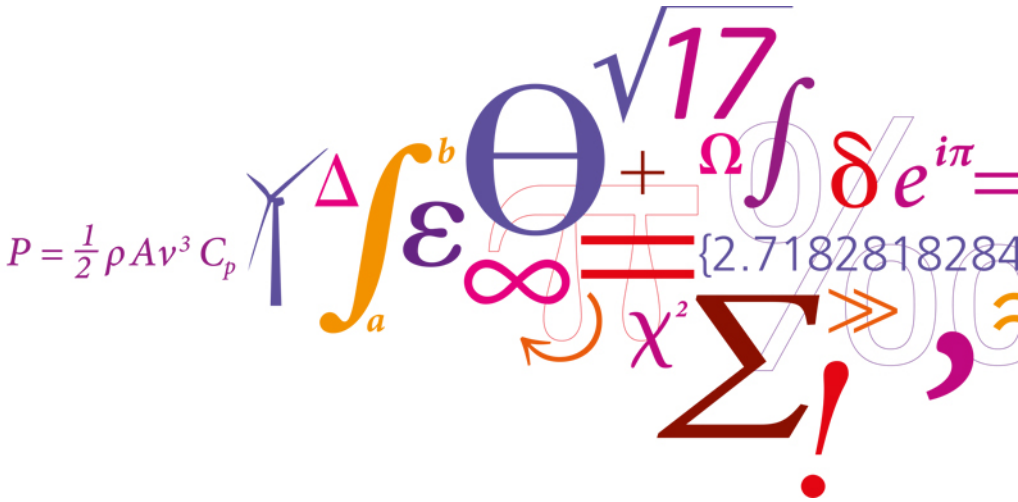
Integrated simulation challenges with the DeepWind floating vertical axis wind turbine concept

D. Verelst, H.A. Madsen, **M. Borg**, U.S. Paulsen, H.G. Svendsen, P.A. Berthelsen



12th Deep Sea Offshore Wind R&D Conference
EERA DeepWind'2015

DTU Wind Energy
Department of Wind Energy

Outline

- Context
- Simulation tool
- Design Approach
- Integrated Simulation Challenges
- Future Design Cycles
- Conclusions

Context

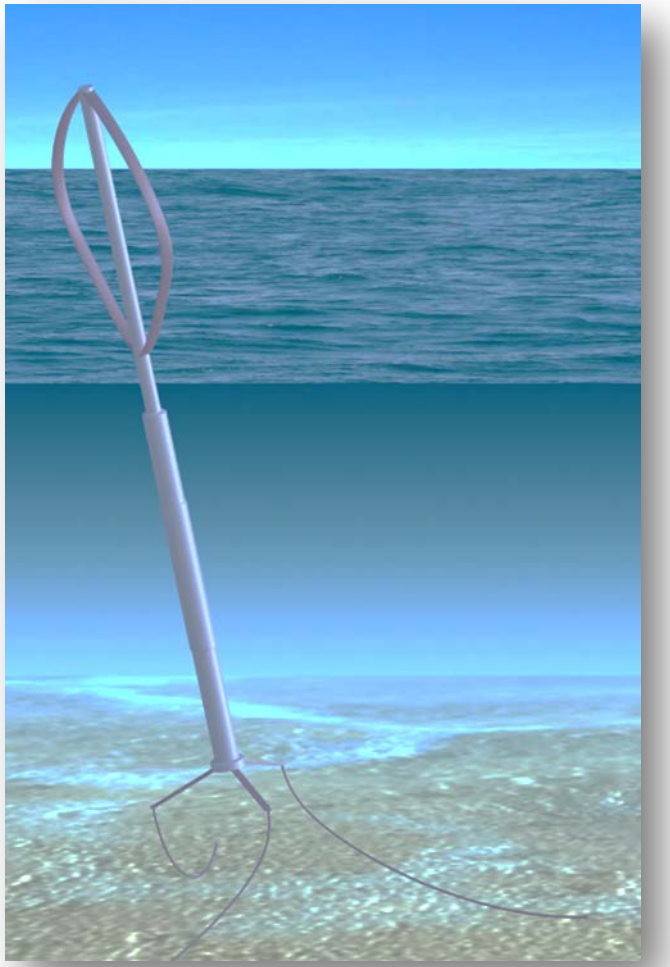
Need to lower the cost of offshore wind energy

