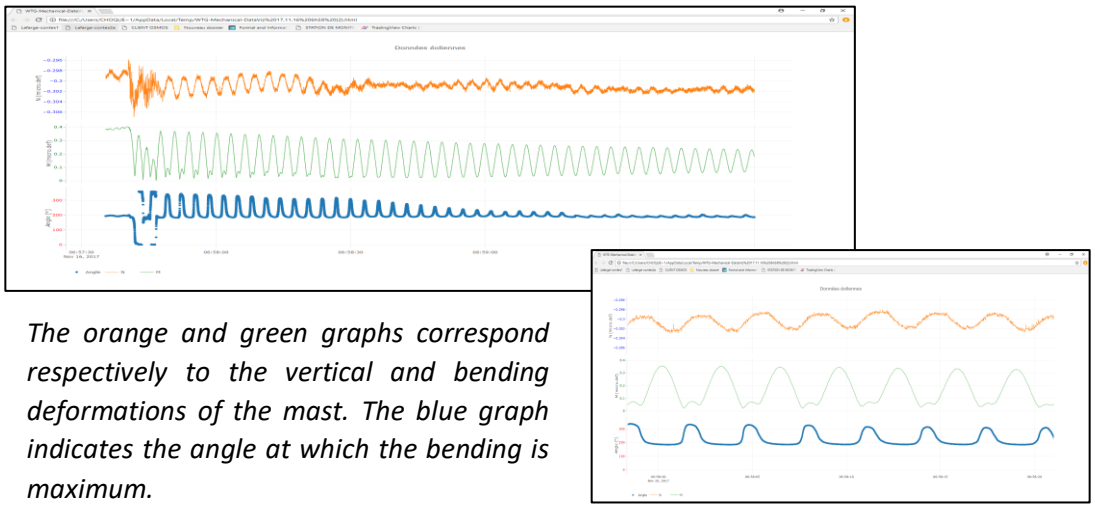
## Information obtained from the solution

What is the impact of an operating incident on the structure? Is the structural behavior of the mast and its foundation always in conformity? What is its residual life span?

The capacity of the OSMOS structural monitoring system to respond to these questions by providing usable and conclusive information is illustrated by the following real case study of a wind turbine located in Greece. An example of the analysis and post-processing procedures of accidental impacts on the mast is briefly described below and concerns a strong dynamic event that was held on 16 November 2017.

### ANOMALY DETECTION DURING EXPLOITATION

The single event below corresponds to a "Shut Down" of the machine. It was identified from intelligent statistical indicators that had abnormally high amplitude values compared to the normal behavior of the structure. Shortly after the start of the recording, the bending of the mast due to the action of the wind suddenly relaxed and the mast then began to oscillate freely.

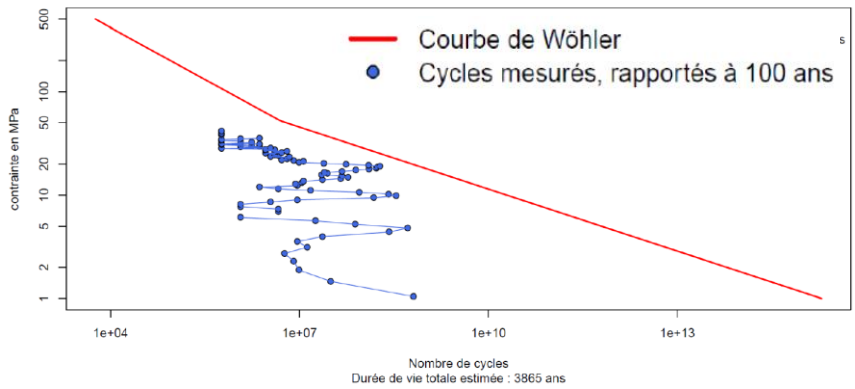


*The orange and green graphs correspond respectively to the vertical and bending deformations of the mast. The blue graph indicates the angle at which the bending is maximum.*

### DAMAGE RATE CALCULATION

**The damage rate is a criterion that quantifies the level of fatigue of a structure** under the effect of repeated loads such as vibrations or wind gusts. It is calculated at regular intervals and returned as a feature to facilitate continuous monitoring.

