Operational Modal Analysis of Operating Wind Turbines: Application to Measured Data

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ABSTRACT

Previous works by the authors have shown that though Operational Modal Analysis (OMA) techniques are suitable for global dynamic analysis of a wind turbine under parked conditions, there are several issues in their application to operational wind turbines. These issues including time varying nature of the structure, presence of harmonic content in the loading (due to rotor rotation), considerable aerodynamic damping etc. prevent straightforward application of OMA to operational wind turbines. The authors have further proposed a strategy to combat these issues and modify OMA methodology to tune it for operational wind turbines. A successful implementation of this strategy was employed and demonstrated to work satisfactorily on simulated vibration response data for a 3MW wind turbine.

Work presented in the current paper in an extension of the pervious work and describes the details of the measurement campaign aimed at identifying modal parameters of ALSTOM's ECO 100 wind turbine. Since measuring on an operational wind turbine is a challenging job in itself, the paper also describes measurement planning and execution phases. The paper illustrates various key aspects related to practical measurements on an actual wind turbine and underlines the importance of proper planning and experiment design. The importance of a priori knowledge provided by finite element model based simulations is also underlined.

1. INTRODUCTION

Current focus of designing bigger and efficient wind turbines to meet the growing energy demands has put several challenges in front of wind turbine designers and manufacturers. A thorough understanding of wind turbine dynamics is necessary to meet these requirements. In this regard, use of Operational Modal Analysis (OMA), as a tool to understand wind turbine dynamics based on measured data, seems very promising.

Work presented in this paper builds on the studies showcased in [1-3]. While application of OMA is quite straight forward in case of parked wind turbines [4], several challenges are posed in case of operational wind turbines. Study [1] discussed the applicability limits of OMA to operational wind turbines. This work showed, based on analytical and simulation studies, that presence of considerable aeroelastic effects and rotational components in the excitation along with time varying nature of wind turbine structure restricts application of OMA to operational wind turbines as they stretch the basic OMA assumptions.

It is shown that since a wind turbine structure consists of several substructures that move with respect to each other (yawing of nacelle, pitching of blades, rotor rotation etc), the assumption regarding time invariance of the structure is not valid anymore. Additionally, it is further observed that aeroelastic forces exciting an operational wind turbine are characterized with prominent peaks which are accompanied with thick tails, there by not fulfilling the OMA requirement that excitation forces should have uniform broadband spectra. These forces are also found to be quite correlated at the rotational frequency and its harmonics. This nature of excitation forces also results in violation of basic OMA assumptions. This work was carried forward in [2] by combining the knowledge gained on the basis of these investigations and the recommendations that have been suggested to perform OMA on operational wind turbines.

In [2] it is shown by means of simulated data, how the above mentioned challenges can be overcome and OMA can be applied to operational wind turbines using careful planning and techniques such as multi-blade coordinate (MBC) transformation. The feasibility of OMA approach for understanding dynamics of operational wind turbines was shown by means of simulations on a model of ALSTOM WIND ECO 100 wind turbine; a 3 MW turbine.

Work presented in this paper is in continuation of the work presented in [2] and focuses on the experiment phase of the overall OMA campaign on ECO 100 turbine installed in La Collada, Tarragona, Spain. It is important to note that overall goal of this ongoing project is to utilize the strategies (formulated and consolidated by means of simulated data in [2]) to perform OMA on data acquired on ECO 100 turbine in operation for its dynamic characterization.

The paper is organized as follows. Section 2 describes the main motivation behind the project and lays down the goals and objectives for the two campaigns, short term and long term, in which the project is split. Section 3 discusses the design of the measurement campaigns, including test set up planning keeping in view the goals of the project, understanding gained from simulation based studies and limitations of OMA. The instrumentation and data acquisition phase is described in section 4. Main goal of this section is to not only provide the details of instrumentation and test layouts for short term and long term campaigns, but also share practical issues and challenges during this task and measures taken to overcome the same. Following this some preliminary results are presented and finally conclusions are drawn.

2. OBJECTIVES

The main motivation of this project is to obtain a reliable dynamic model of the wind turbine. Typically there exist several numeric models (such as aeroelastic models, finite element models etc) of a wind turbine to characterize its dynamics. However, it is imperative from dynamics point of view to validate these models by means of experimentation in order to prove and improve their reliability. Based on its suitability and applicability on large real-life structures and its ability to characterize the dynamics of large structures, Operational Modal Analysis (OMA) is chosen as a technique for experiment based characterization of wind turbine dynamics. The choice of OMA as a preferred technique for this task was validated by means of a pre study whose results are already published in [2].

The objectives of this project can be viewed from three different perspectives;

- ***Structural***: To get an understanding of the dynamic behavior of the wind turbine and the interaction between the main structural elements (systems and subsystems) of the turbine (i.e. tower, drive train, rotor and main frame) with other mechanical and electrical subsystems (i.e. generator, transformer, gearbox and inverter). This understanding is expected to aid in the overall design process of these structural elements by means of verification of existing design and redesigning if necessary. Yet another objective in this respect is to correlate the experimentally identified system with FE/Multibody analysis based simulations.
- ***Controls***: Use the OMA based system identification for better controller design by using results from system identification and extracting linear models from real experiments and compare them with linear models extracted from the simulations. This is important since control performance is dependent on accuracy of these linear models and hence it's important to validate these models for achieving optimal control [5].
- ***Mechanical***: Validation of models of drive train and elastic mounts of mechanical components (gearbox and generator).