↓

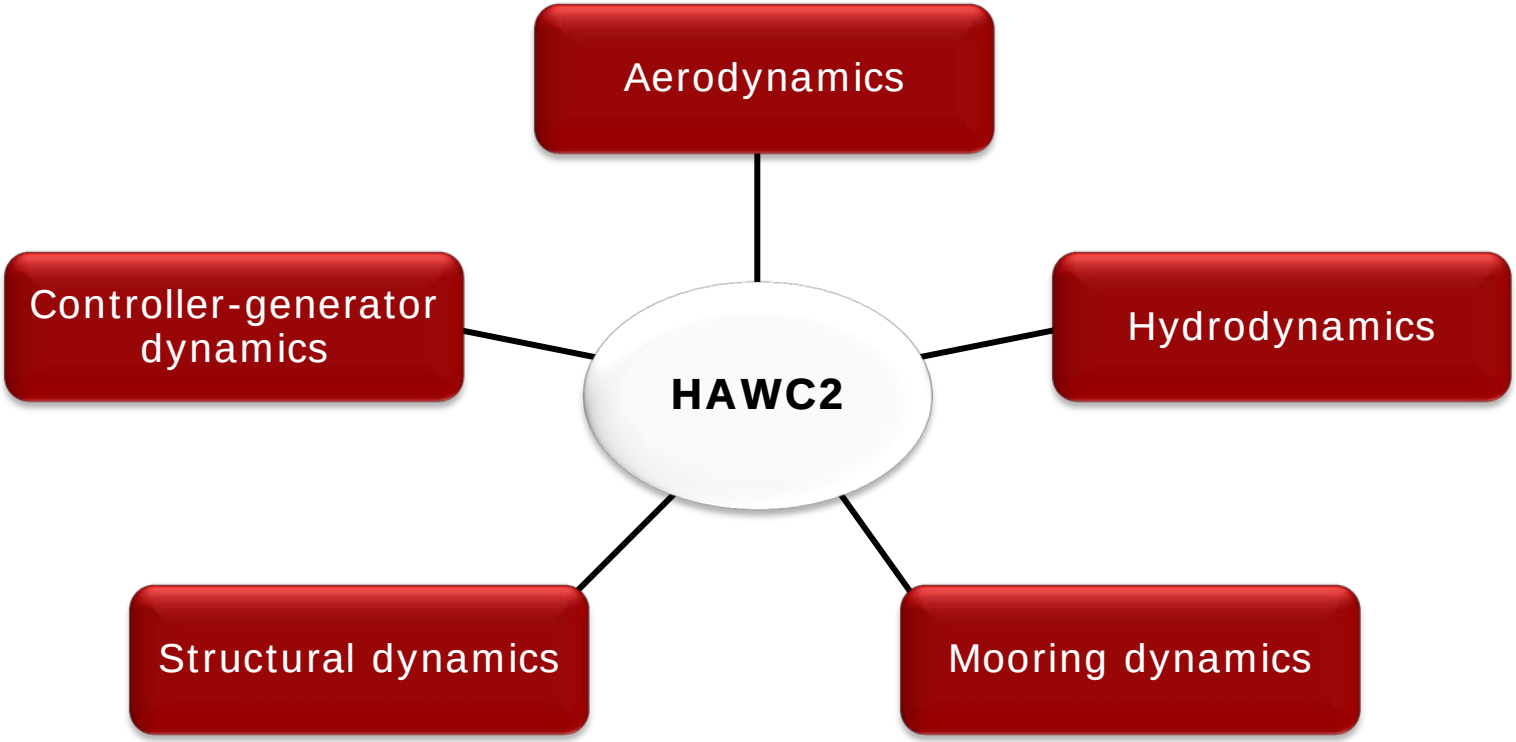
Novel Designs

↓

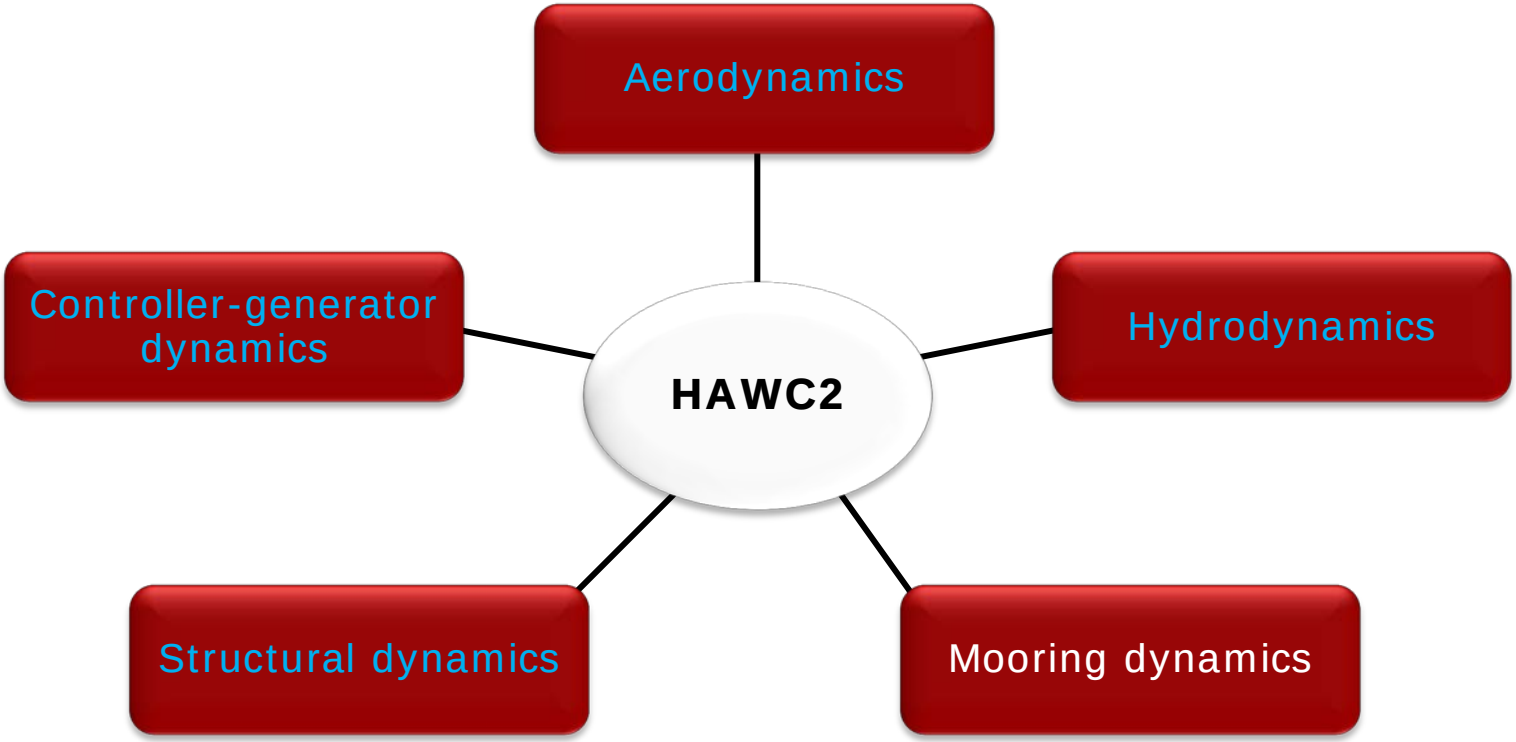
Challenges for current simulation tools



Simulation Tool



Simulation Tool



Design Approach

DeepWind floating vertical axis wind turbine concept

- Rotor & tower
- Floating support structure & mooring system
- Generator & electrical system
- Turbine controller

