DESIGN OF A SEMI-SUBMERSIBLE FLOATING VAWT WITH ACTIVE BLADE PITCH CONTROL

17 JANUARY 2018, TRONDHEIM

Fons Huijs

THE PIONEERS OF OFFSHORE ENGINEERING

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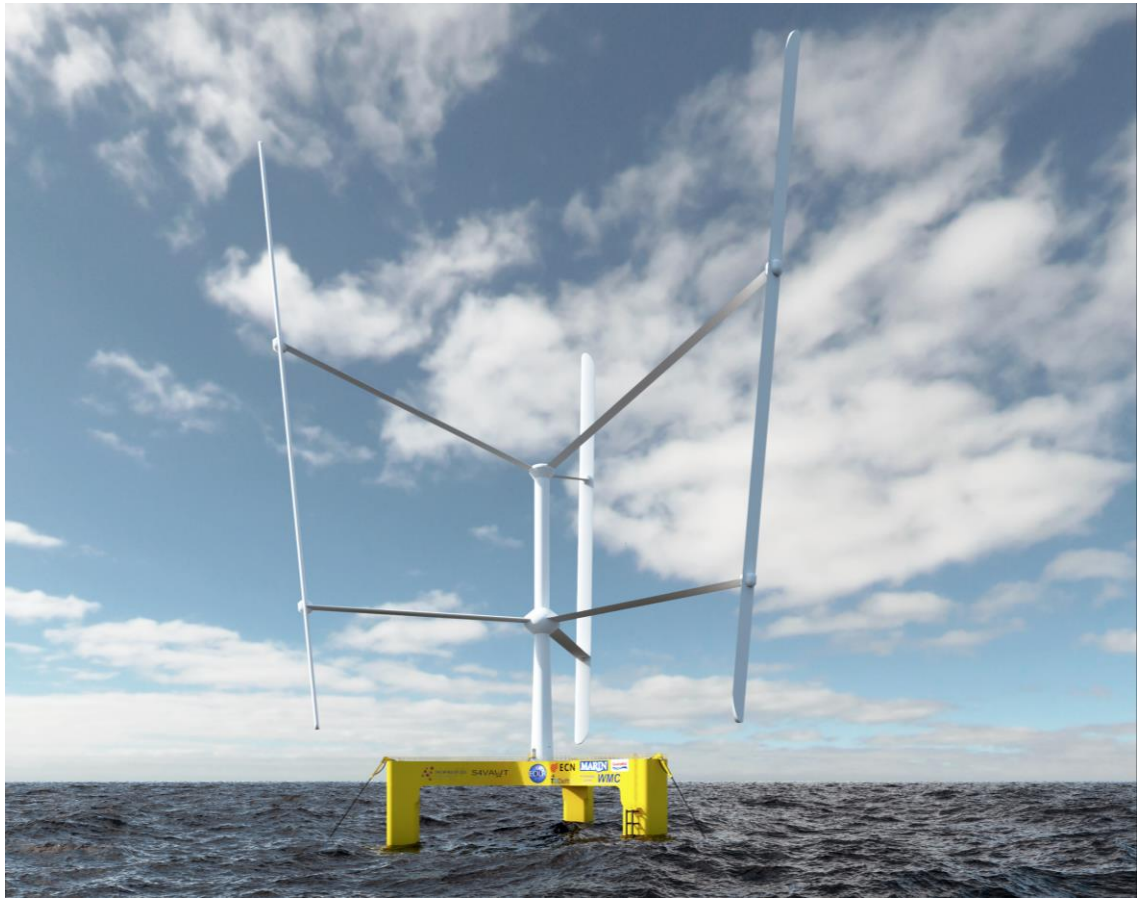
OUTLINE

