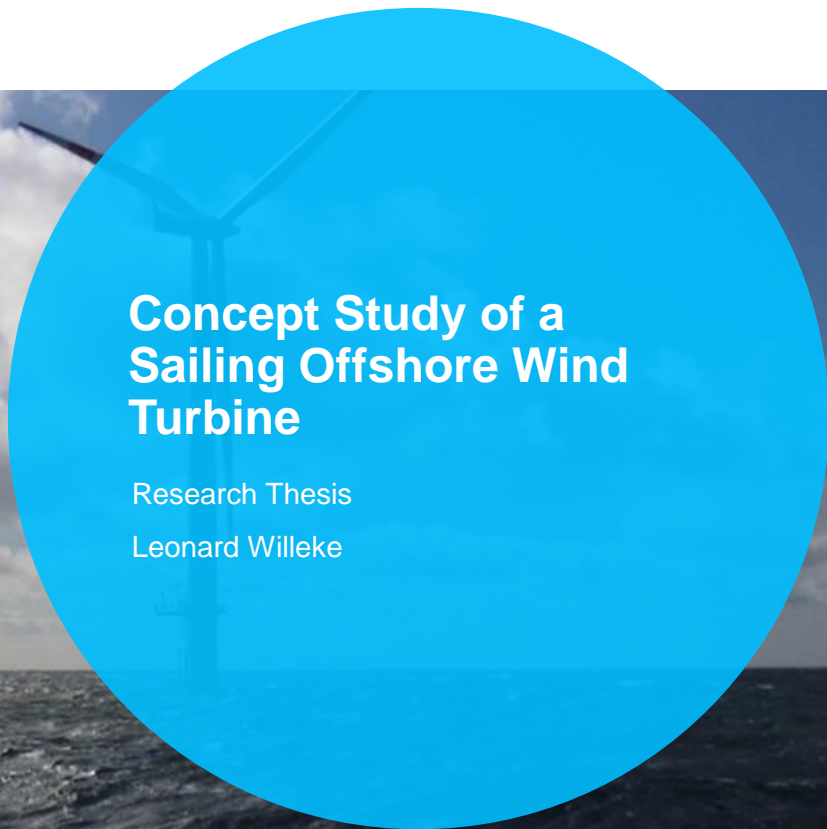
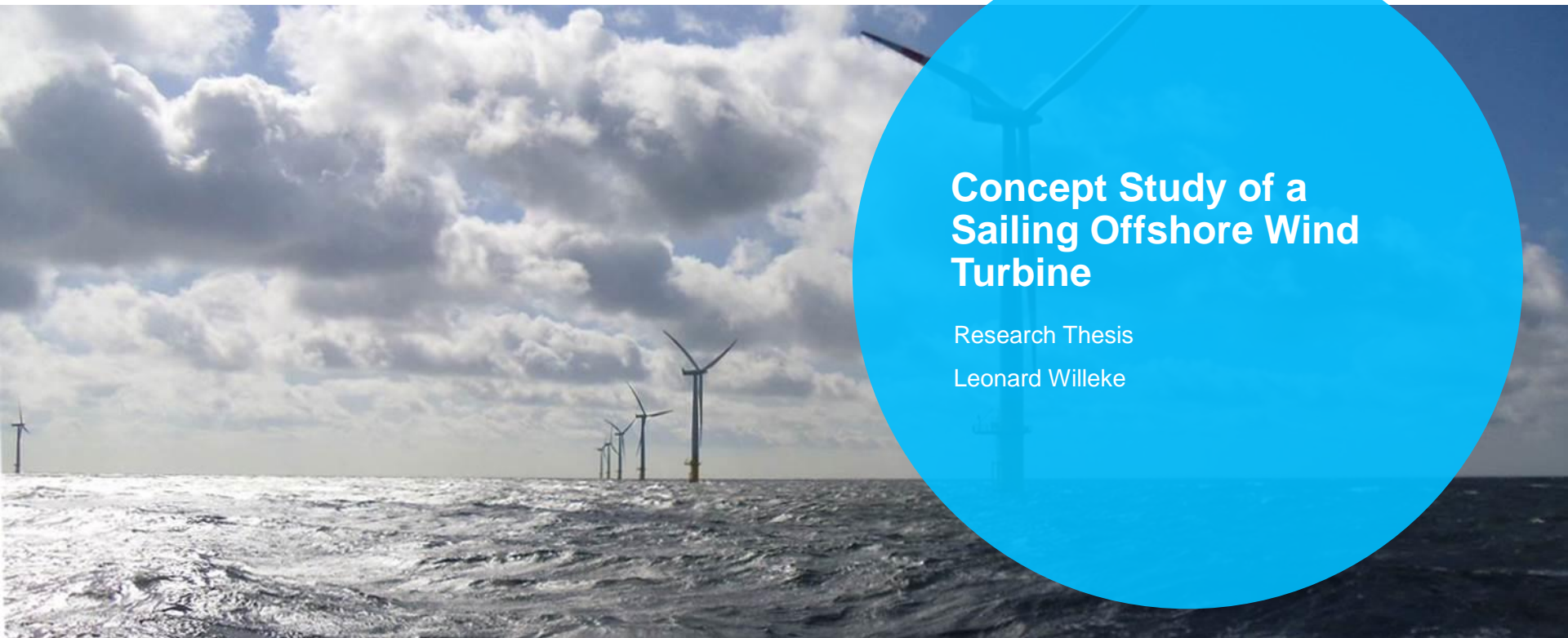