Integrated Simulation Challenges

Overview

Simultaneous development of design & design tool

↓

New tool capabilities, design changes, improved reference data

↓

Challenging design environment

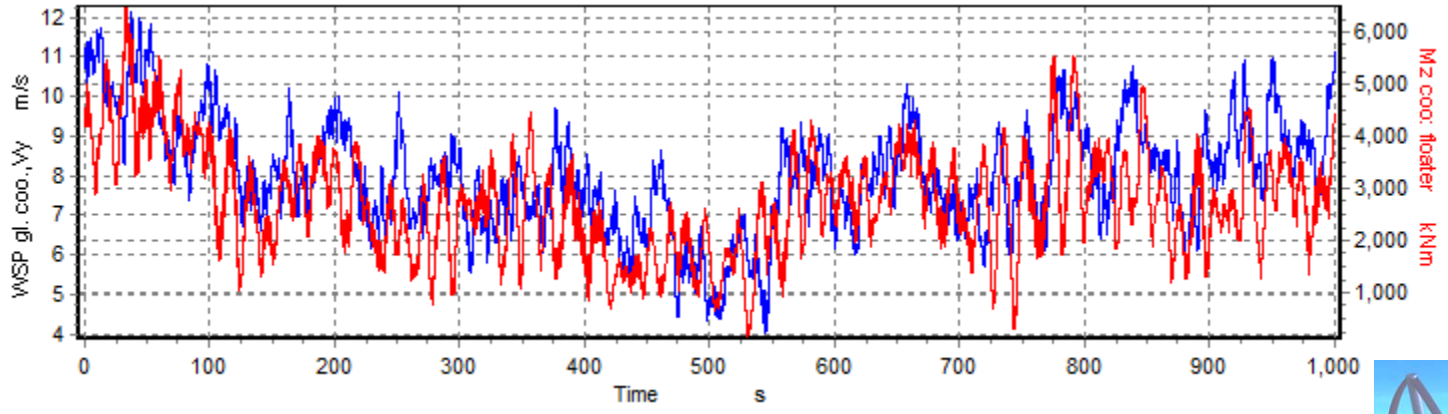
↓

Issues with integrated simulation instabilities

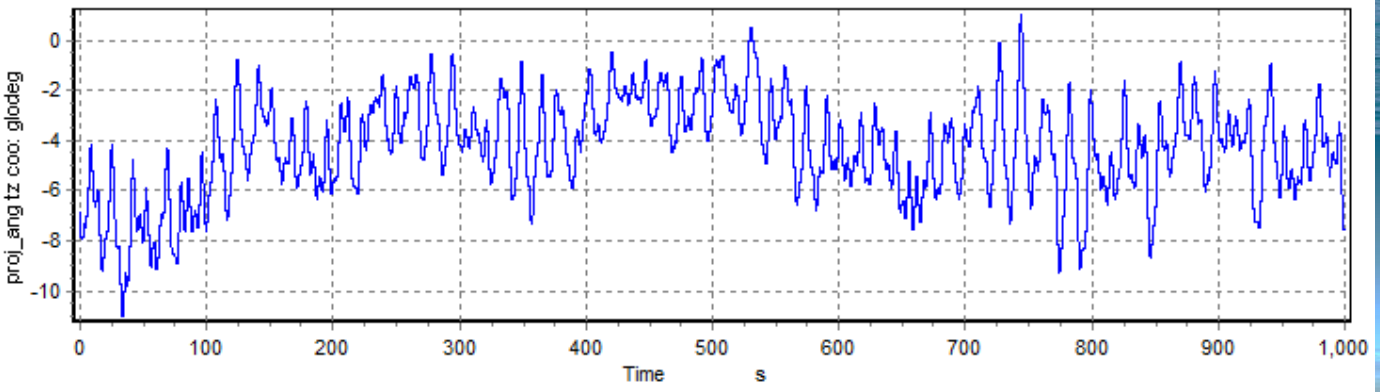
Integrated Simulation Challenges