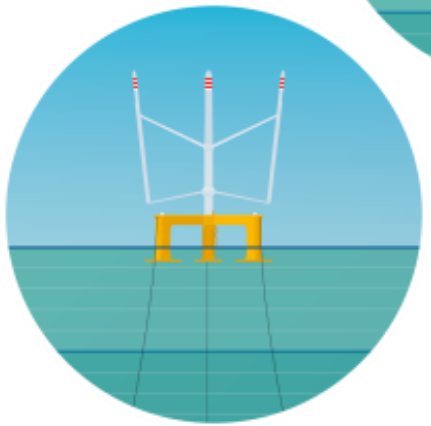
- Introduction
- Floating VAWT design
- Coupled analysis
- Conclusions



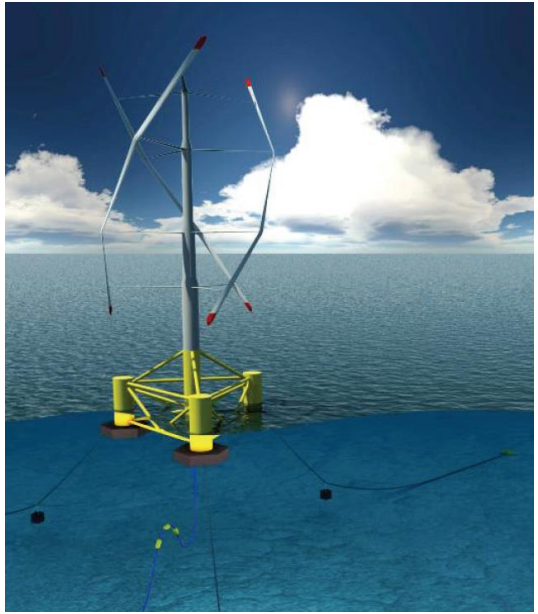
INTRODUCTION - FLOATING VAWT

- Deeper waters
- Larger wind turbines
  - ↳ Increasing interest for floating wind

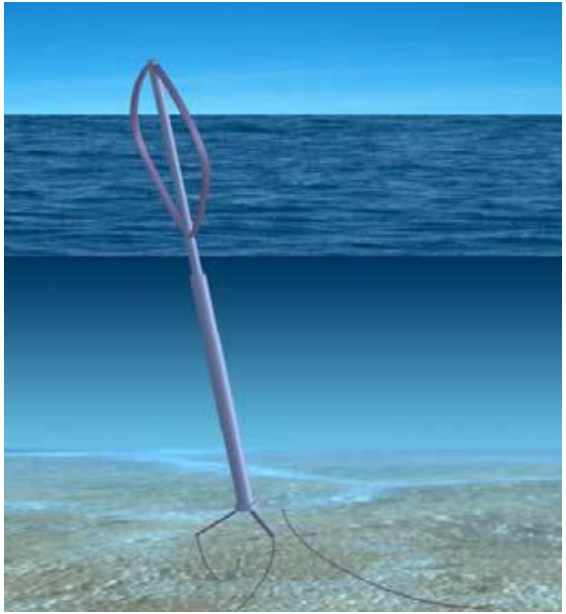
- Low centre of gravity position
- Large allowable tilt angle
- Potential for scaling up
  - ↳ VAWT promising for floating



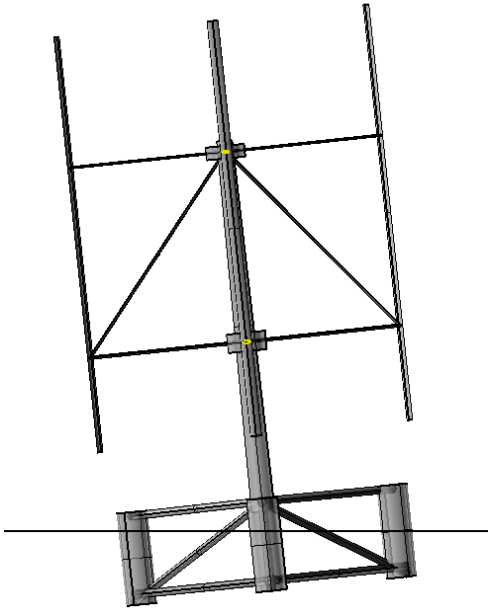
INTRODUCTION – PREVIOUS WORK



Technip, Nenuphar
Cahay et al, OTC 21704, 2011



DeepWind project
Paulsen et al, DeepWind'2013



GustoMSC, TU Delft
Blonk, MSc thesis, 2010

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INTRODUCTION - S4VAWT PROJECT

