VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Francisco De Nolasco Santos**

The public defense will take place on **Thursday 14th December 2023 at 3:00pm** in room **D.2.01** (Building **D,** VUB Main Campus)

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DATA –DRIVEN METHODOLOGIES FOR FARM-WIDE FATIGUE LOAD ESTIMATION ON OFFSHORE WIND TURBINE

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Abstract of the PhD research

With older wind farms quickly reaching their end of lifetime and newer farms taking fatigue into their design consideration, an accurate strategy for fatigue life monitoring which optimizes the management of the asset is a pressing industry challenge. A successful methodology which enables to accurately estimate fatigue across the farm will aid all industry players – operators and developers alike – to optimize their assets and reduce the overall cost of offshore wind energy. This context presents big opportunities for a more widespread use of sensors and the employment of machine learning algorithms, which might in some instances suppress the need to directly monitor fatigue through strain gauges (of labour-intensive installation and maintenance for a single-purpose sensor), thus dramatically reducing costs. This would be achieved through the inclusion of accelerometers which, either already are installed, or have a low-cost installation. It is in this framework that this thesis seeks to support offshore wind operators and developers into making better maintenance and lifetime decisions, such as possible lifetime extensions, by providing farm-wide fatigue load estimation. This work's research questions attempt to address this by asking if fatigue estimation is feasible without farm-wide strain gauge instrumentation, which of full bending moment signal reconstruction or ten-minute statistical description is the better approach, if the described methodology is applicable to different foundation types and if physical knowledge and uncertainty can be embedded in the baseline methodology and provide a more nuanced view. Some key findings of this work entailed the preference for statistical description instead of full signal reconstruction due to mounting error rates, effective employment of the algorithm for fatigue estimation in jacket- and monopile-foundations wind turbines, optimal sensor and feature selection, embedding problem-related physics into the data-driven methodology and re-framing the work done based on a continuous monitoring assumption and the ability of performing population-based model training. Additionally, the cornerstones for further developments of the main methodology were set by addressing uncertainty quantification and viewing wind farms as a whole system, representing them as graphs.