**University of Stuttgart**  
Stuttgart Wind Energy (SWE)  
@ Institute of Aircraft Design



# Concept Study of a Sailing Offshore Wind Turbine

Research Thesis  
Leonard Willeke



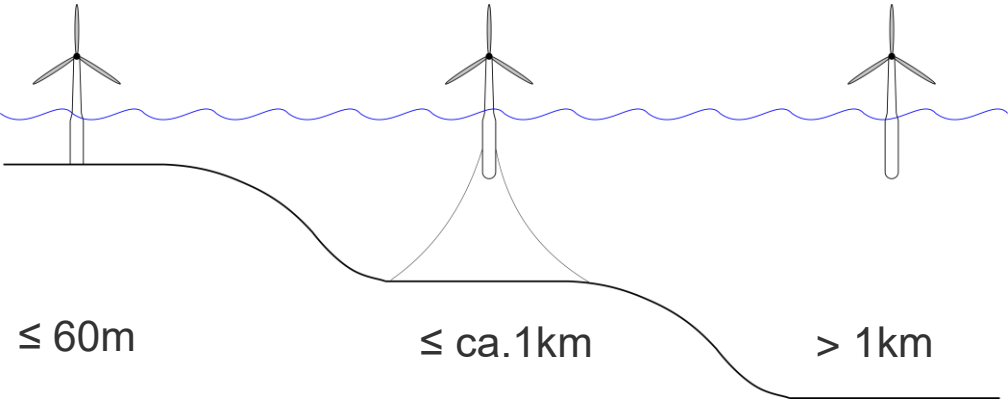
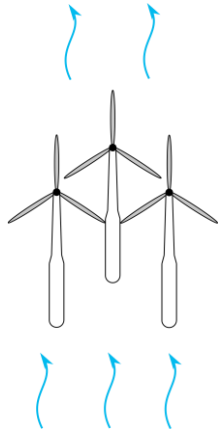
# Introduction

## Why sailing?

Need for clean energy

Limited sites & conflicts for wind turbines on land

Use wind streams eg. Trade Winds



Build turbines in the sea



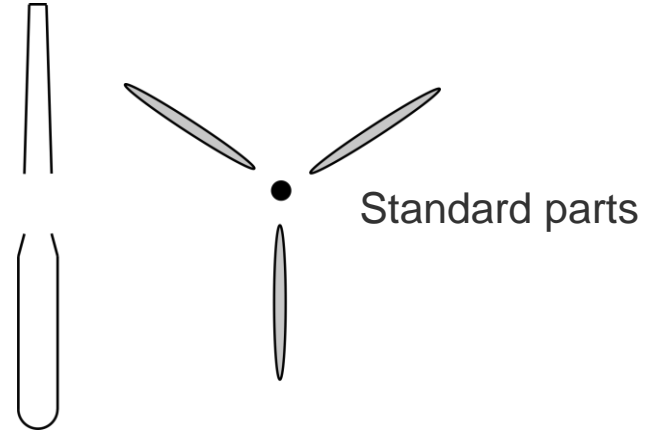
World map by Vecteezy.com

60% of earth surface

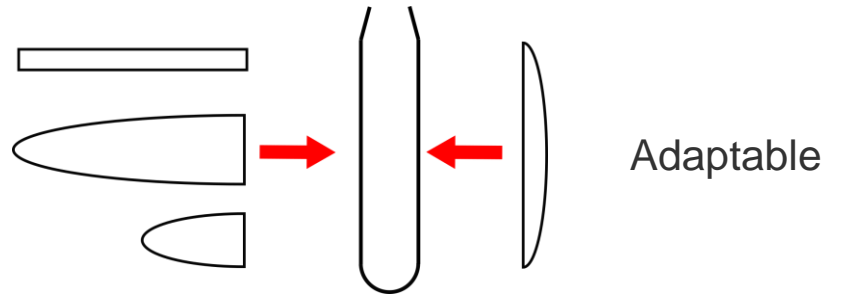
# Introduction

Why wind turbine on a spar platform?