- Active blade pitch control for VAWT
  - Improved aerodynamic efficiency (power production)
  - Lower wind loads above rated (power production)
  - Lower survival loads (parked)

- Objectives S4VAWT project:
  - Verify & quantify VAWT advantages
  - Design semi-submersible floater
  - Verify design by simulations

S4VAWT

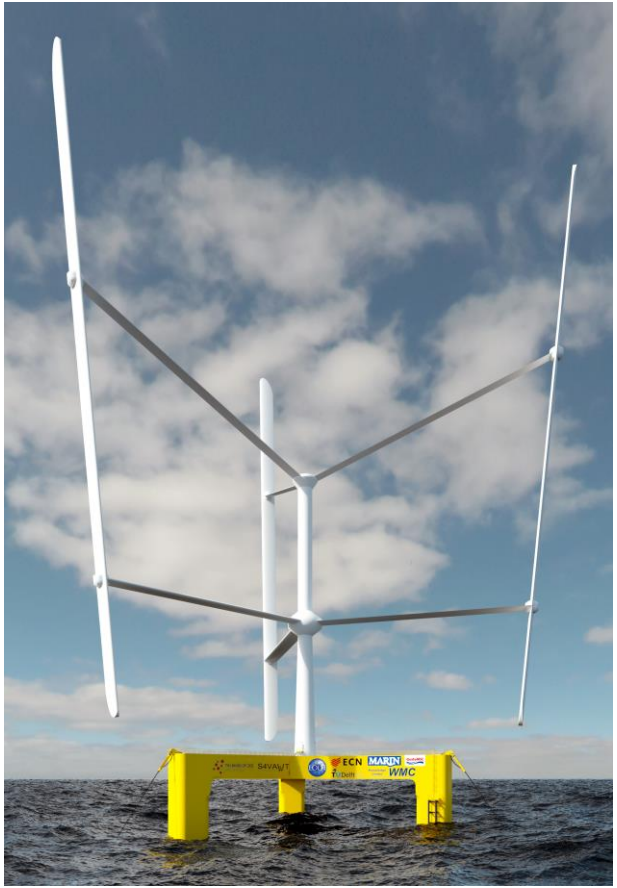
Semi-Submersible Support Structure
for Vertical Axis Wind Turbines

DESIGN - BASIS

- 6 MW VAWT
- Maximum static tilt during production < 10°

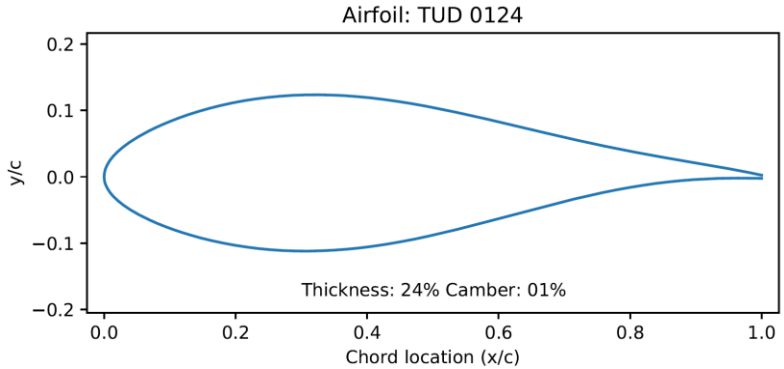
- French Mediterranean Sea
- Water depth ~ 100 m
- 50-year significant wave height ~ 6.5 m