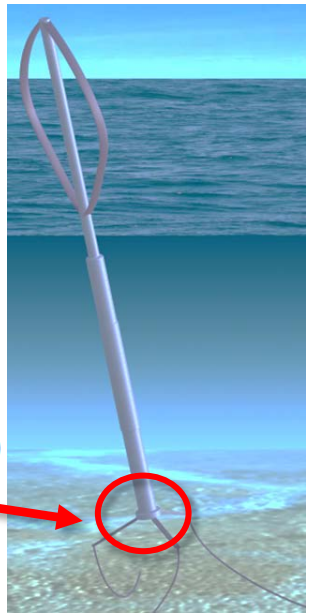
Stable operation – U=8m/s

Torque



Generator housing yaw



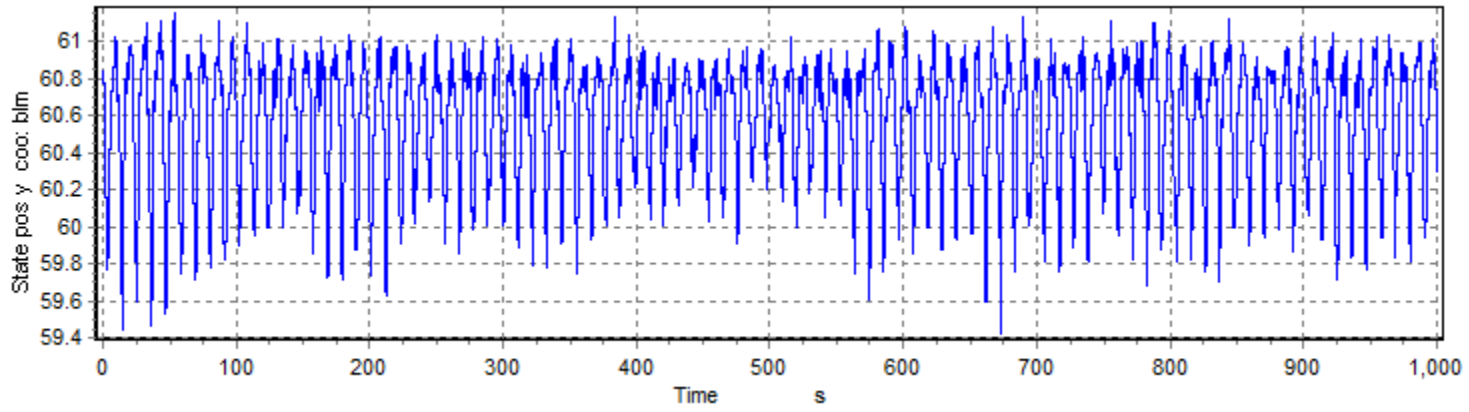


Integrated Simulation Challenges

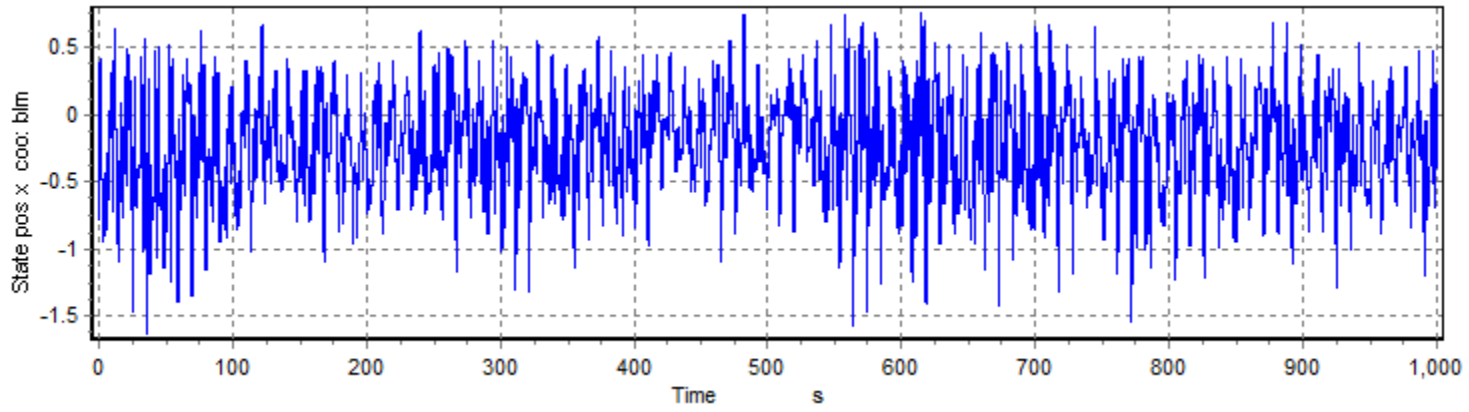
Stable operation – U=8m/s

Blade mid-point

Flapwise defln.



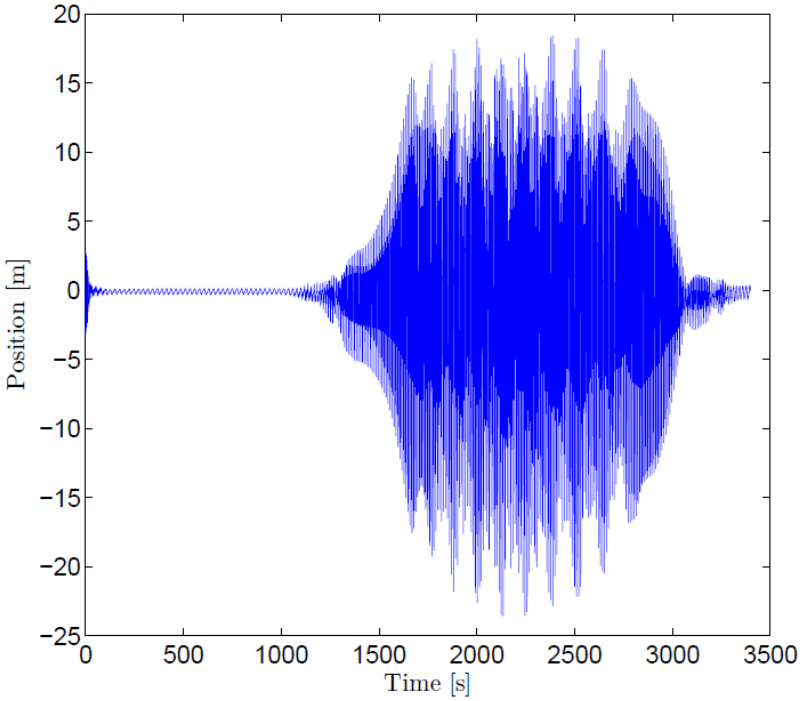
Edgewise defln.

