# Modelling tools and Methodologies for Floating Offshore Wind Turbines

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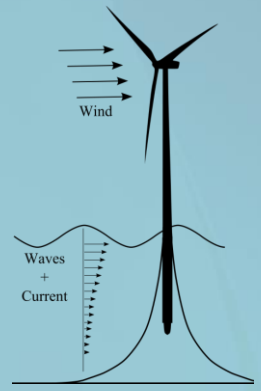
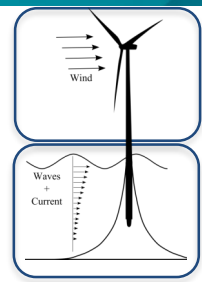
**Final Workshop**

**Project coordinator:** WavEC

**MARIN (Maritime Research Institute Netherlands)**

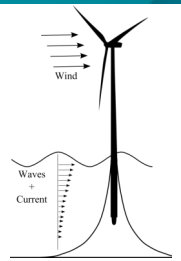
**GRANT AGREEMENT Nº:** 607656
**PROJECT:** OceaNET





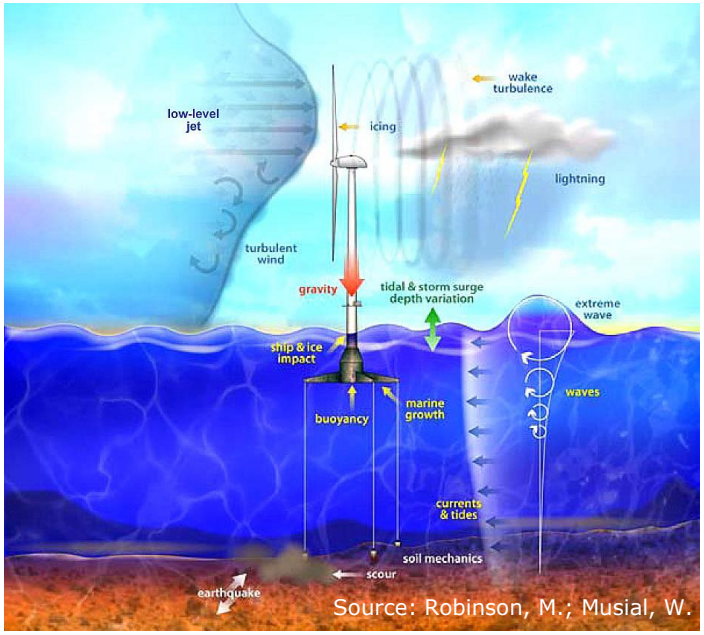

# Introduction

- Standard practice for offshore industry:
  - Numerical simulations with engineering codes, e.g.:
    - Potential flow solver
    - Blade-Element Momentum Theory codes
- Different approach:
  - Investigation of the usage of a more sophisticated tool:
    - Viscous flow solver (RANS based CFD code)
  - Looking at advantages and disadvantages of using such tools
    - In which cases do we need viscous flow solvers?




# Introduction

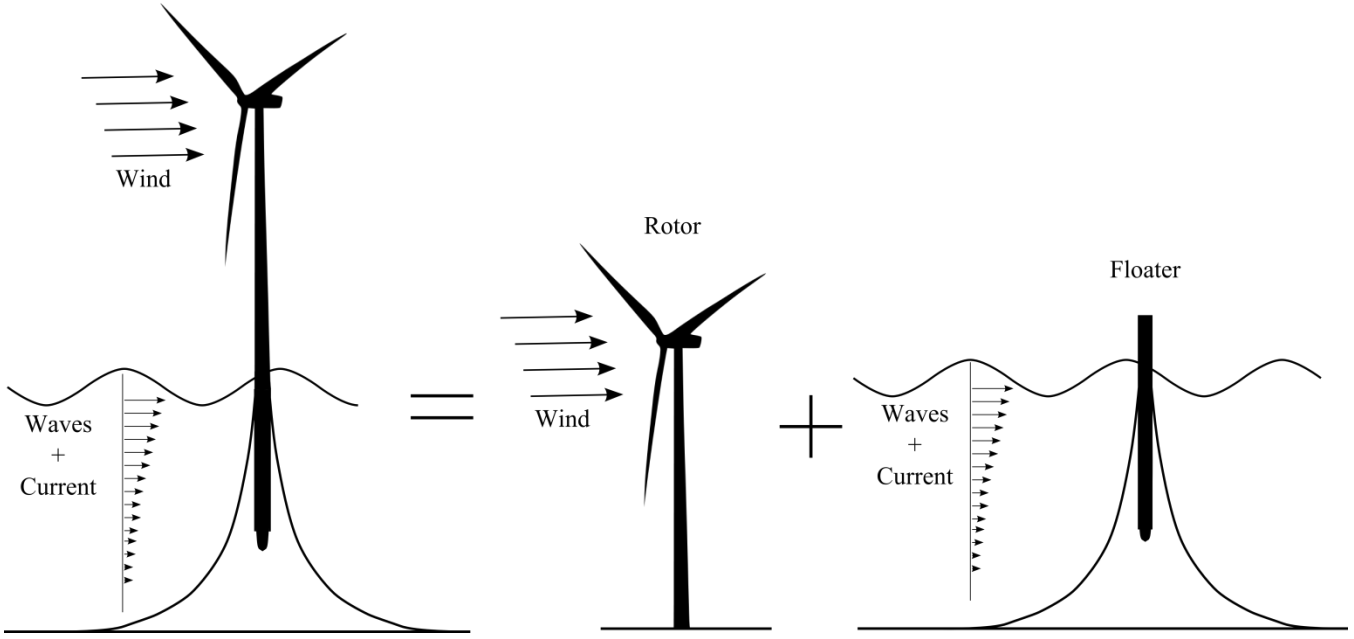
- FOWTs reside in complex environments
- Main loads on a FOWT: Wind, wave and current
- Investigation about the usage of numerical tools to calculate the main loads
- Objective: Improvement of numerical assessment of the main loads acting on a FOWT and its response to these loads