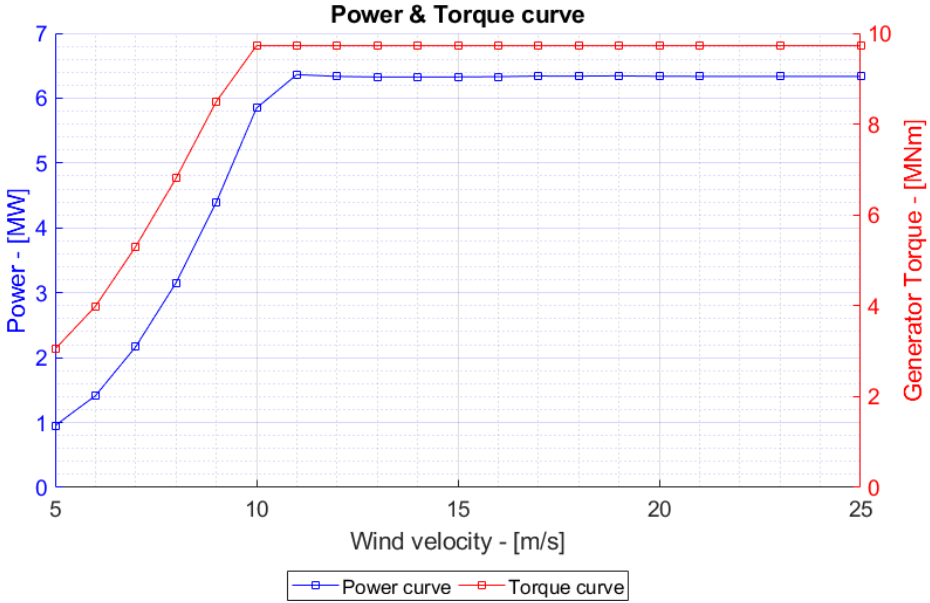
- DNV GL standards

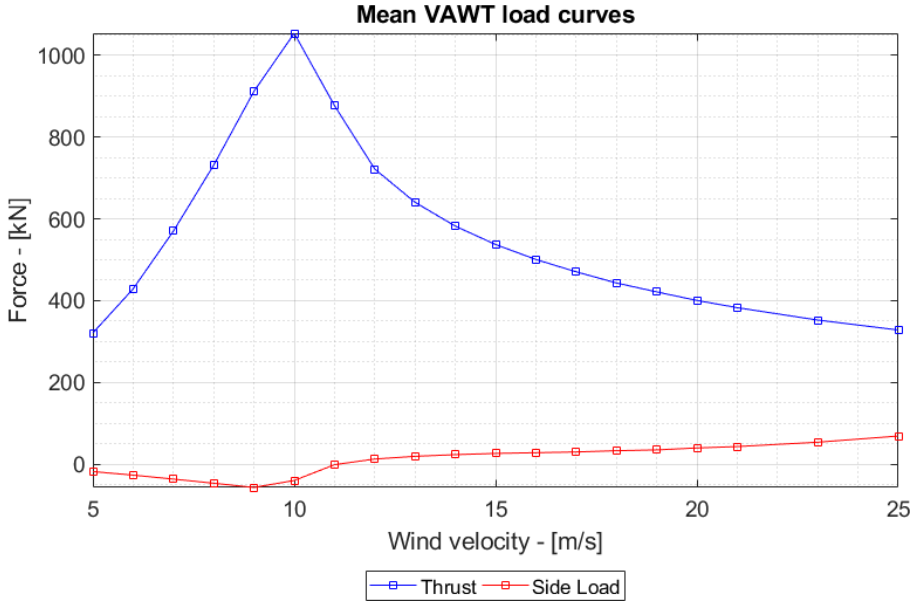


DESIGN - 6 MW VAWT

- Active blade pitch control







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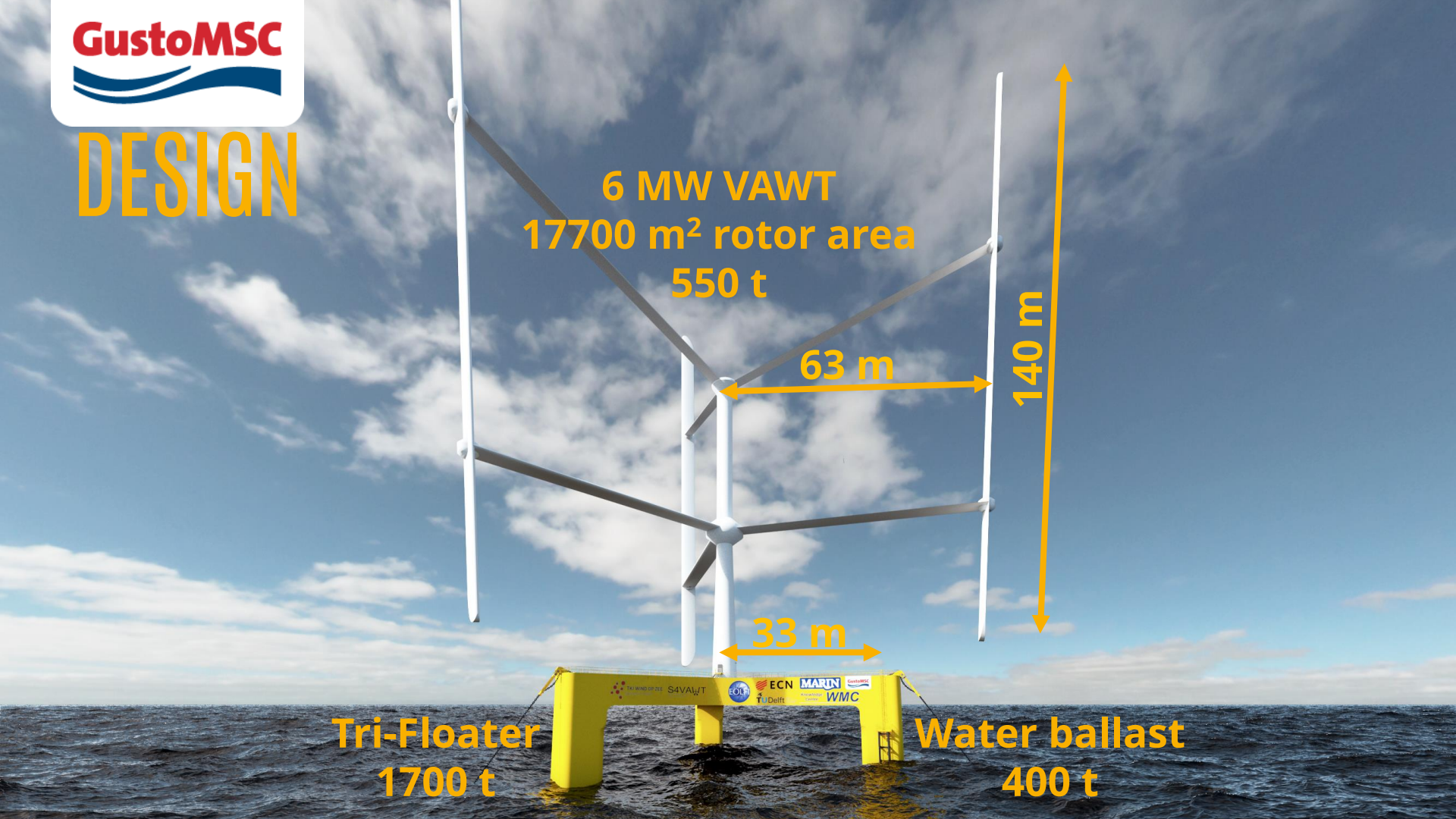