To accomplish the goals and objectives of characterizing the dynamics of wind turbine structure and substructures under the variety of operational conditions, it is decided to carry out the project in two stages; a *long term campaign* and a s*hort term campaign*.

The aim of the l*ong term campaign* is to experimentally determine the modes of the main structural components of the wind turbine; i.e. estimation of tower modes, rotor modes, drive train mode and mainframe modes for a number of operational working points that collectively represent the complete operational conditions of the wind turbine. Since this requires data acquisition for a long period of time (that is deemed sufficient in order to ensure that data corresponding to various operational conditions is acquired), this campaign is termed long term campaign. In addition to the above mentioned modes, the gearbox and generator modes are also required to be estimated when turbine is operating at nominal power and when it's operating at 1/3 of nominal power. On the other hand, the s*hort term campaign* is aimed at identification of modes of other mechanical and electrical subsystems (transformer and electrical cabinets) and understanding their interaction with nacelle and mainframe. The details of these campaigns, keeping in view the overall objectives of the project, are provided in the next section, which describes the design and planning of experiments pertaining to the two campaigns.

3. DESIGN OF EXPERIMENTS

The results of the long term campaign are to be presented in the form of a Campbell diagram [6] which is a representation of wind turbine dynamics in its operating regime, typically given in terms of varying wind speeds. Thus, to characterize the dynamics of the operational turbine, operational working points are chosen in the wind speed range of 3 m/s to 25 m/s in steps of 2 m/s. For the short term campaign, aimed at identification of modes of other mechanical and electrical subsystems, the identification procedure is independent of turbine operating conditions. The modes of interest (for both campaigns) are listed in Table 1.

While designing an experiment of this kind, one has to keep in mind the practical constraints which play a significant role in terms of what is measurable and what is not. One of the foremost practical issues associated with this experimental campaign is that measurement on the turbine blades is quite difficult. From the observability point of view, it would have been ideal to instrument the three blades at various sections (along the length) as that would have significantly enhanced the chances of observing and estimating the rotor modes. However, in this project, this was not a possibility as only a limited section of the blades was approachable for sensor instrumentation and that too would have required special arrangements with regards to measured data transfer and synchronization. However it was expected that the rotor-related modes will affect dynamics of the tower and nacelle, thus these modes can be detected from the tower and nacelle measurements. This supposition was partly confirmed by OMA performed on simulated data: the rotor modes were found in tower measurements, although it was comparatively difficult to distinguish and classify them.

Significance of simulation studies in test planning is further underlined by the fact that the simulations provide considerable aid in choosing the sensor locations so as to observe all the modes of interest.

Large size of the turbine also makes it important to plan the placement of various data acquisition systems. There are other considerations as well, with regards to the data acquisition system, which are important from test planning perspective. A measurement campaign along the lines of this project puts the following requirements on the design of data acquisition system; a high quality data acquisition system that

- can continuously acquire data for a long period of time (several months),
- can be used as a distributed and synchronized system,
- can support a large number of measurement channels,
- can support auxiliary channels (such as wind speed, yaw angle, tacho signals etc), and
- can be remotely monitored and operated.

Since the measurement system is a distributed system, placement of data acquisition front ends plays an important role in optimizing the required cable length and also effective management of the cables, thus aiding in minimizing the workload related to wind turbine instrumentation.

The demands of a robust data acquisition system also emerge from the need of long term campaign. Since the project aims at characterizing the dynamics of an operational turbine under various operating conditions, it is necessary that the data is acquired over a long period of time. This requires data acquisition system to be remotely monitored, capable of automatic operation and needs of emergency backup in case of power shutdowns. These points are also taken into consideration while planning the measurement phase. It is further decided, keeping in view these requirements that the duration of long term campaign is 3 months from August, 2010 to October, 2010. The choice of this period is governed by the fact that the site at which the wind turbine prototype is installed is expected to experience sufficient wind during this timeframe, and that three months time period should suffice in terms of capturing all the operational modes of the turbine.

Table 1: Modes to be identified

	Systems and Subsystems	Modes	Abbreviations
Main Structural Components	Tower Dominated Modes	1st Fore Aft Mode	T1FA
		2nd Fore Aft Mode	T2FA
		1st Side to Side Mode	T1SS
		2nd Side to Side Mode	T2SS
		Torsional Mode	T1T
	Drive Train Dominated Modes	1st Drive Train Mode	DT1
	Rotor Dominated Modes	1st Collective In Plane Mode	I1C
		2nd Collective In Plane Mode	I2C
		1st Collective Out of Plane Mode	O1C
		2nd Collective Out of Plane Mode	O2C
		1st Forward and Backward In Plane Whirling Modes	I1FW, I1BW (when parked: I1Vert, I1Hor)
		2nd Forward and Backward In Plane Whirling Modes	I2FW, I2BW (when parked: I2Vert, I2Hor)
		1st Forward and Backward Out of Plane Whirling Modes	O1FW, O1BW (when parked: O1Yaw, O1Tilt)
		2nd Forward and Backward Out of Plane Whirling Mode	O2FW, O2BW (when parked: O2Yaw, O2Tilt)
	Main Frame	Fore Aft Bending Mode	
		Side to Side Bending Mode	
		Torsional Mode	
	Nacelle	Fore Aft Bending Mode	
		Side to Side Bending Mode	
		Torsional Mode	
Other Mechanical and Electrical Components	Transformer	3 first modes (3 principal axes of inertia)	
	Electrical Cabinets	3 first modes (3 principal axes of inertia)	
	Generator	3 first modes (3 principal axes of inertia)	
		Vertical Mode	
	Gearbox	3 first modes (3 principal axes of inertia)	
		Vertical Mode	

4. INSTRUMENTATION AND MEASUREMENTS

The measurements are performed on ALSTOM ECO 100 prototype located in La Collada, Tarragona, Spain (Fig. 1). ECO 100 is a three bladed turbine with a rated power output of 3 MW and has rotor diameter of 100.8 m [7].