Calculation methods  
and tools

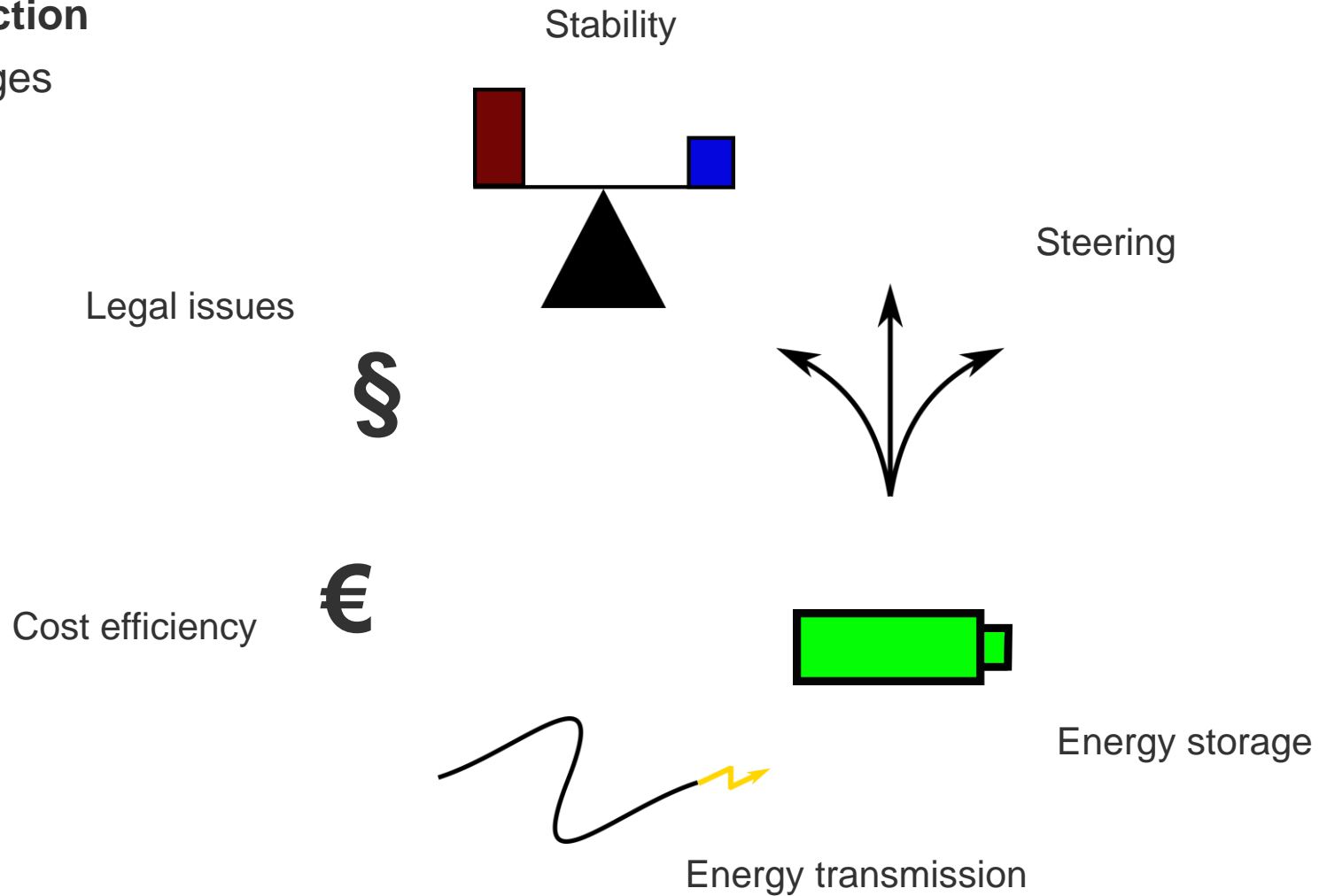


Proof of concept ???