DESIGN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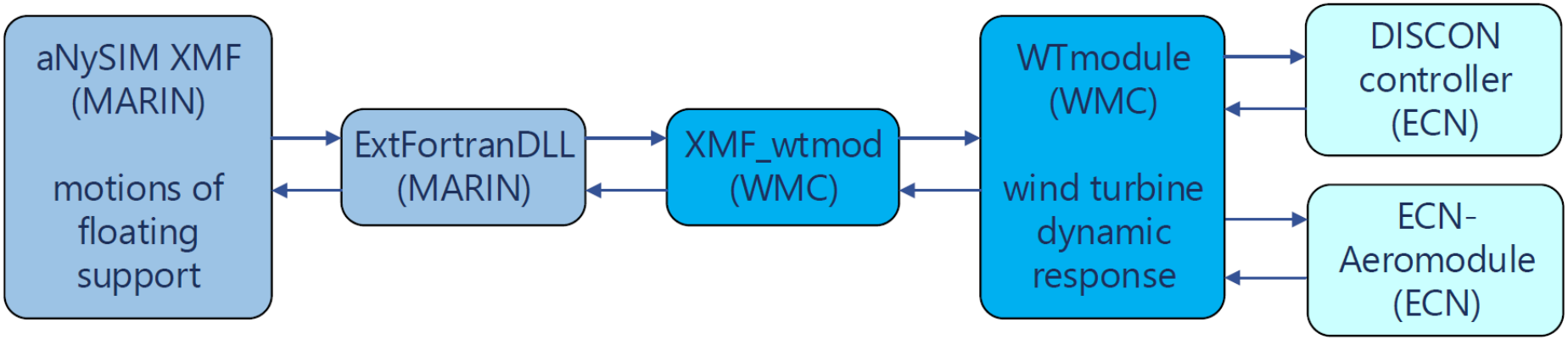
DESIGN
6 MW VAWT
17700 m² rotor area
550 t
63 m
140 m
33 m
Tri-Floater
1700 t
Water ballast
400 t
S4VAWT
ECN
MARIN
WMC
TuDelft