Figure 1: The ECO 100 Wind Turbine

4.1 Control Signals

As previously stated, the project is run in two stages aiming at different set of objectives. Since the project comprises of two separate measurement campaigns, the choice of locations where acceleration signals are to be measured differ in case of long term and short term campaigns. However, there are several control signals that are to be measured in case of both campaigns. These control signals are required in order to define the turbine operating conditions or status, as one of the project objectives requires measurement of turbine dynamic characteristics under various operating conditions. The control signals measured in this project are: wind direction, wind speed, convertor torque, torque reference, yaw angle, low speed shaft rotation, high speed shaft rotation, pitch angle and active power. While all of these signals help in characterizing the operating conditions of the turbine, they also serve a very useful purpose of classifying the vast amount of data collected during the project. At this point, it is important to realize that the combined time span of both campaigns is close to 3.5 months during which the acquisition system will be continuously acquiring data. Hence an effective means of classifying this data is paramount to thoroughly exploit the acquired data for dynamic analysis. Further, yaw angle signal is also used for coordinate transformation in order to correctly align the nacelle and the tower when the turbine is yawing, as explained in section 3.5.

4.2 Data Acquisition System and Transducers

Keeping in view the demands of the project and based on the criterion listed in previous section, four Bruel & Kjaer PULSE IDA Frontends (Type 3560) are used. These frontends are capable of being configured for functioning as a distributed system by means of a synchronization cable. An important reason for choosing this particular type of frontends is the need to have a wide dynamic range so as to cover all the possible vibration levels during the entire measurement campaign. The frontends are also capable of handling the auxiliary signals coming from the control system of the turbine.

Fig. 2 shows the location of Frontends in the turbine during the measurement phase. Two frontends are placed in the tower and other two are placed in the nacelle. The two frontends in the tower, with 6 channels each, are located at 24m and 62m level platforms and are only used for tower acceleration measurements during long term campaign. These are not utilized in the short term campaign during which data is acquired by means of two frontends in the nacelle only.

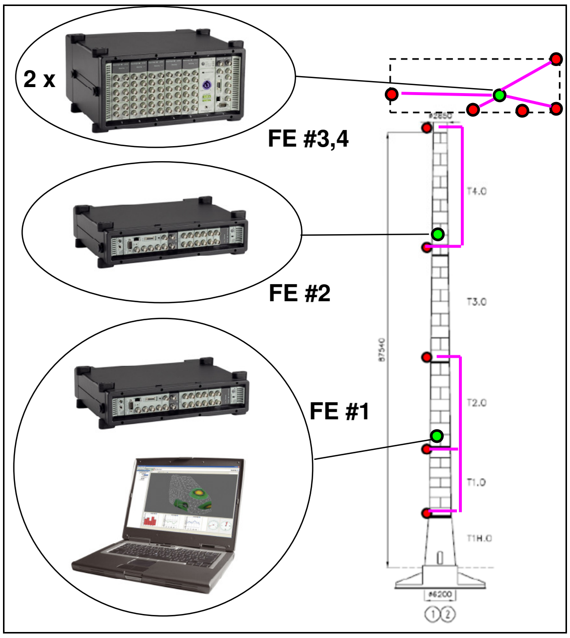


Figure 2: Frontend Locations

Since the nacelle is capable of yawing about the tower during operation, special care has to be taken with regards to cable handling since the data acquisition system is distributed in the tower and the nacelle. This requires ascertaining proper length of various cables (synchronization cables, data cables etc.) so that cable coiling due to yaw is avoided.

The modal frequencies of interest, for the wind turbine structure, are expected to be below 50 Hz, and the expected vibration magnitude is below 2g. Based on these considerations, Bruel & Kjaer DC accelerometers Type 4575 are chosen as they are very sensitive and have suitable measurement and frequency range. An optical tachoprobe (B&K Type MM-0360) is also used to precisely measure the low shaft RPM.

4.3 Softwares

Data acquisition software used in this project is Bruel & Kjaer PULSE Data Recorder Type 7780. Apart from the data acquisition software, remote monitoring software is also used to monitor the system for variety of reasons including restarting of acquisition software, rebooting the computer, downloading the measured data etc.

Once the measurement campaign is over, the data will be analyzed with PULSE OMA Type 7760 to estimate modal parameters for dynamic characterization of the turbine.

4.4 Short Term Measurement Campaign

The main goal of the short term campaign is to identify the modal parameters of various mechanical and electrical subsystems and understand their dynamics in terms of their interaction with nacelle mainframe. This campaign also serves a secondary purpose of providing a check for the performance of the data acquisition purpose before the start of the long term campaign. The structures instrumented in this campaign are nacelle mainframe, transformer, convertor and control cabinets. During this campaign, acceleration measurements are taken at 20 locations, with nacelle frame instrumented most heavily (14 locations, 38 channels, including central and frontal mainframe, see Fig. 3).