# Introduction

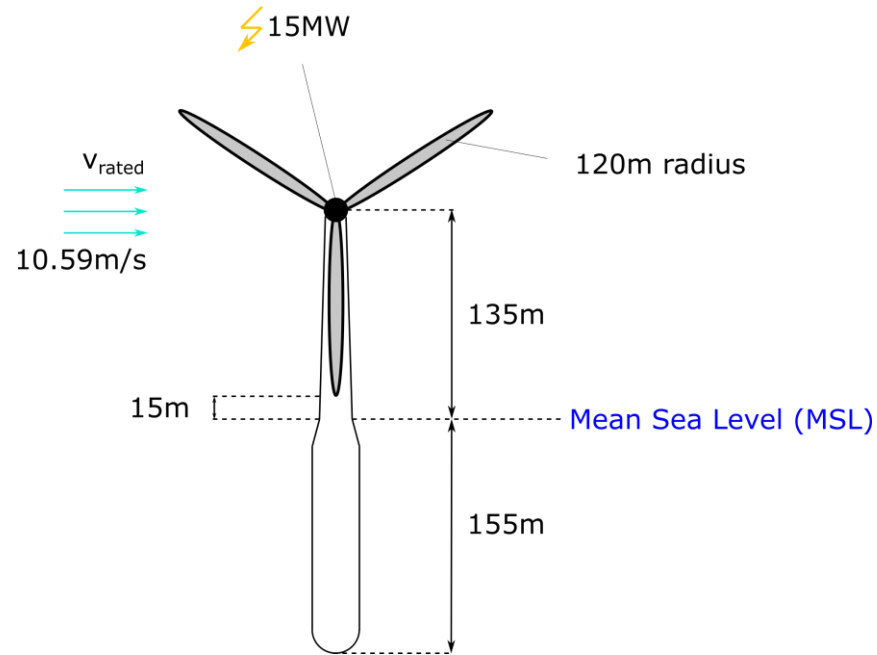
## Challenges



# Introduction

## Models of spar and turbine

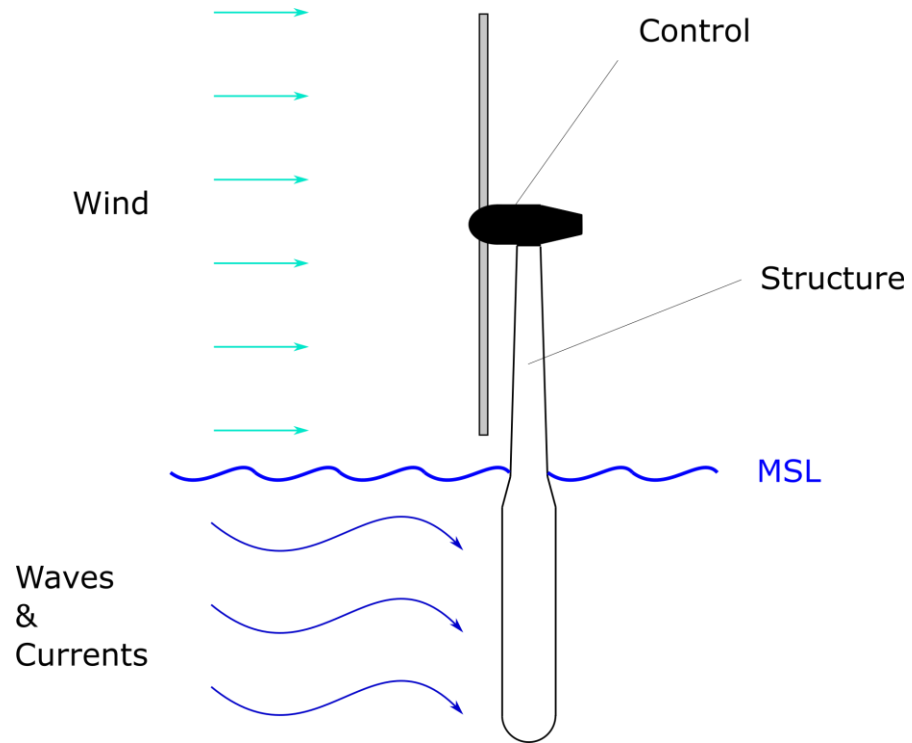
### IEA Wind 15 MW reference turbine



WindCrete spar

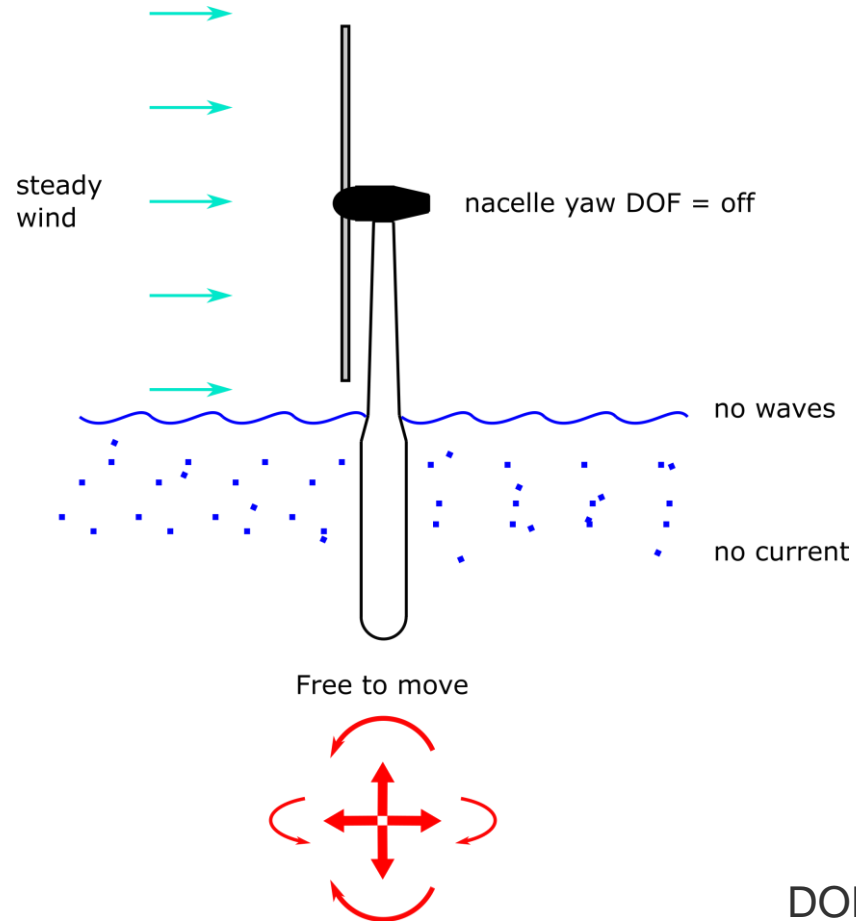
# Introduction

## Simulation program OpenFAST



# Spar sailing turbine

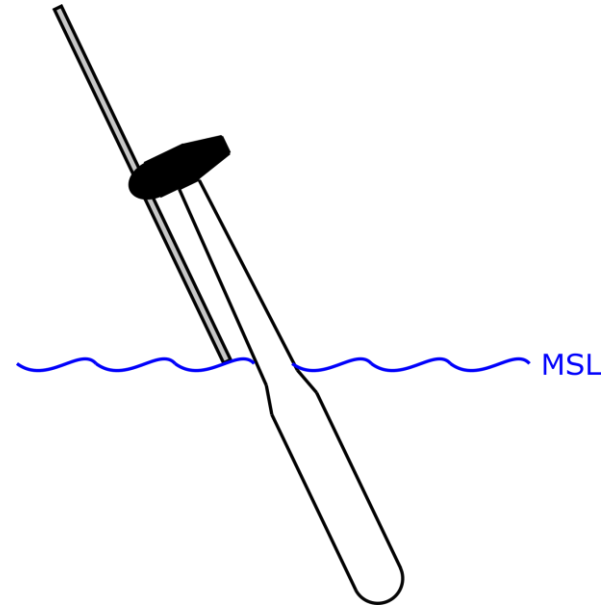
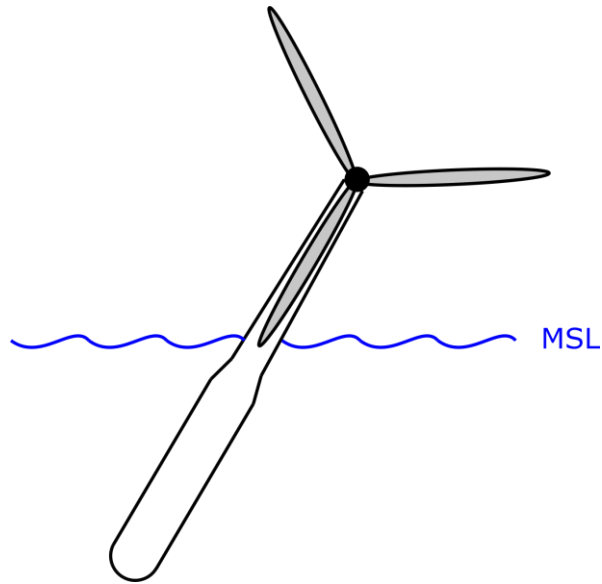
## Simulation case