COUPLED ANALYSIS - SOFTWARE

- Aerodynamics: Lifting line free vortex wake method
- Turbine and control: Structural dynamics, gyroscopic effects, etc.
- Hydrodynamics: Potential flow, full QTF, quadratic damping
- Mooring: Dynamic lumped-mass model



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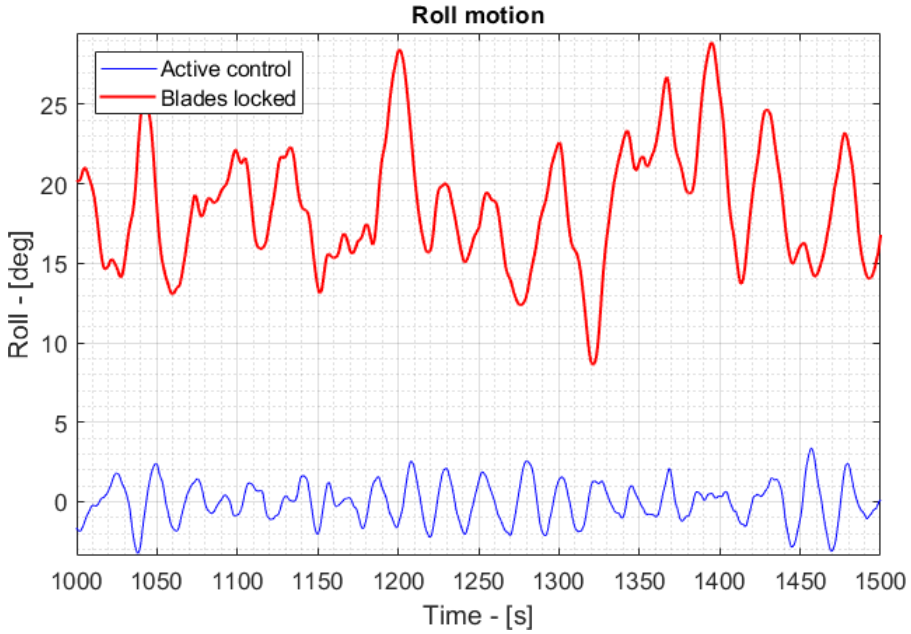
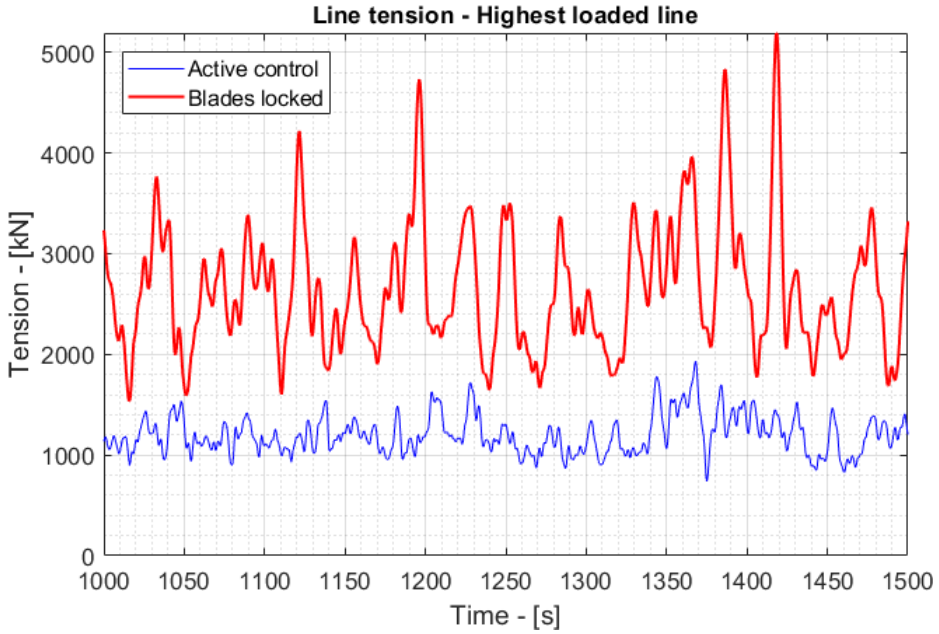
COUPLED ANALYSIS – MOTION RESULTS