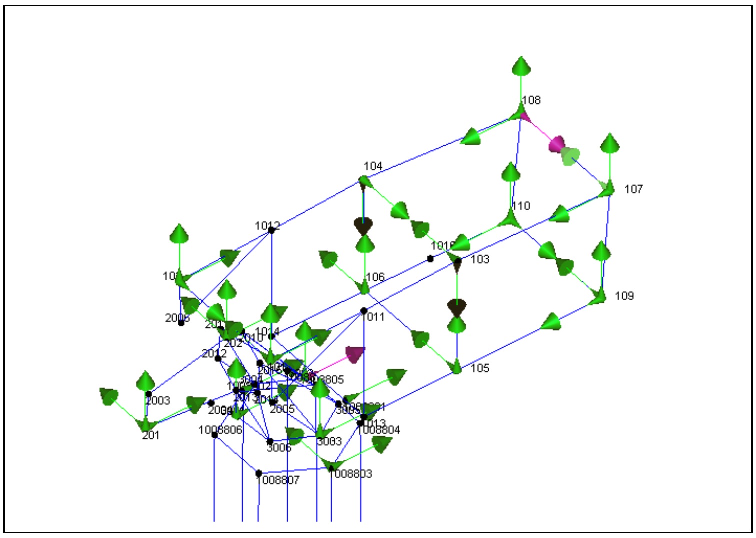


Figure 3: Nacelle Mainframe Instrumentation for Short Term Campaign

The instrumentation set up on transformer and electrical cabinets consists of two measurement points each primarily on the big diagonal of the structures and acceleration is measured in all three principal directions.

4.5 Long Term Measurement Campaign

In the long term campaign, spanning over 3 months, the tower is also instrumented along with the gearbox and the generator, in addition to the nacelle, which is also instrumented in case of short term campaign.

Instrumentation on the tower is shown in Figure 4. The measurement locations are indicated in the Fig. 4(a) by red circles. While choosing these locations, the convenience of sensor mounting and other practicalities are taken in consideration. Thus these locations are chosen such that there are platforms available nearby. The chosen levels are at an height of 12, 24, 42, 62 and 90 m. There are two accelerometers mounted as shown in Figure 4(c) at the all the levels except the top level (at 90 m) where 4 sensors are mounted in the configuration shown in Figure 4(b). The chosen configuration is primarily aimed at identification of tower bending modes. The two extra sensors on the tower top are placed to capture the tower torsion. Thus in total the tower is instrumented at 5 levels (11 locations) using 12 accelerometers.

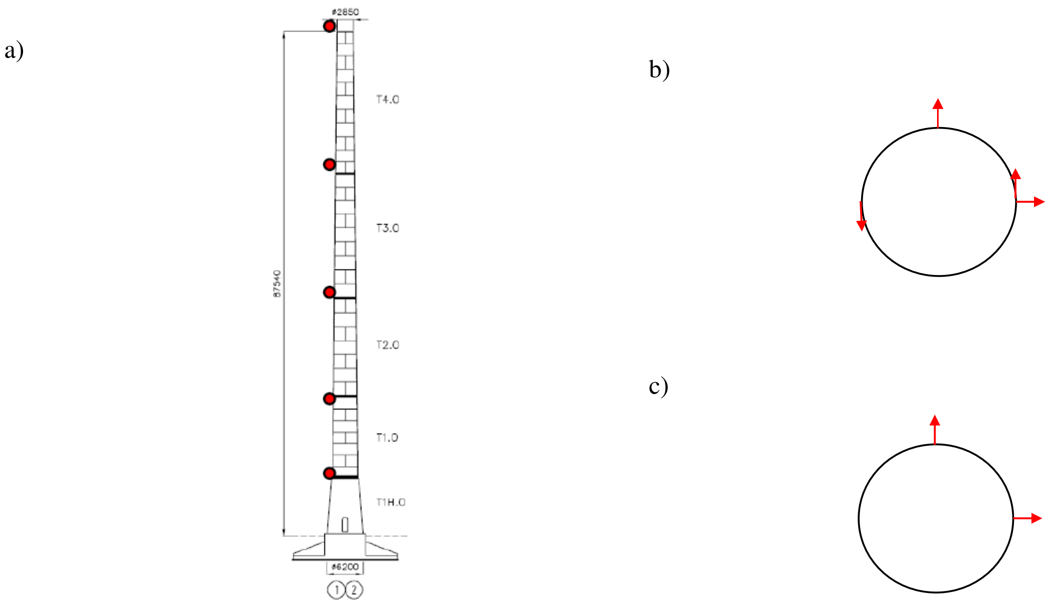


Figure 4: Tower Instrumentation for Long Term Campaign

In case of gearbox and generator, 3 locations each are selected and acceleration is measured in all three directions at these locations.

The fact that a wind turbine is a complex structure, which involves rotational movement of various substructures with respect to each other, necessitates careful defining of various coordinate systems and the relation amongst them in order to understand the dynamics of the overall system and the interactions between individual subsystems. In context of this project, motion of tower-nacelle subsystem is of particular importance. This is due to the fact that proper designing of various coordinate systems will ensure correct visualization of estimated mode shapes, which is very necessary for correct understanding and nomenclature of the identified modes.

The relative motion of the tower-nacelle subsystems is due to the yawing of the nacelle about the top of the tower; this rotation being defined by the yaw angle. Accelerometers mounted on the tower measure the tower vibration w.r.t. ground coordinate system (GCS) and along the axes of GCS; while accelerometers mounted on the nacelle measure accelerations w.r.t. GCS but along the axis of the nacelle. In order to analyze the two subsystems together, it is necessary to describe them in the same coordinate system before analyzing them. Thus it is necessary to take yaw into account.