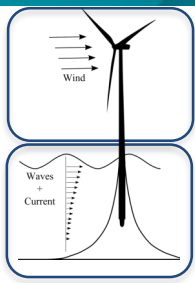
# Introduction

- Problem is divided into two main parts:
  - Aerodynamic loads on the rotor (using RANS)
  - Hydrodynamic loads on the floater (using RANS)

ReFRESCO

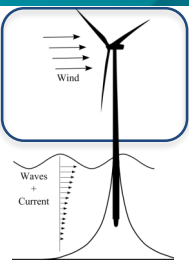


# Numerical codes

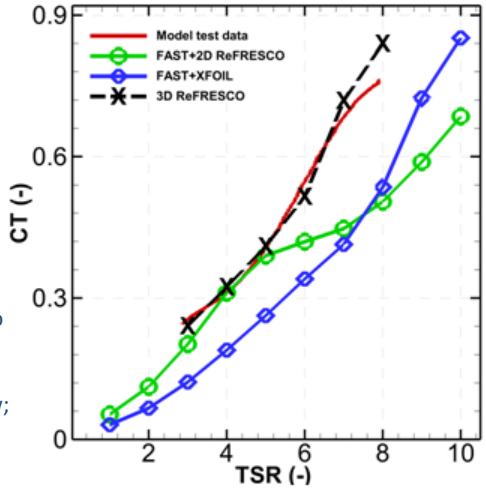



- Viscous flow solver
  - ReFRESCO
  - Community-based open-usage RANS-based CFD code
  - Multiphase incompressible viscous flows (using VOF)
  - Discretization with finite-volume method (FVM)
- Potential flow solver
  - Time-domain solver developed at WavEC
  - Incompressible and inviscid fluids
  - Frequency-wise excitation forces from WAMIT, adds 2nd order Froude-Krylov force component
  - Morison-like drag members to account for viscous effects
- BEMT code
  - FAST, accounts for coupling of rotor aerodynamics and floater hydrodynamics to simulate FOWTs
  - AeroDyn subroutine to solve BEMT (Blade-Element Momentum Theory)

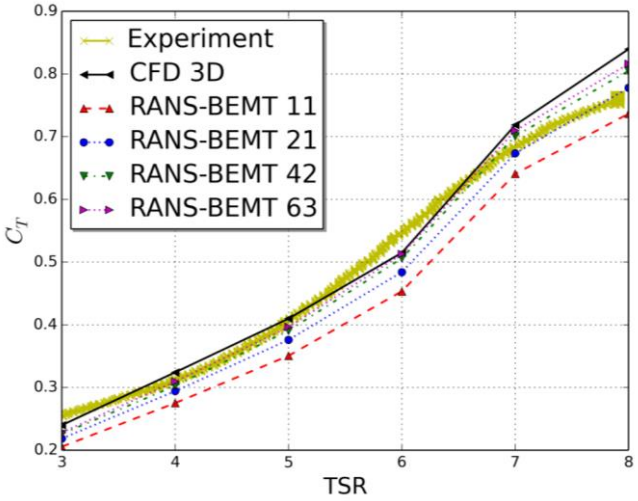
# Aerodynamic loads




- Aerodynamic loads on the rotor
  - Reproduction of model test data of the performance coefficients of a WT typically used for testing of FOWTs by coupling BEMT with the viscous flow solver
  - WT is used at Froude scaled wind (low Re numbers) => Flow separation due to large boundary layer, stronger radial flow
  - These 3D effects cannot be captured with 2D tools (neither by potential nor viscous flow solvers)



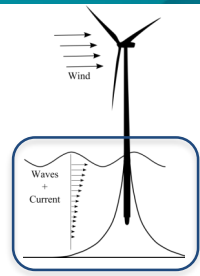

➢Fernandes et al.: Sensitivity to Aerodynamic Forces for the Accurate Modelling of Floating Offshore Wind Turbines; Renew; 2014.