		Rated	Cut-out	Survival
10-min mean wind velocity [m/s]		11	25	39
Significant wave height [m]		4.0	5.4	6.5
Floater surge [m]	mean	42	39	**42**
	max	46	43	**51**
Floater tilt (roll & pitch) [deg]	mean	**7**	3	2
	max	**11**	6	5
Floater yaw [deg]	mean	5	**6**	0
	max	8	**9**	6

COUPLED ANALYSIS - PARKED SURVIVAL

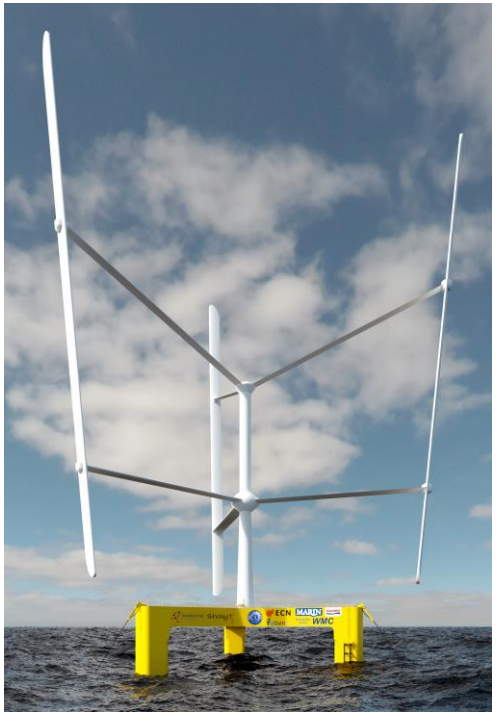




CONCLUSIONS – FLOATING VAWT DESIGN

- Active blade pitch control makes design drivers floater for VAWT more similar to HAWT:
  - Rated wind governing for floater tilt & tower base moment
  - Parked survival still governing for surge & mooring tensions

- Yaw induced by rotor torque no issue for Tri-Floater



CONCLUSIONS - VAWT

- Known advantages VAWT for floating wind:
  - Low centre of gravity position
  - Large allowable tilt angle
  - Potential for scaling up

- Active blade pitch control:
  - Mitigate large loads above rated and parked

- Floater for VAWT 20% lighter than for HAWT

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THANK YOU FOR YOUR KIND ATTENTION