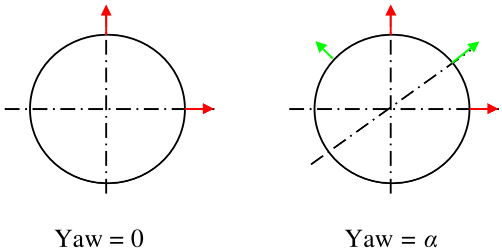


Figure 5: Yaw angle illustration

In the current project it is the tower accelerations that are transformed into the local coordinate system (LCS) of the nacelle. In Figure 5, the red arrows represent the physical accelerometers on the tower. As yaw changes, the acceleration signals are transformed so that they are in the coordinate system defined by the green arrows. This is mathematically equivalent to performing simple rotation using Eqn. 1. These new "virtual" accelerations signals are to be used as input for OMA.

$$
\begin{aligned}
x_1(t) &= x_0(t)\cos\alpha + y_0(t)\sin\alpha \\
y_1(t) &= -x_0(t)\sin\alpha + y_0(t)\cos\alpha
\end{aligned}
\qquad (1)
$$

4.6 Data Acquisition

During the course of the entire project, data is acquired at a sampling rate of 256 Hz. Duration of each measurement is 15 minutes. As mentioned earlier, each recording file contains (meta) data channel with wind speed and direction, yaw angle, state of the wind turbine, etc. Using the metadata, a recording database was created. Querying such a database, one can quickly find datasets satisfying the required parameters, e.g. mean wind speed, RPM, production state, etc.

5. PRELIMINARY RESULTS

Since the measurements are still in the progress at the moment of writing the paper, only preliminary results will be discussed in this section.

As mentioned before, one of the main challenges of this project was mode identification based on incomplete datasets (no information about blade acceleration is available). The approach taken in this project is to use the general knowledge about wind turbine dynamics [8] combined with the results of simulations using commercial aeroelastic code. The latest, however, models the wind turbine in a quite simplistic way, for example, the tower is modeled without torsional stiffness; the nacelle is modeled just as a point mass. Trial operational modal analysis using incomplete datasets from the simulations showed that some important modes cannot be observed or identified. This required us to create another finite element model in order to better simulate the details of the nacelle and tower dynamics.

The model of the ALSTOM ECO100 wind turbine was developed using ANSYS software in IKERLAN. The model includes the main structural and inertial components. The tower, blades, low speed shaft and rear frame were modeled as beam elements. Geometry, stiffness and mass properties for the tower and blades were taken from the blades and tower suppliers. The stiffness of the beam elements of the rear frame were updated using an existing shell elements model, so that the main structural mode shapes and frequencies are better correlated.

Heavy components as the central mainframe, front mainframe and hub were modeled using superelements, which were previously calculated from 3D FE models. Gearbox casing was also modeled as a superelement. Some other components as the generator, electric cabinets and converter were also included as rigid boxes with concentrated mass properties. Elastic connections between components and bearings were modeled using 6 DOF spring elements.

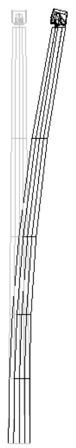
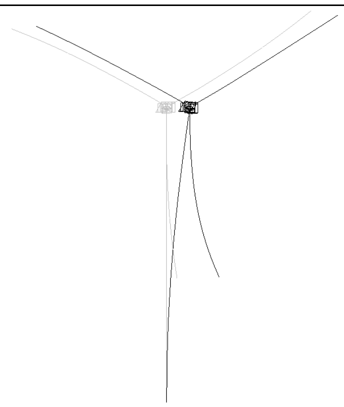
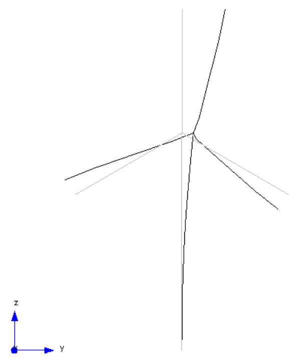
As discussed in [1, 2], the dynamics of a wind turbine while operating is quite rich and complicated. Therefore it was decided to start with a simpler parked case. Also to start with, a dataset is chosen with a steady in strength and direction moderate wind (8 m/s); the wind turbine is not yawing, and the pitch of all blades is 84^0 thus creating least aerodynamic forces acting on the blades. During the observed 15 minutes the rotor is slowly rotating (just few full revolutions during the recording period).

