Identification of Offshore Wind Turbine Foundation Properties from Monitoring Data

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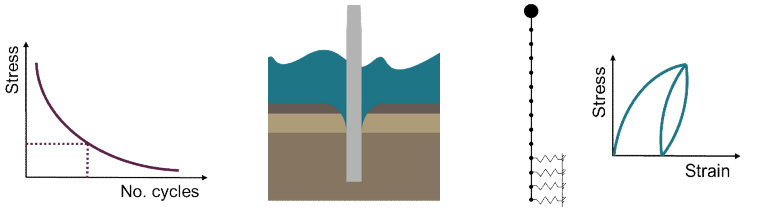
Introduction

Problem: Inherent uncertainties in the foundation properties of offshore wind turbines (OWT)

Effect: Overly-conservative design, incorrect prediction of dynamic properties, inaccurate fatigue life estimation

Aim: Predict foundation properties from OWT monitoring data using system identification techniques

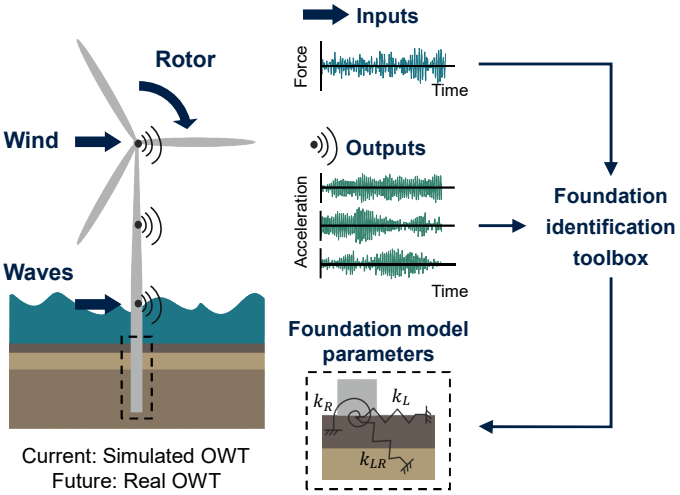
Motive: Knowledge of in-situ foundation properties could enable:



Lifetime assessment | **Damage detection** | **Design method development**

Project concept

Develop **foundation identification** toolbox for OWT with monopile



Current: Simulated OWT
Future: Real OWT

Identification methods

The toolbox will contain various methods adapted for OWT

Method Characteristics	Capable of identifying:	
	Modal Properties	Structural Properties
Linear only	**N4SID** **ERA**	**T-SSID**
Linear or Nonlinear		**Kalman Filter** **Model Updating**

Deterministic – gives most likely value
Stochastic – gives likelihood distribution

- N4SID and ERA are subspace state space methods
- T-SSID extends N4SID to identify structural parameters
- Kalman Filter and Model Updating require a system model

Modelling an OWT using FAST*

Investigating the **simulated dynamic behaviour** with **varied foundation conditions** led to the following conclusions

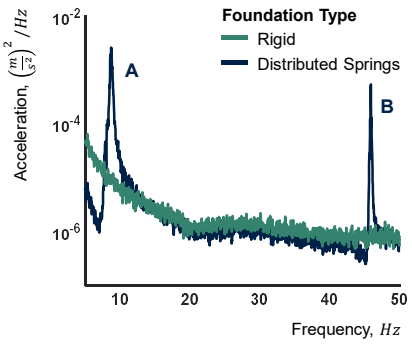
Difficulties for identification methods:

- Strong interaction between blade and tower bending
- Higher frequency and blade dominated modes

Foundation indicators:

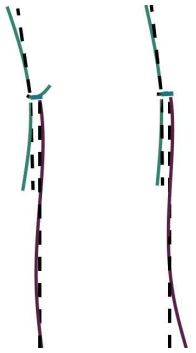
- 2nd tower mode more dependent on foundation stiffness than 1st
- Foundation flexibility introduces high frequency modes (demonstrated below)

Power spectral density of OWT mid-tower acceleration



The peaks, labelled A and B, indicate structure natural frequencies

Natural frequency modeshapes



A Foundation rotation | **B** Foundation translation

**FAST is an open source aero-elastic tool*

Summary

- The project will develop a toolbox capable of identifying OWT foundation properties from monitoring data
- An OWT with multiple foundation models was simulated to analyse the effect of foundation flexibility on the dynamics
- The insights gained will be used to adapt existing identification methods to work for OWTs
- The toolbox will exploit the different characteristics of various identification methods