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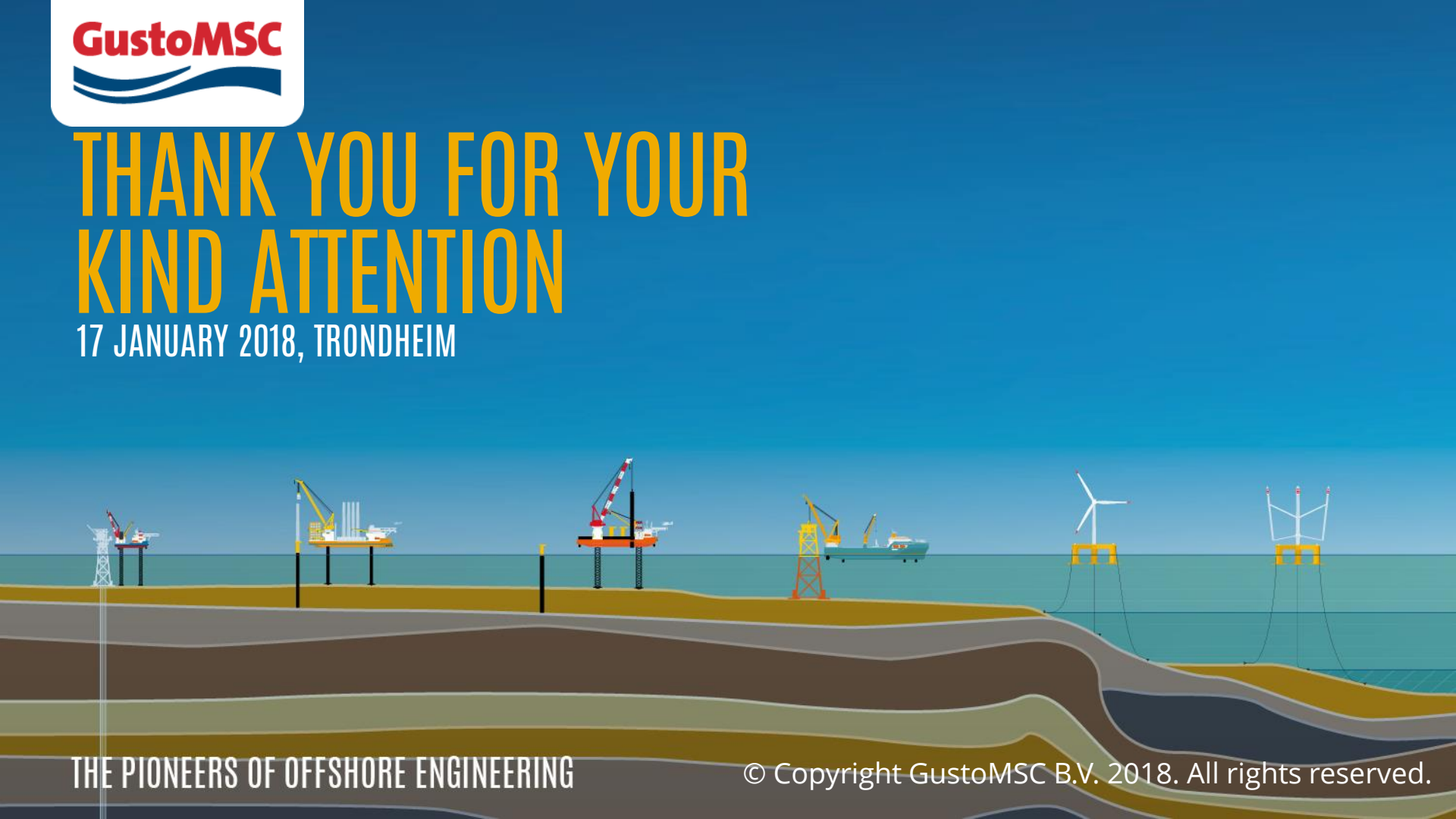

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