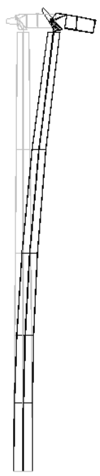
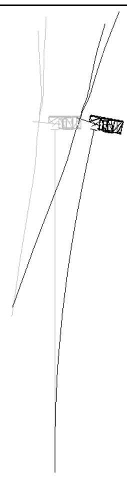
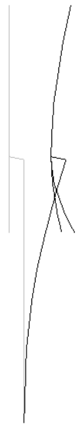
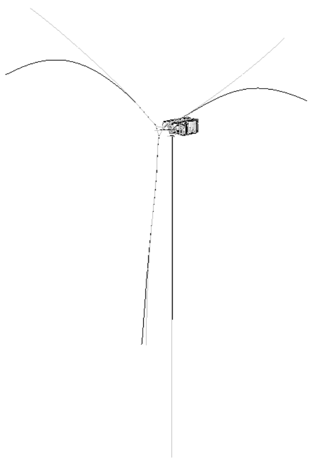
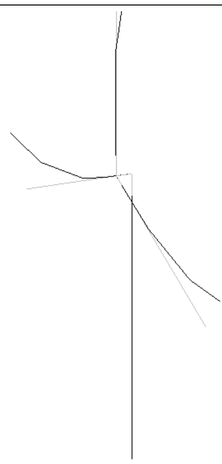
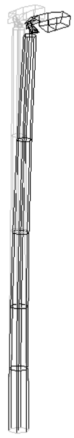
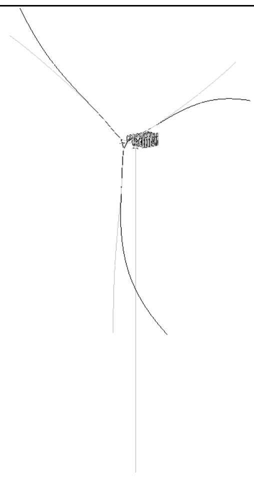
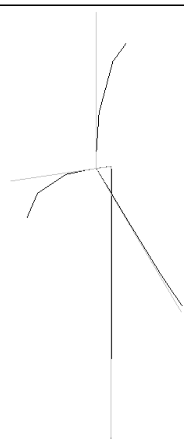
The obtained acceleration data is preprocessed according to (1) in order to take into account the yaw (i.e. the mutual orientation of the tower and the nacelle). Bruel and Kjaer PULSE Operational Modal Analysis Type 7760 is used for data analysis and SSI UPC algorithm with enabled Crystal Clear SSI option is chosen for modal parameter estimation [9].

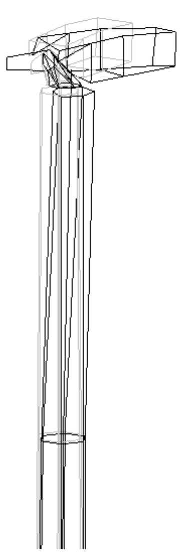
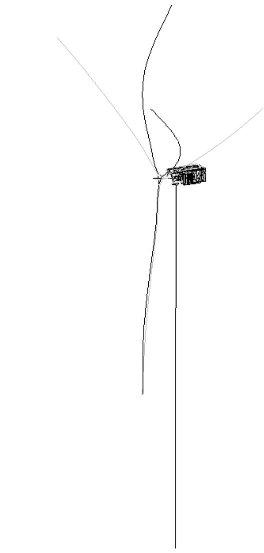
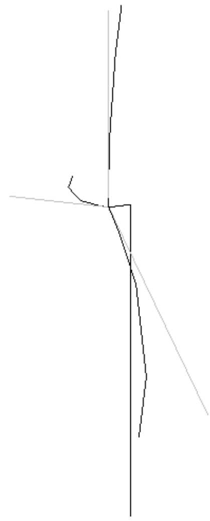
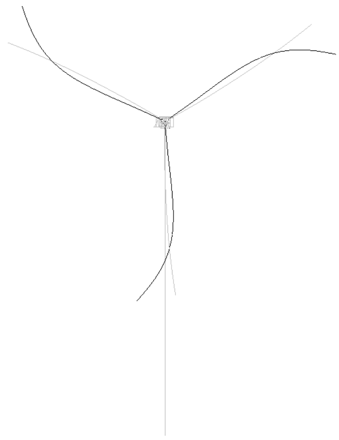
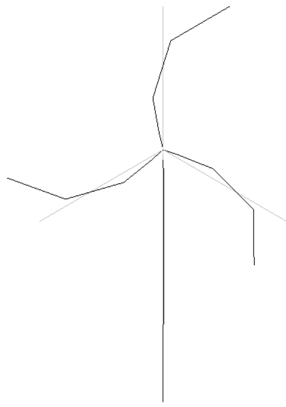
Table 2 compares the mode shapes obtained using three different techniques: OMA on experimental data, eigenmodes obtained using ANSYS eigenvalue solver and OMA on simulated data [2]. The table demonstrates how the similarity in mode shapes is used for naming the experimentally obtained mode shapes (see also comments placed in the table).

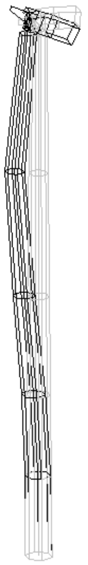
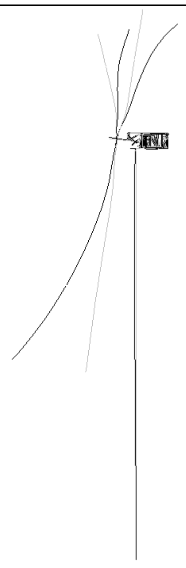
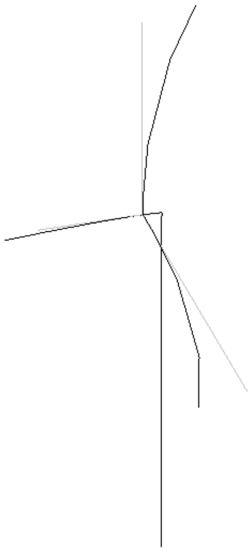
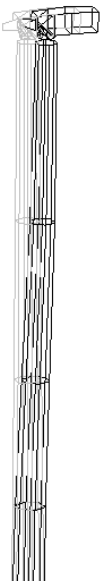
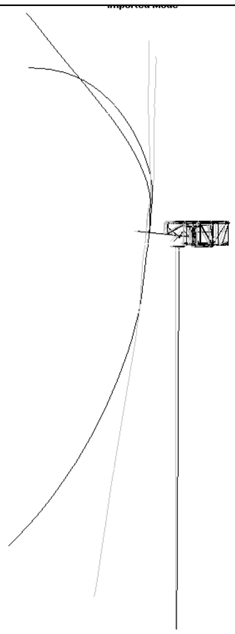
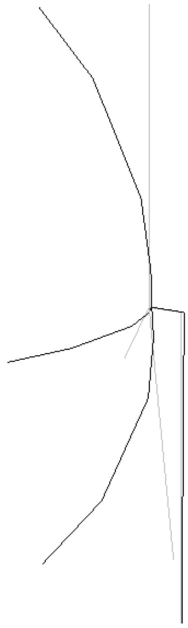
Based on this study it can be said that the technique generally works but there are still difficulties with naming some modes, e.g. mode number 4 which seemingly belongs to in-plane family but it is difficult to tell if this is a vertical (I1Vert) or horizontal (I1Hor) mode.