DOF = Degree of Freedom

# Spar sailing turbine

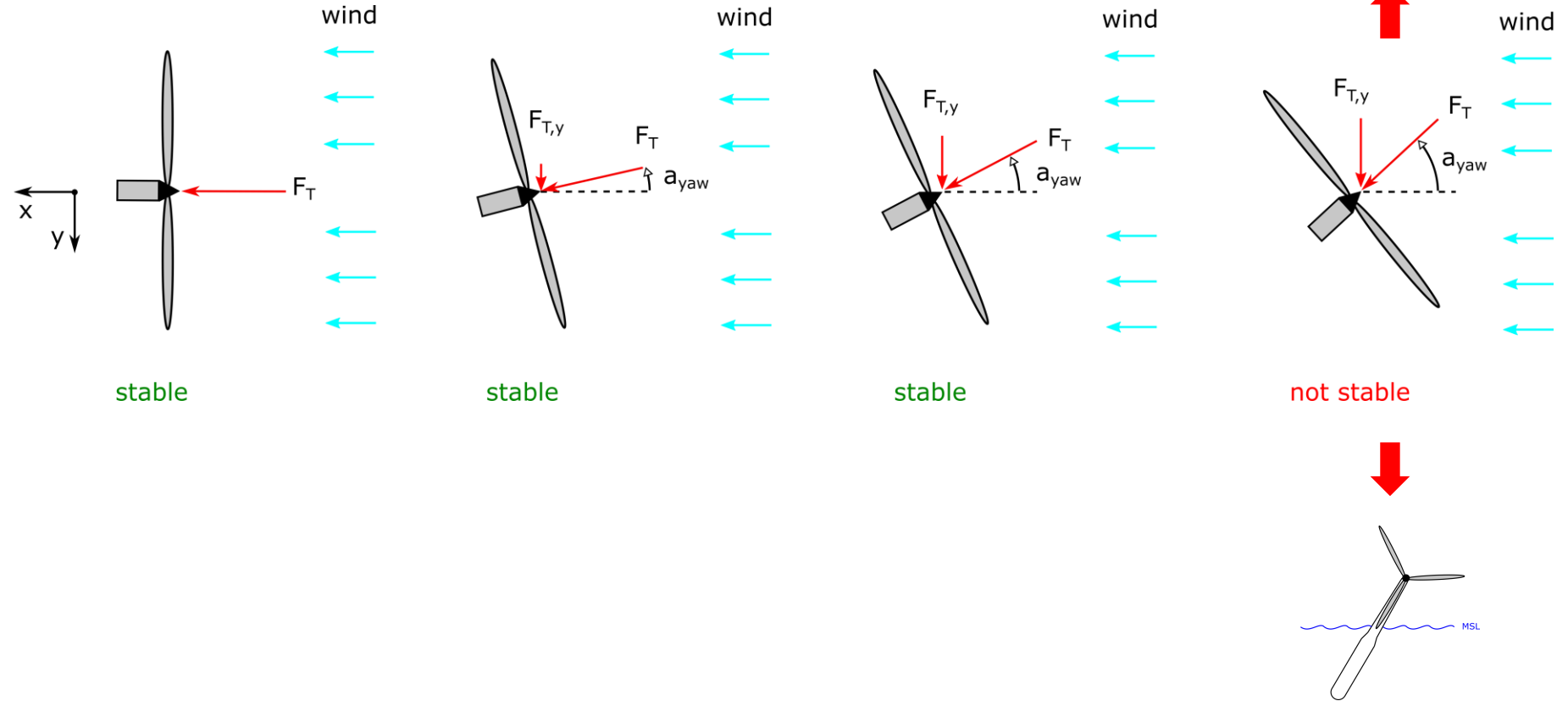
Problem: strong motions





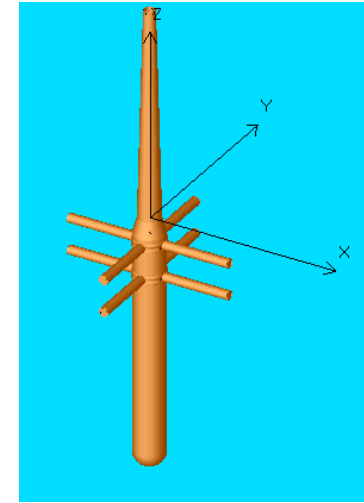
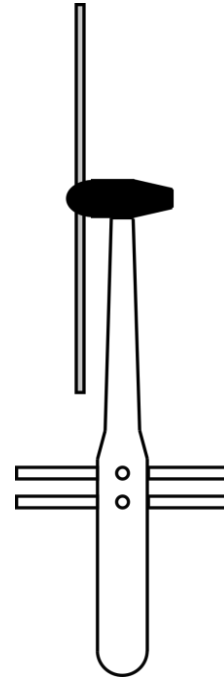
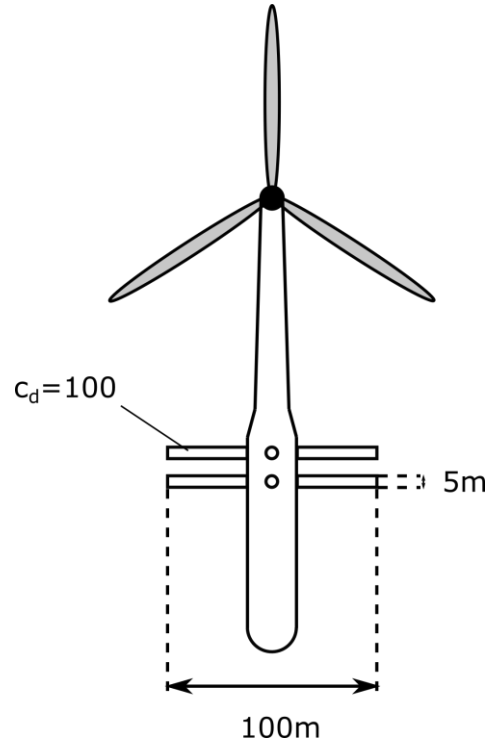
# Spar sailing turbine

What happens?