In the episode, the damage rate was higher than normal because the stress variations were repeated and of high amplitude. **When they are too frequent, these incidents have a major impact on the level of fatigue damage to the structure.**

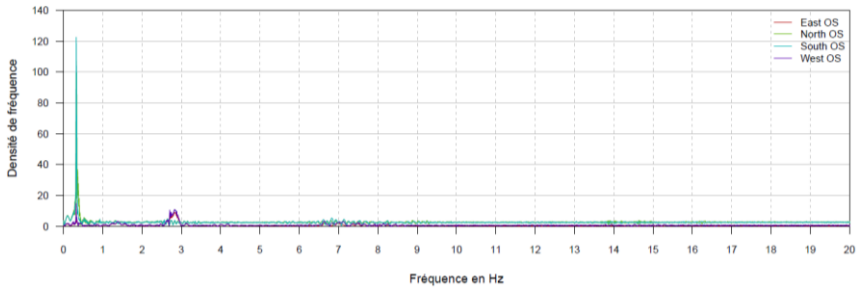



**Damage cycle counting example**

## REAL STRUCTURAL BEHAVIOR QUALIFICATION

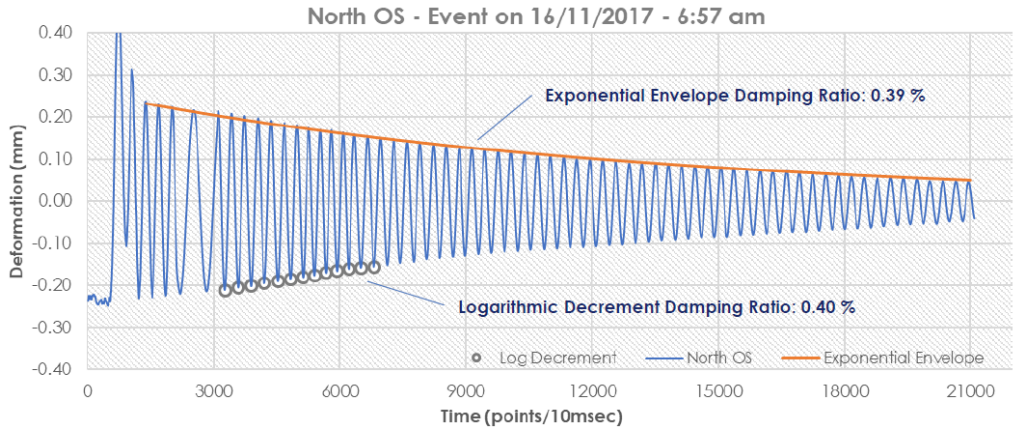
The analysis of the free oscillations of the wind turbine after the "shutdown" made it possible to qualify its dynamic behavior with precision.

The frequencies of the first natural modes are calculated by FFT (Fast Fourier Transform): 0.3 Hz for the first mode and 2.7 Hz for the second. These values are in accordance with those specified by the manufacturer.




**FFT : 1st Mode at 0.3Hz**

In addition, the analysis of these measurements allows to calculate the actual damping coefficient* of the structure and compare it with the theoretical values taken in the calculation note. This valuable information can be used later to refine the assumptions made in the calculation notes.




**Damping coefficient calculation**

## IMPACT ASSESSMENT OF THE EXPLOITATION INCIDENT ON THE STRUCTURE

Analysis of the measurements and output data from the monitoring system showed that the reached stress levels remained below acceptable limits despite more severe damage than normal.

In addition, the dynamic behavior of the structure was not modified following this incident. The frequencies of the vibration modes remain in accordance with those specified by the manufacturer.

**This incident had no impact on the structure and the machine can therefore be restarted.**

## Data Exploration Strategy

**How to increase information value?**

Data exploration possibilities and output information increase with the duration of the monitoring and the number of turbines equipped with the OSMOS Optical Strands.

### A SINGLE WT

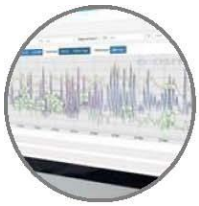
- CHARACTERIZE THE STRUCTURAL BEHAVIOUR OF THE WTG
- VALIDATEPERFORMANCE CONFORMITY
- INCREASE SAFETY & EFFICIENCY DURING OPERATION
- DETECT EARLY AND LONGTERM BEHAVIOR MODIFICATIONS
- REDUCE UNCERTAINTIES AFTER NATURAL DISASTERS

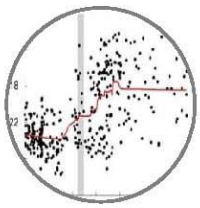
### A WIND FARM

- COMPARE STRUCTURAL BEHAVIOUR BETWEEN TURBINES
- EVALUATE AGEING OF EACH WIND TURBINES
- PLAN & OPTIMIZE GLOBAL MAINTENANCE EXPENSES
- EVALUATE & COMPARE EXECUTION QUALITY OF CONTRACTOR S WORKS

### A GLOBAL FLEET

- COLLECT & LEARN FROM VOLUMES OF DATA
- (statistical analysis, clustering, classifications, machine learning)
- MODEL & COMPARE INFLUENCE OF PARAMETERS (AGE, PLACE, SOIL, FOUDATION DESIGN)
- IMPROVE & OPTIMIZE FUTURE FOUNDATION DESIGNS AND COSTS





**Osmos Hellas SA**
**13 Garivaldi Street, 11742 Athens, Greece**
**Tel. +30 2107473630, e-mail: info@osmos-group.com.gr**