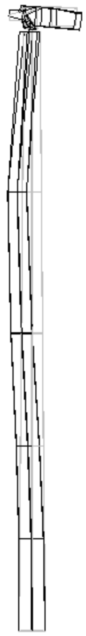
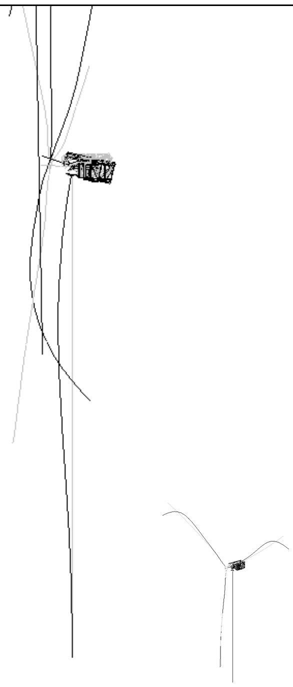
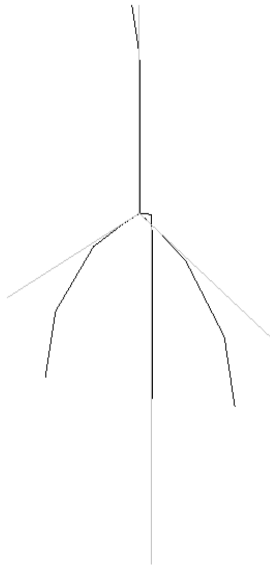
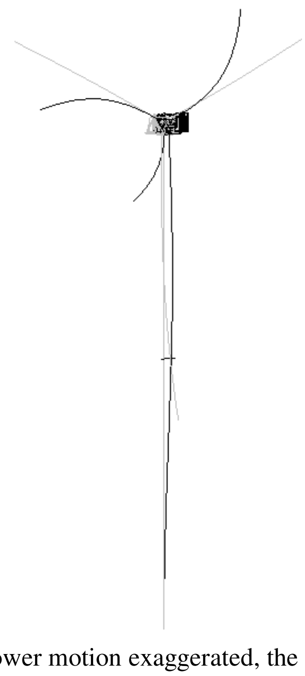
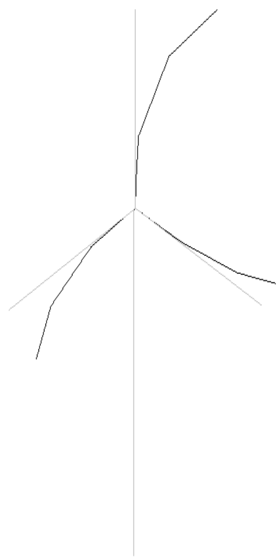
Table 2: Mode Shape Comparison

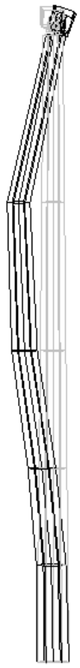
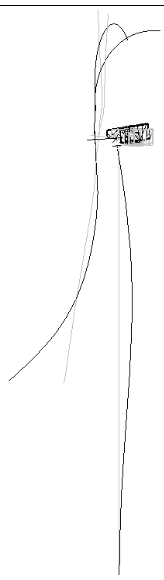
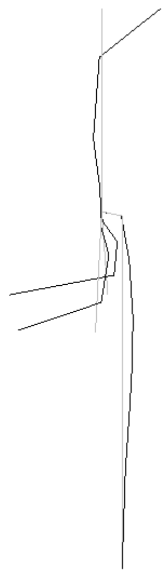
<table>
<tr><th rowspan="2">#</th><th rowspan="2">Mode name</th><th colspan="3">Mode shapes obtained using</th></tr>
<tr><th>OMA on experimental data</th><th>ANSYS eigenvalue solver</th><th>OMA on simulated data</th></tr>
<tr><td>1</td><td>T1SS</td><td>
This mode has much higher damping comparing to T1FA which is probably due to higher aerodynamic resistance of the nacelle and blades (pitch is 86^0)</td><td></td><td>
The mode was found using frequency domain decomposition OMA algorithm (FDD) [9].</td></tr>
</table>

