

#### Challenging wind and waves

Linking hydrodynamic research to the maritime industry

# Determination of Scaled Wind Turbine Rotor Characteristics from 3D-RANS Calculations

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- 1. Motivation and objectives
- 2. RANS-BEMT Approach
- 3. Results + Discussion
- 4. Conclusions and Perspectives





# CONTENT

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## **MOTIVATION AND OBJECTIVES**

- Model tests of FOWTs to validate numerical models (BEMT)
- Performance-matched wind turbine:
  - MARIN Stock Wind Turbine (MSWT)

<-> NREL 5MW turbine (scale 1/50)

Good C<sub>T</sub> results for 3D RANS [1]







#### MOTIVATION AND OBJECTIVES III

- ReFRESCO (in-house RANS code) used for aerodynamic loads
- FAST (BEMT code of NREL) for coupling of:
  - Rotor aerodynamics
  - Floater hydrodynamics
- 'Coupling' of ReFRESCO and FAST
  - RANS-BEMT approach
- Verification with direct CFD computation
- Validation with model test data and







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# RANS-BEMT APPROACH

- Starting point: CFD 3D
- Obtaining axial and tangential forces:
  - Integration of pressure and shear stress for 2D section
- Calculation of {C<sub>L</sub> , C<sub>D</sub> and  $\alpha$ }
  - Induction is neglected!
- Input for FAST

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- Results of FAST:
  - Thrust and power coefficient (RotCt and RotCp)
  - Axial and tangential induction factors (a and a')





# RANS-BEMT APPROACH II

- Update of input data with induction:
  - New C<sub>L</sub>, C<sub>D</sub> and  $\alpha$
  - 3 loops to ensure convergence
- Output of FAST
  - RotCt and RotCp
- $C_T$  and  $C_P$





## RANS-BEMT APPROACH IV

- NREL 5MW turbine at full scale
- $C_T$  and  $C_P$  vs. TSR (TSR= $\Omega^*R/V$ )
- CFD 3D: direct RANS computation of Make and Vaz [1]





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## **RESULTS AND DISCUSSION I**

- MSWT at model scale
- $C_T$  and  $C_P$  vs. TSR
- CFD 3D: direct RANS computation of Make and Vaz [1]
- Experimental data of de Ridder et al. [3]



## **RESULTS AND DISCUSSION II**

- Flow around turbine blade more 2D for full scale [1]
  - Full scale results more appropriate for this approach
- Similar results for CFD 3D and RANS-BEMT
- RANS-BEMT approach relies on RANS and BEMT results
  - Differences are acceptable







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# **CONCLUSIONS AND PERSPECTIVES**

- Link between RANS and BEMT calculations of FOWTs at low Re flows (during model tests in basin)
- Use of 3D RANS results as input for BEMT computations
- Applied on NREL 5MW at full scale and MSWT at model scale
- RANS-BEMT coupled approach is an option to be considered at model scale
- For each TSR: CL and CD per section for AoA=? and Re=?
  - A method to define the AoA in RANS
  - Ways to have results for more (a range of) AoAs and Re





# THANK YOU!



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# LITERATURE

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