# Spar sailing turbine

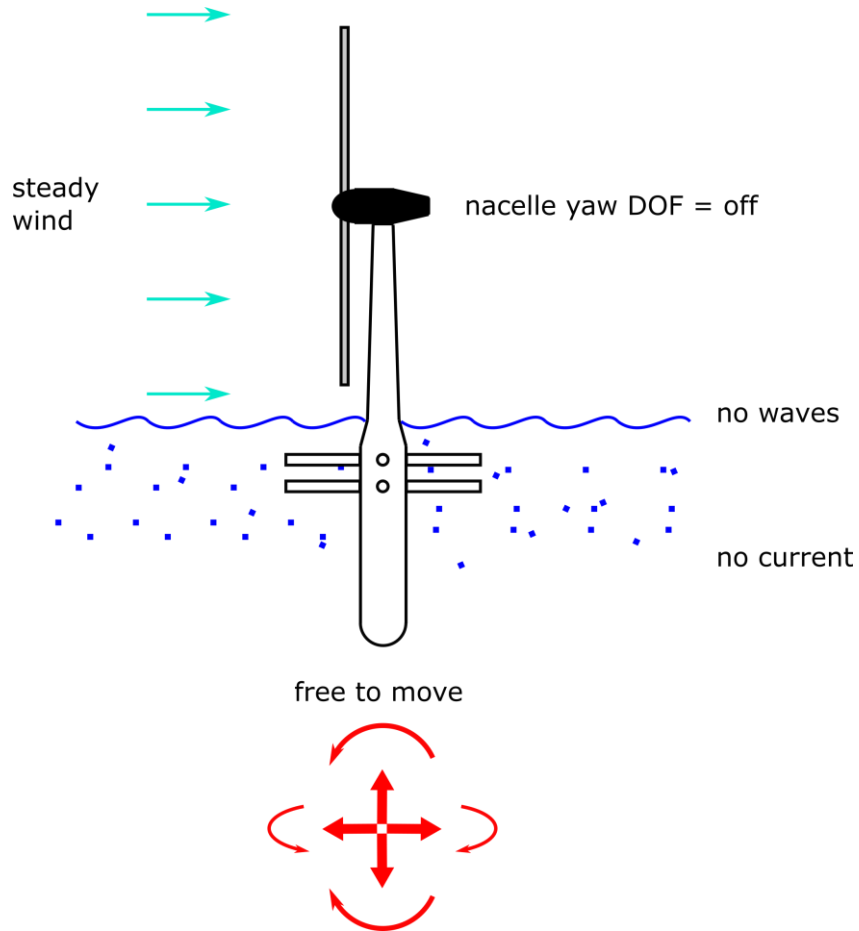
Solution: Adapted platform



Effect: drag force  $\rightarrow$  slow yaw movement down  $\rightarrow$  delay instability

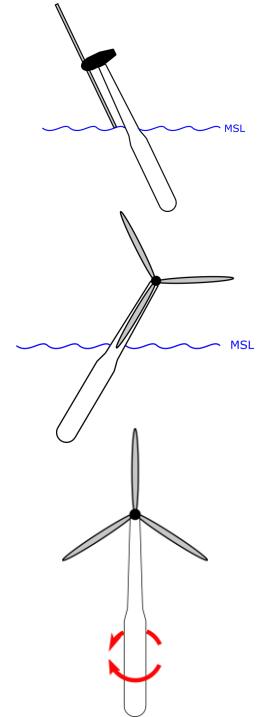
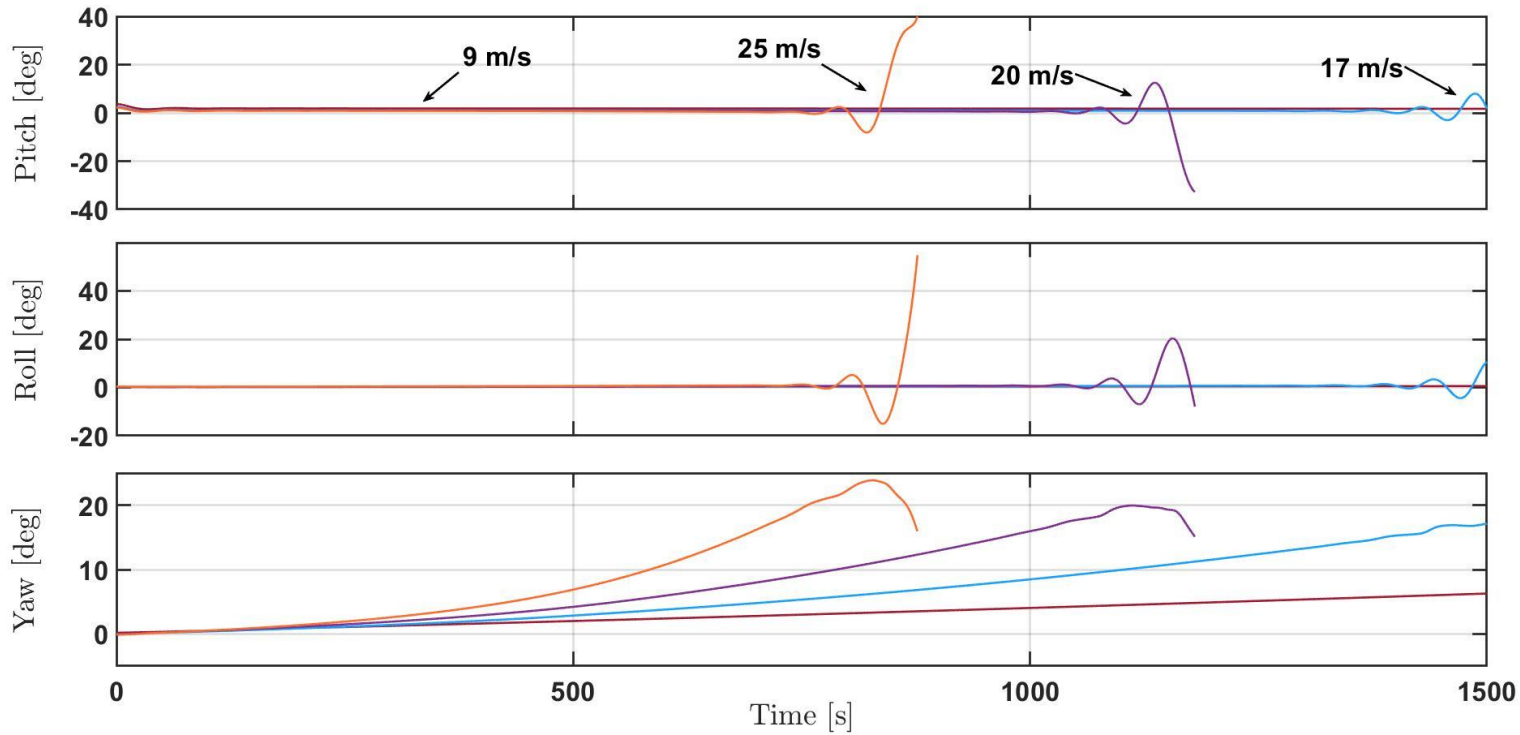
# Adapted spar sailing turbine