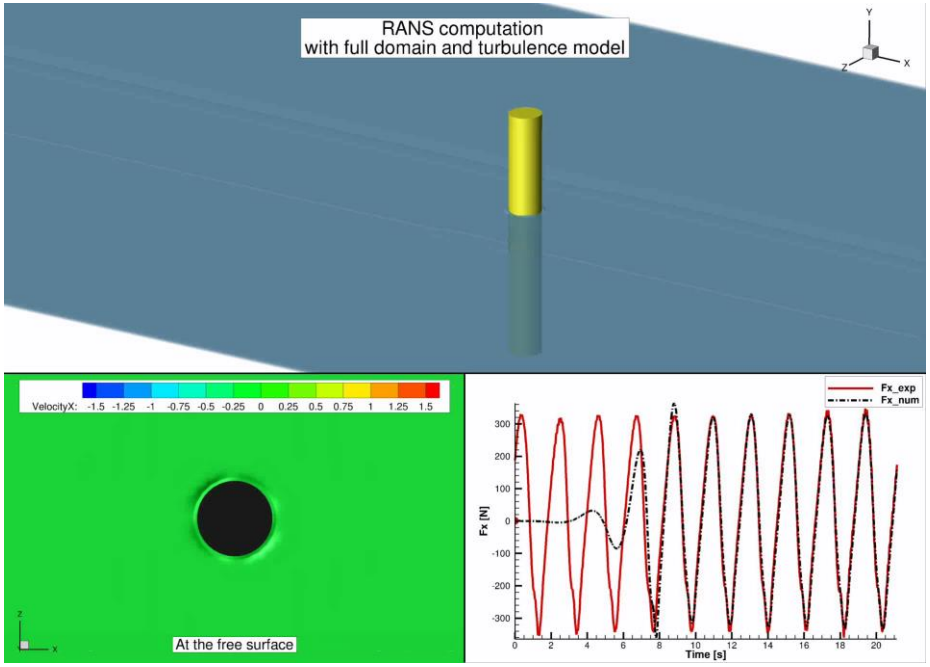

➢Burmester et al.: Determination of Scaled Wind Turbine Rotor Characteristics from Three Dimensional RANS Calculations. Journal of Physics: Conference Series 753 (2016) 082003

# Hydrodynamic loads I

➢Burmester, Guerinel: Calculations of Wave Loads on a Vertical Cylinder Using Potential-Flow and Viscous-Flow Solvers. OMAE 2016-54467