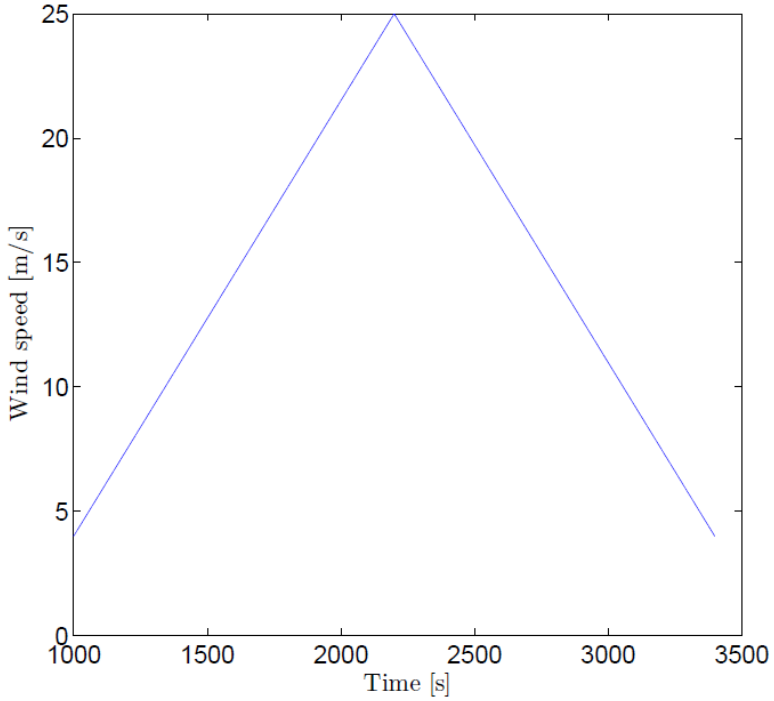


Integrated Simulation Challenges

Blade Instabilities

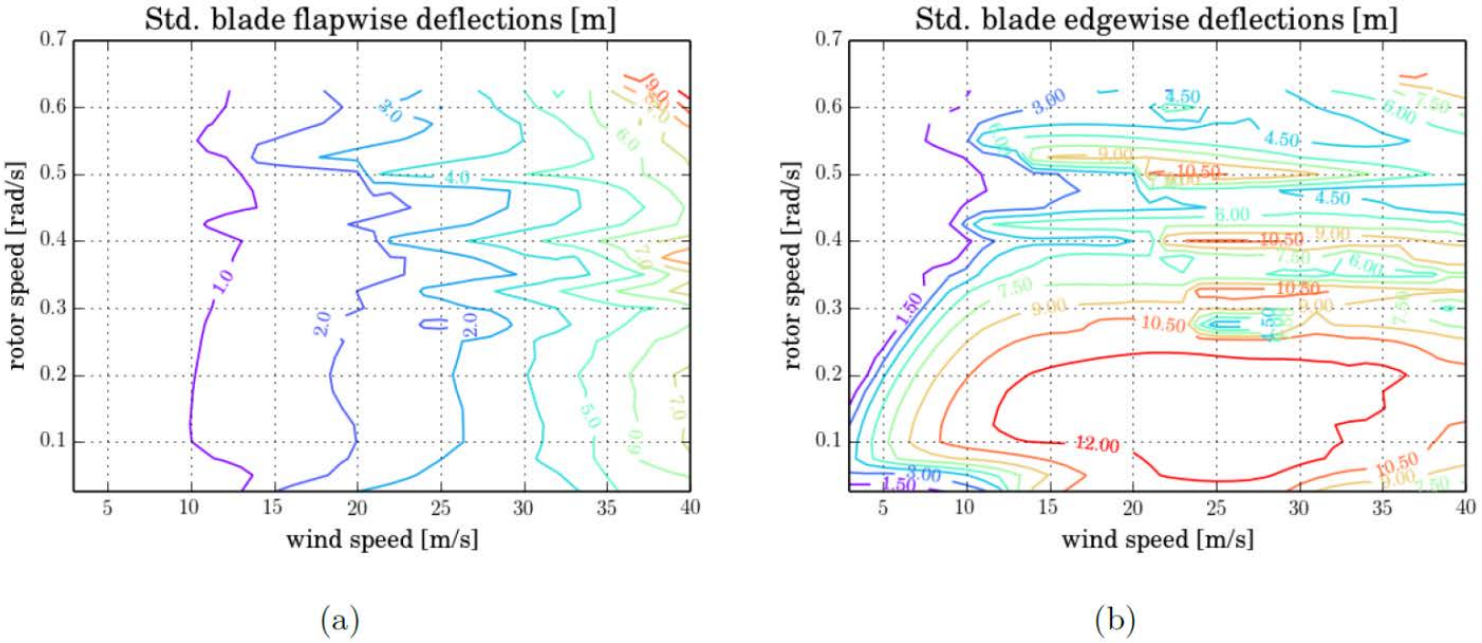
- Very large 2p load fluctuations.
- Stall controlled rotor → low, possibly negative blade edgewise damping