## Simulation case



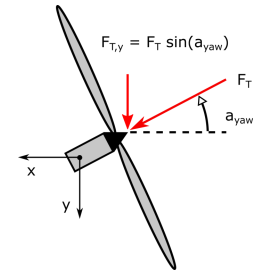
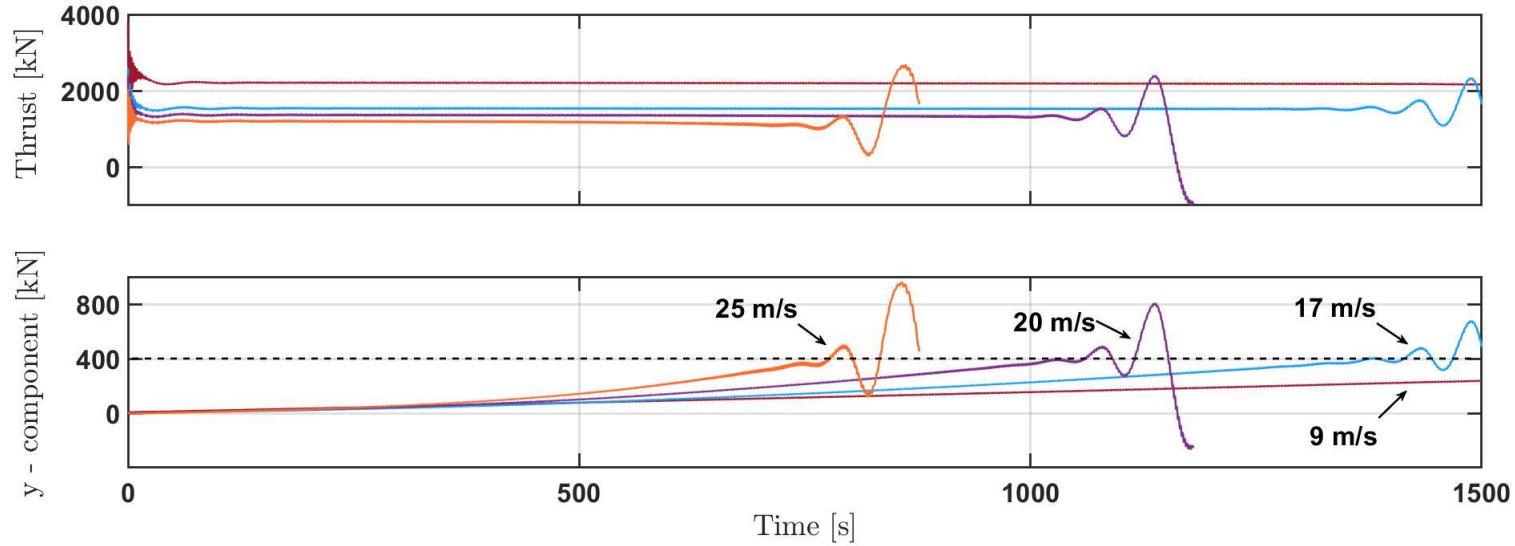
# Adapted spar sailing turbine

## Movement



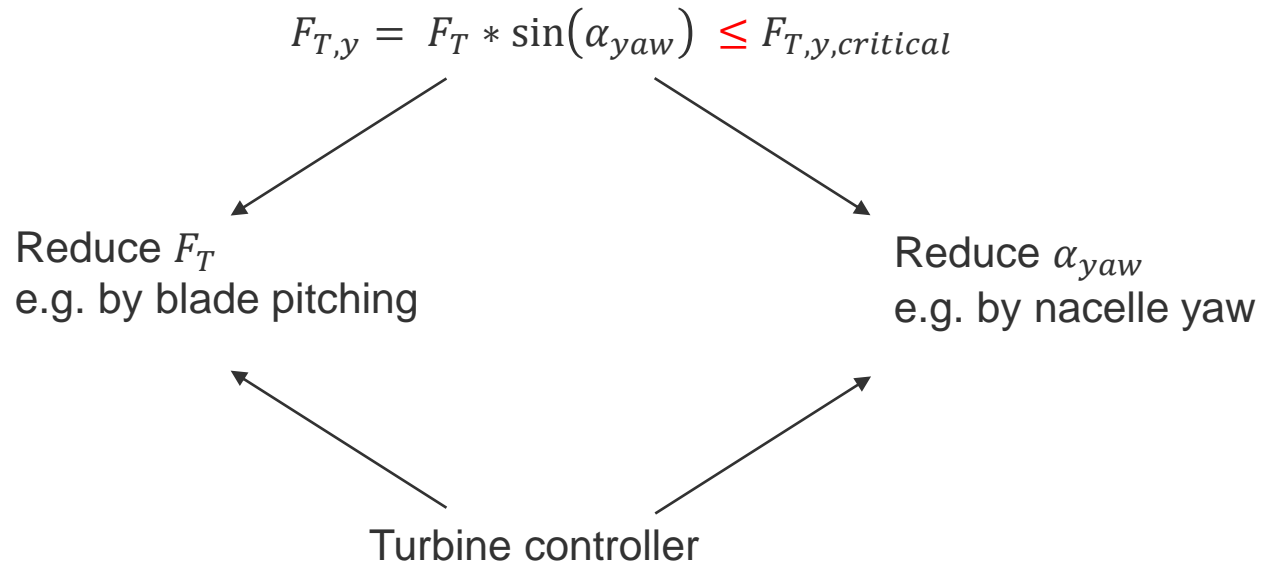
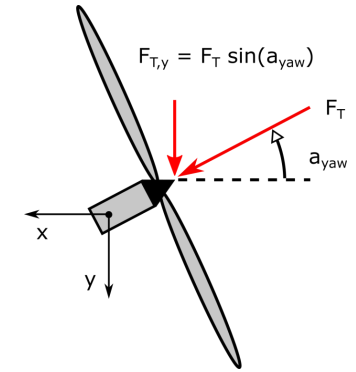
# Adapted spar sailing turbine