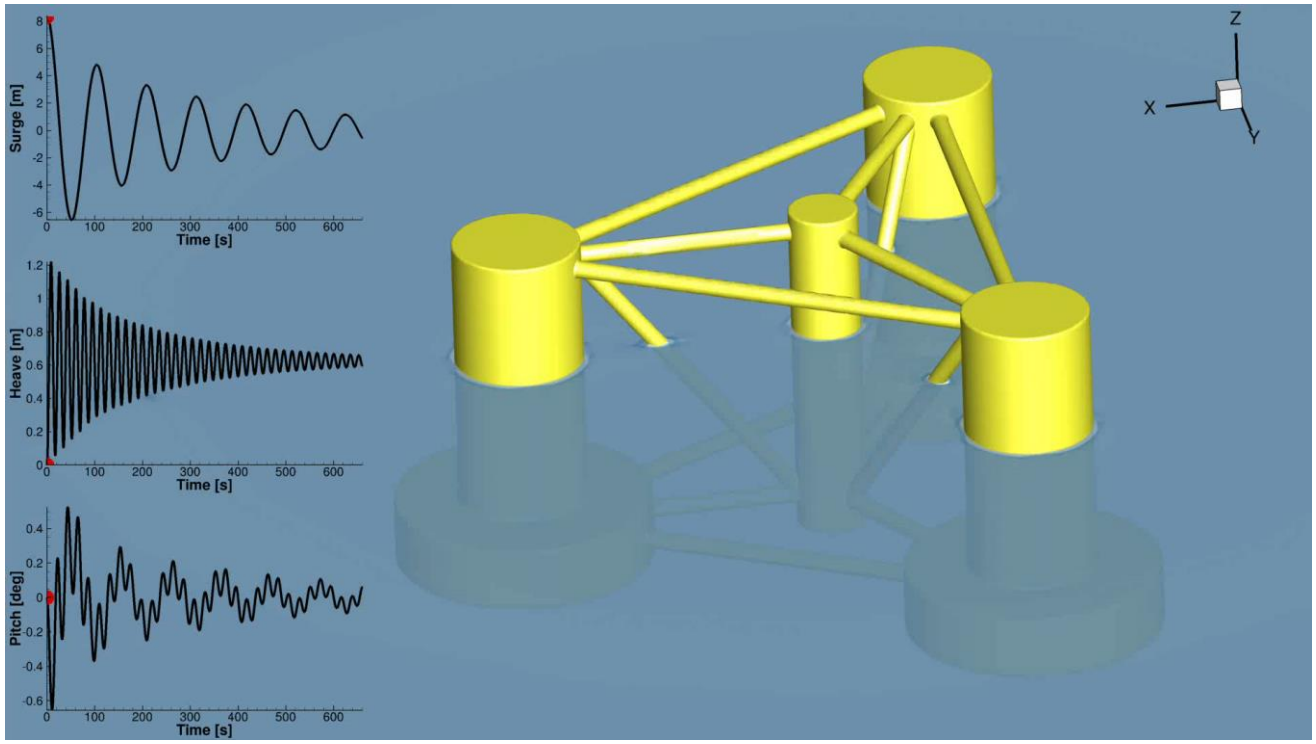



- Hydrodynamic loads due to waves
  - Validation of wave loads on a vertical cylinder with regular waves using potential flow and viscous flow solvers
  - Computational costs for viscous flow solvers are a lot larger
  - Viscous flow important when investigating:
    - Steep waves
    - Drag dependent solutions
    - Suction effect around cylinder
    - Vortex shedding in long slowly varying waves

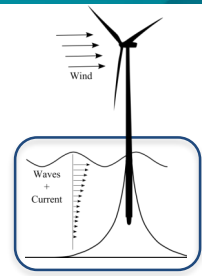


# Hydrodynamic loads II

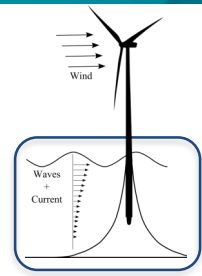
- Hydrodynamic loads on the floater
  - Calculation of the hydrodynamic damping with a viscous flow solver
  - Validation with experimental data of decay tests
  - Importance of coupled motion and scaling effects



# Hydrodynamic loads II

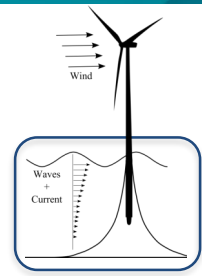



- Hydrodynamic loads on the floater
  - Viscous flow simulations of a semi-submersible floater are needed, e.g.:
    - For severe sea-states
    - A structure equipped with damping plates (heave damping plates)
    - Investigation of scaling effects (larger boundary layer at small scales)
    - Investigation of hydrodynamic damping (viscous damping)
    - Excitation at lower frequencies
    - Investigation of vortex shedding, VIV and VIM




# Summary

- Floating wind turbine tools
  - Aerodynamics:
    - 2D tools for full scale conditions (BEMT codes in combination with pot. flow or viscous flow solvers)
    - 3D viscous flow solver for scale effect studies
  - Hydrodynamics:
    - Potential flow codes or Morison formulation for most hydrodynamic cases, in which viscous effects are small
    - Viscous flow solver or higher order potential flow models are needed for loads due to steep waves
    - Viscous flow solver are needed for cases in which viscous effects plays a role: small and long waves, at model scale, structure with damping plates, hydrodynamic damping estimation, severe sea conditions, vortex shedding, VIV and VIM, suction effects, excitation at lower frequencies




# Summary

- Publications:
  - Make, Vaz, Fernandes, Burmester, Gueydon: Analysis of Aerodynamic Performance of Floating Wind Turbines using CFD and BEMT Methods. OMAE 2015-42086
  - Burmester, Gueydon, Make: Determination of Scaled Wind Turbine Rotor Characteristics from Three Dimensional RANS Calculations. Journal of Physics: Conference Series 753 (2016) 082003
  - Burmester, Guerinel: Calculations of Wave Loads on a Vertical Cylinder Using Potential-Flow and Viscous-Flow Solvers. OMAE 2016-54467
  - Burmester, de Ridder, Wehmeyer, Asp, Gujer: Comparing Different Approaches for Calculating Wave Impacts on a Monopile Turbine Foundation. In Submission: OMAE 2017-61182

# Thank you!

Renewable Energy?

I am a big fan!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