Integrated Simulation Challenges

Blade Instabilities

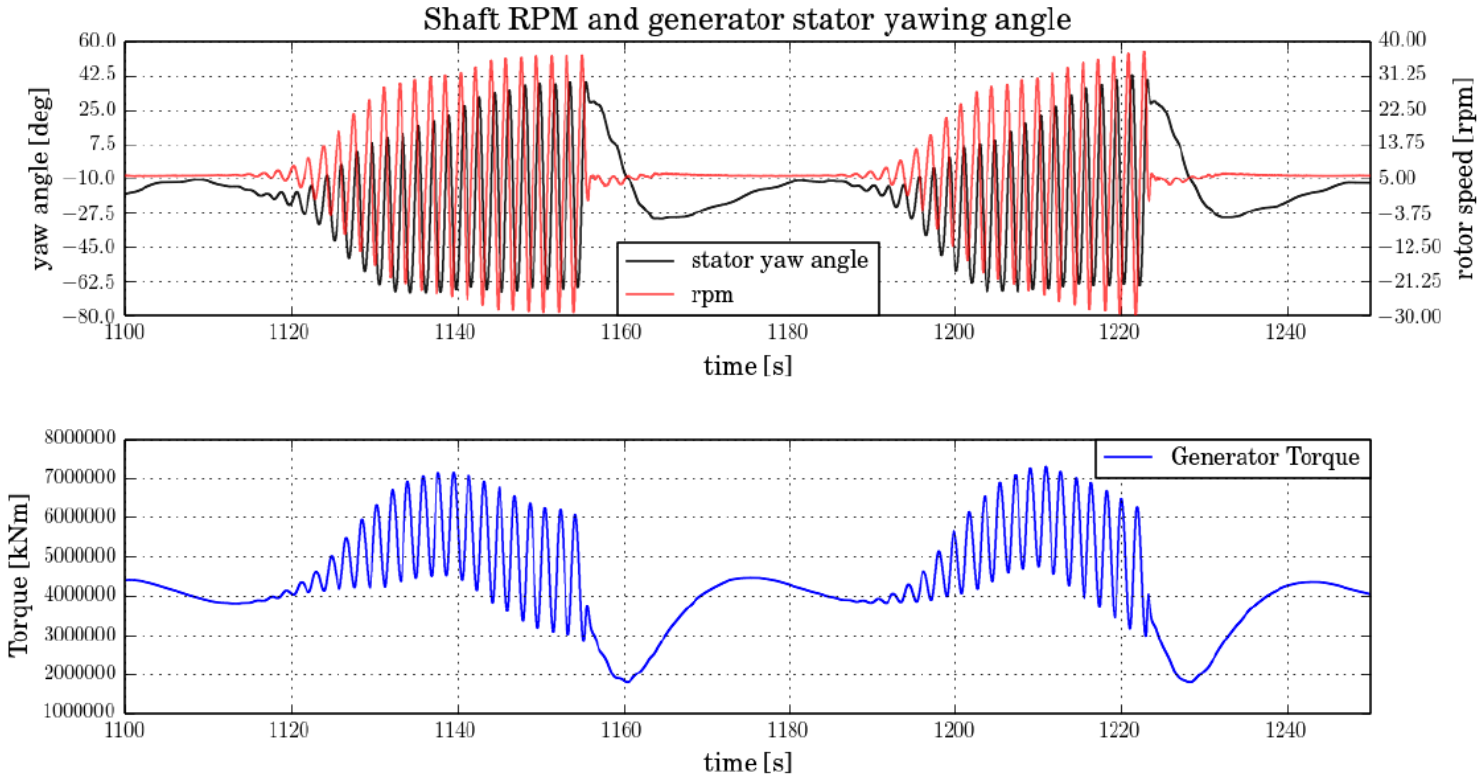


(a) (b)

Integrated Simulation Challenges

Controller/Drivetrain Instabilities

- Conventional PI controller with gain scheduler
- Simplified aerodynamic load model