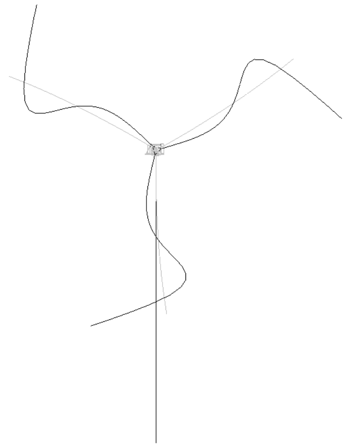
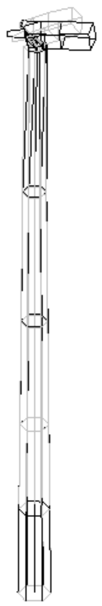
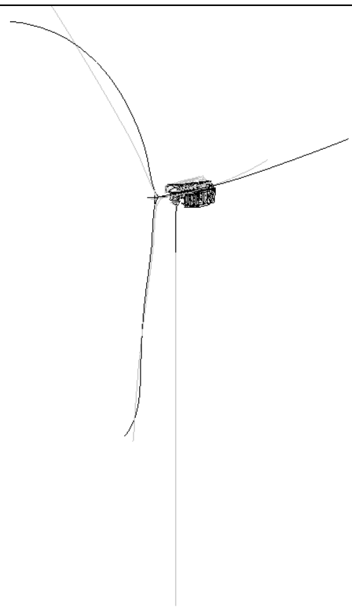
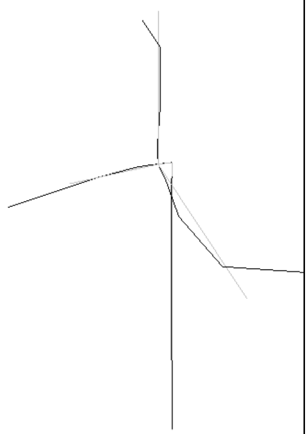
2	T1FA			
3	I1Vert	Not found so far. Probable reason is that this mode is heavily damped due to the blades aerodynamics	 In contrast to I1Hor, this mode does not have tower side-to-side component but rather has for-aft one due to designed rotor 5^0 tilt.	
4	I1Hor	 Not certain, this can also be I1Vert. More likely this is I1Hor due to tower side-to-side motion		

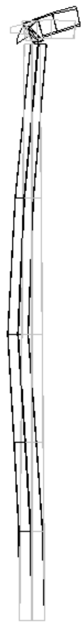
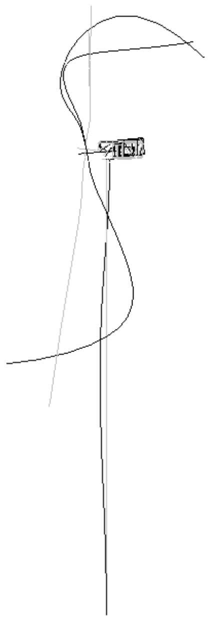
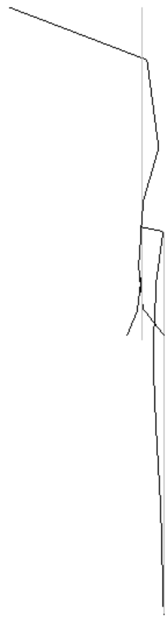
5	O1Yaw	 This mode can be identified due to a torsional component in the tower motion		
6	I1C	Not found so far. Probable reason is that this mode is heavily damped due to the blades aerodynamics		

7	O1Tilt	 The mode can be identified by second tower bending component in fore-aft direction		
8	O1C	 This mode can be identified by tower fore-aft motion		

9	I2Vert	 The mode can be identified by second tower fore-aft component and nacelle tilt	 The tower displacement is exaggerated and blades cut out. The inset at the bottom shows blades' deformation	
10	I2Hor	 The mode can be recognized by second tower side-to-side motion and nacelle yaw. This mode is antisymmetric to I2Vert	 Tower motion exaggerated, the blades are cut off.	

11	T2SS	 This mode has a higher damping compare to T2FA which is probably due to higher aerodynamic resistance of the nacelle and the fully pitched blades	 Due to blades' curvature and rotor plane inclination, this mode is coupled with T2FA which has almost the same frequency.	Not found. Probably because of the higher damping.
12	T2FA		 Note, the tower and blades have comparable magnitude in contrast to e.g. I2Vert where the tower displacement had to be exaggerated in order to notice its deformation with respect to the blades	

13	I2C	Not identified. Probably, not observable using tower and nacelle instrumentation. In FEM, we cannot see any tower and nacelle motion associated with this mode (very little Fore-Aft motion)		This mode is located higher in frequency range.
14	O2Yaw	 The mode is characterized by significant torsional motion of the tower and the nacelle		 The nacelle and tower torsion is not modeled. Thus one cannot observe these two motions which are important for identification. ANSYS-based FEM which takes into account tower torsion and nacelle deformations is used instead.

15	O2Tilt	 This mode involves the tilt of the nacelle and tower fore-aft bending mode		

6. CONCLUDING REMARKS

Experimental dynamic characterization of an operational wind turbine is a challenging task from both instrumentation and algorithmic points of view. This paper describes the measurement phase and preliminary results for ALSTOM's ECO 100 wind turbine prototype. The main aim of the project is to perform experimental dynamic characterization of the operational wind turbine using Operational Modal Analysis. Since measurements form a key part of the project, the paper shows how the planning and design of experiments are done in order to achieve the objectives of the project.

The preliminary results, corresponding to a simple case (parked wind turbine), are shown. It is observed that the main problem lies in observability and identification of rotor-related modes due to unavailability of acceleration data from the blades. The paper shows how this limitation can be dealt with the aid of mode shapes obtained from FEM based simulations.

The project described in this paper is currently running and its successful completion is expected to not only achieve the objectives mentioned in the paper but also provide a framework for carrying out OMA based dynamic characterization of wind turbines.

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