FRANCE ENERGIES MARINES

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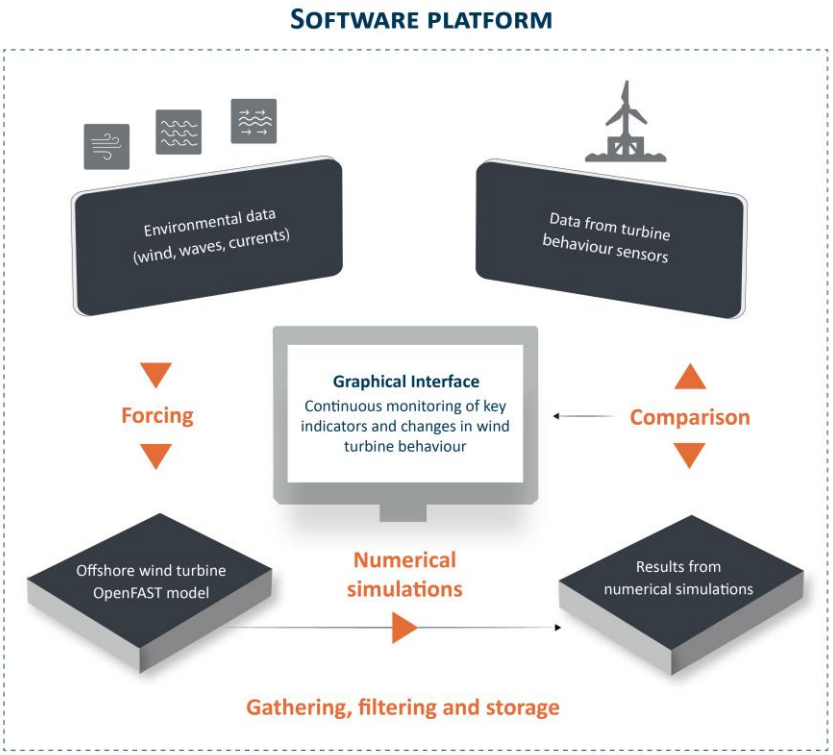
FLOATING WIND - High-performance tools proven in real-life conditions to improve the reliability of offshore systems

Reliability as a major challenge for floating offshore wind turbines

At both national and international level, offshore wind energy is now recognised as one of the pillars of the energy transition. Floating wind technology will gradually take on a significant market share in this sector. In order to control the economic equation linked to maintenance costs, it is crucial to have effective tools for optimising maintenance and improving the management of systems lifetime. One of the major challenges therefore lies in the ability to assess the actual state of fatigue of structures, and to identify any potential anomalies. This is the aim of the DIONYSOS R&D project, which uses a methodology based on the concept of a digital twin, in other words a virtual replica of a physical system that is subjected to the environmental conditions encountered by the system at sea, enabling its performance to be simulated, analysed and optimised in real time.

A high-performance software platform developed in-house and tested on offshore demonstrators



The first two phases in the creation of the digital twin, carried out in parallel, involved developing a digital model of a floating wind turbine, and specifying and then deploying sensors on a machine at sea and in operation.

To enable the data collected at sea to be coupled and analysed with the data from the numerical simulations, a software platform has been fully developed by France Energies Marines. It forms the core of the digital twin developed for this project. This platform gathers and filters the data, as well as forcing the numerical model with environmental data (wind, waves, currents) to run the simulations. It also handles data storage and features a graphical control interface for monitoring key indicators and the continuous evolution of the wind turbine's behaviour.

This platform has been deployed and tested on two floating offshore wind turbines: Zefyros (North Sea, off Norway) and DemoSATH (Bay of Biscay, off Spain). Its modularity allows it to be coupled with various numerical modelling tools available on the market, such as OpenFAST, SIMA™ and DeepLines™.

Open licence tools for use by the sector

Four types of digital tools have been developed as part of DIONYSOS, for use by the sector. They are available under an open licence, documented and accessible on France Energies Marines' GitLab software forge.

- Simuoptuna which is a tool for optimising the parameters intrinsic to the numerical models involved in modelling a floating offshore wind turbine. By forcing the global numerical model with *in situ*-data, it becomes possible to predict key parameters that have not been measured, but which are crucial to the reliability and efficiency of the wind turbine, such as mooring lines tension, electricity production or the bending moment at the blades. Having a digital model calibrated with real data also makes it possible to generate virtual sensors that offer more accurate monitoring of the fatigue life of critical components.
- Torchydra which offers models and tutorials for organising the repository of deep learning models.
- Zefyros OpenFAST which is the OpenFAST numerical model of the Zefyros wind turbine validated with measurements on the offshore system.
- TwinViews which is a graphical interface for comparing simulations from Zefyros OpenFAST with in situ measurements and includes an advanced graphical visualisation system.

Towards better detection and categorisation of behavioural anomalies of floating wind turbines

The results from the digital twin were analysed using a 'model-based method', in which the model is deliberately faulted to simulate abnormal behaviour, which is then categorised (e.g. mooring displacement). The dataset generated in this way can be applied to real data to identify and classify any anomalies. This will enable floating wind farm operators to optimise the maintenance operations required to return the wind farm to normal operation.
In parallel with this work, a deep learning method was used to train a neural network to recognise abnormal behaviour in data from *in situ* measurements, compared with a reference system of situations defined as normal. Compared with a conventional engineering method, the results obtained show greater reliability in predicting anomalies. This method is also perfectly suited to companies that develop sensors and want to improve the performance of their detection algorithms.

DIONYSOS project in a nutshell

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⇨ See web page of the project

Duration: 36 months (2021-2024) | **Budget:** €1,300k

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