Future Design Cycles

Need to increase design iterations within limited timescale

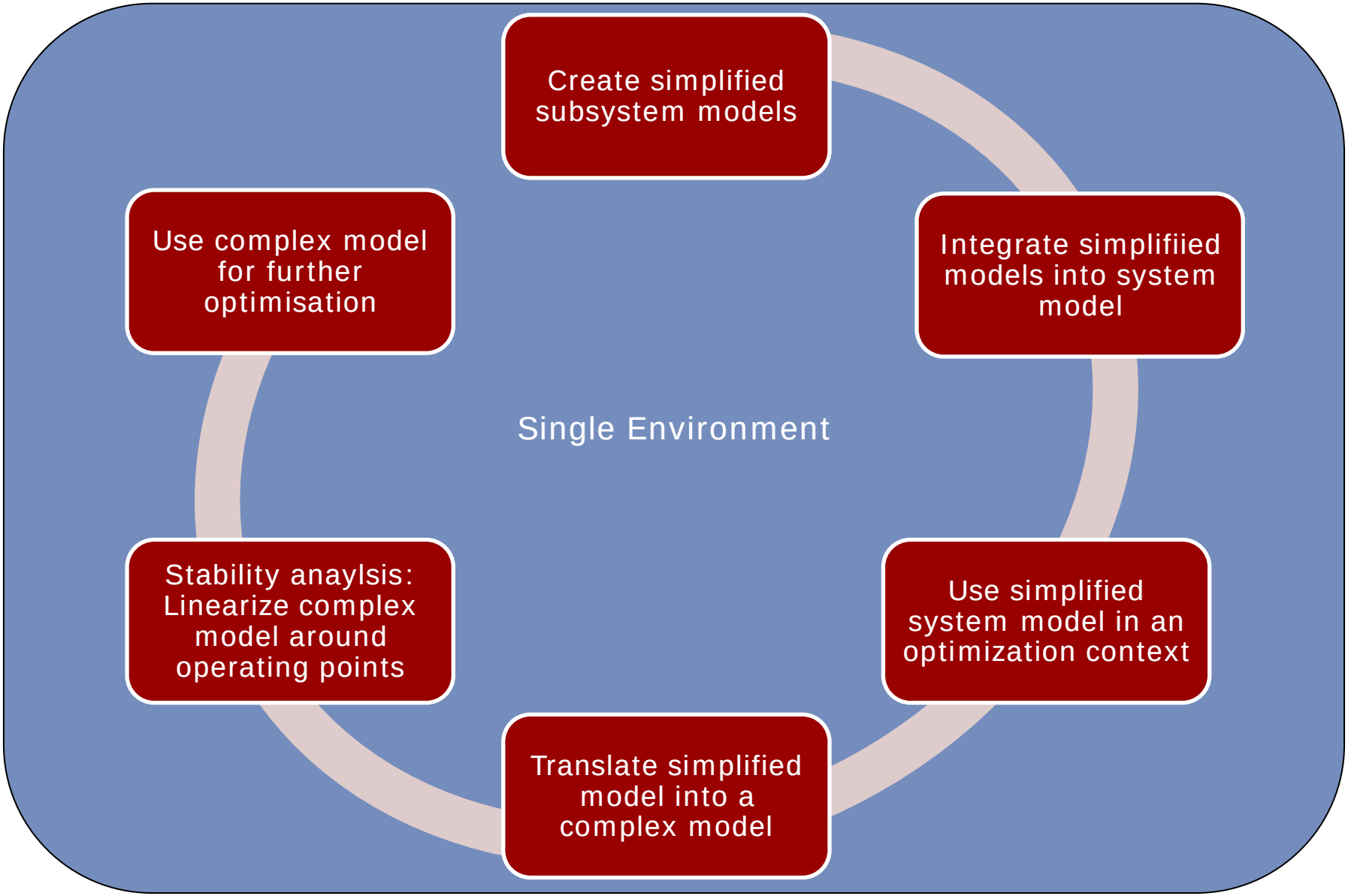
↓

Multi-Discipinary Design, Analysis & Optimization (MDAO)

↓

Integration of design and simulation tools
e.g. OpenMDAO, FUSED-wind

Future Design Cycles



Conclusions

- Design tool that integrates all phenomena taking place
- Independent subsystem design approach
- Simulation challenges when integrating subsystems
- Improve future design cycles

Need for efficient integrated simulation tools and MDAO

Acknowledgements

Thank You for Your Attention

The work is a result of the contributions within the DeepWind project which is supported by the European Commission, Grant 256769 FP7 Energy 2010- Future emerging technologies, and by the DeepWind beneficiaries:

DTU(DK), AAU(DK), TUDELFT(NL), TUTRENTO(I), DHI(DK), SINTEF(N), MARINTEK(N), MARIN(NL), NREL(USA), STATOIL(N), VESTAS(DK) and NENUPHAR(F).

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 256769