## Thrust



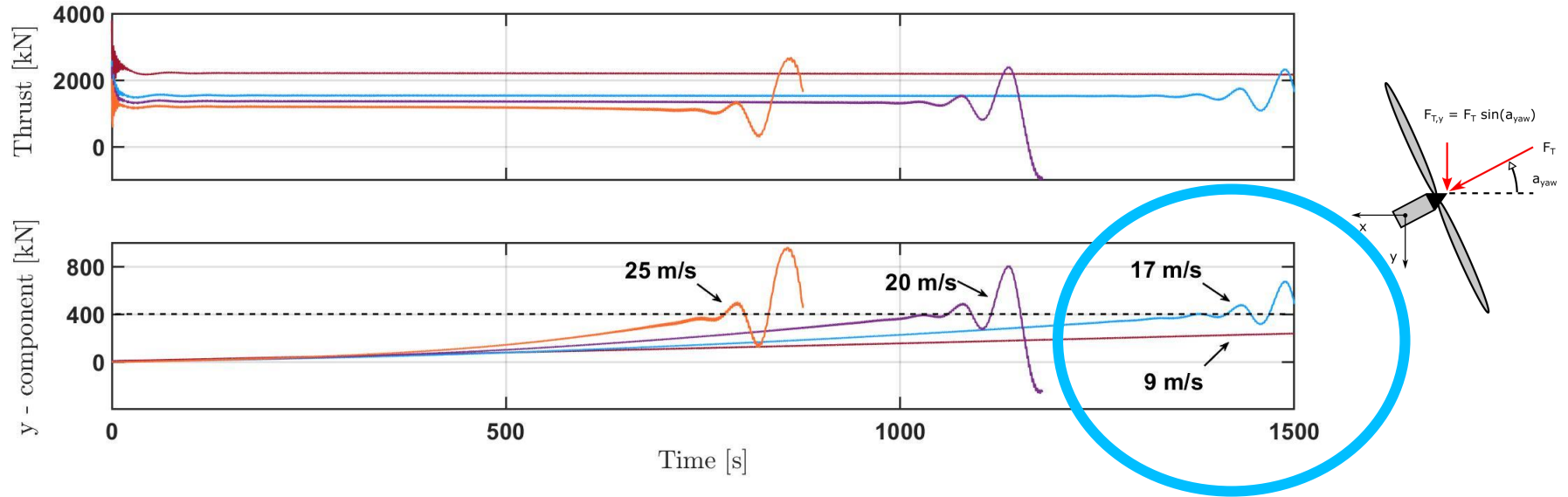
# Adapted spar sailing turbine

Suggestion: Control  $F_{T,y}$



# Adapted spar sailing turbine

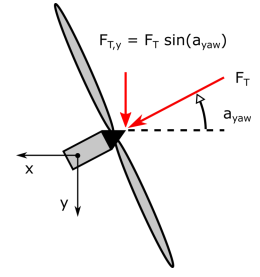
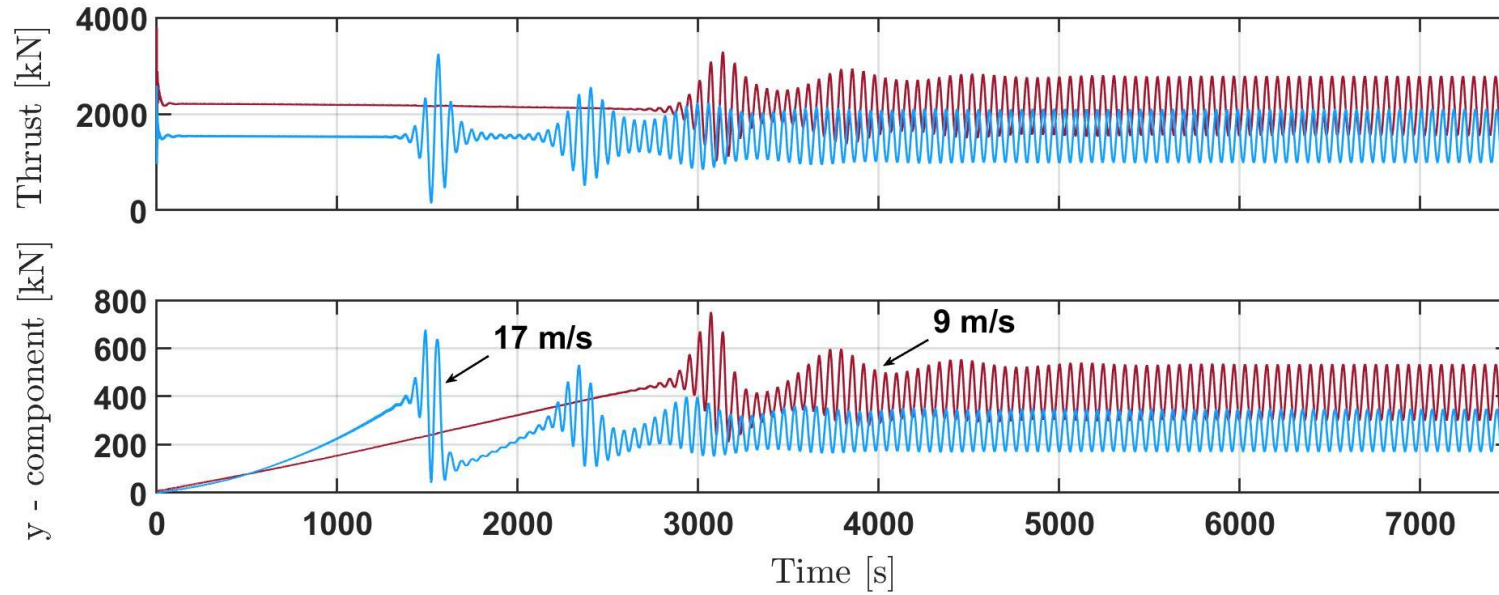
## Thrust



What happens with the simulations for these wind speeds?

# Adapted spar sailing turbine

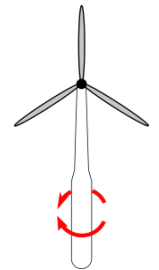
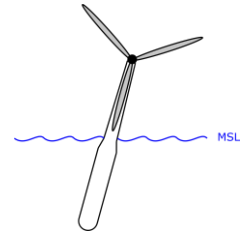
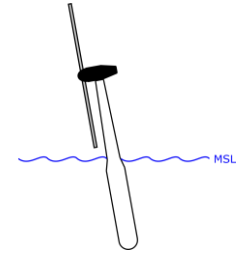
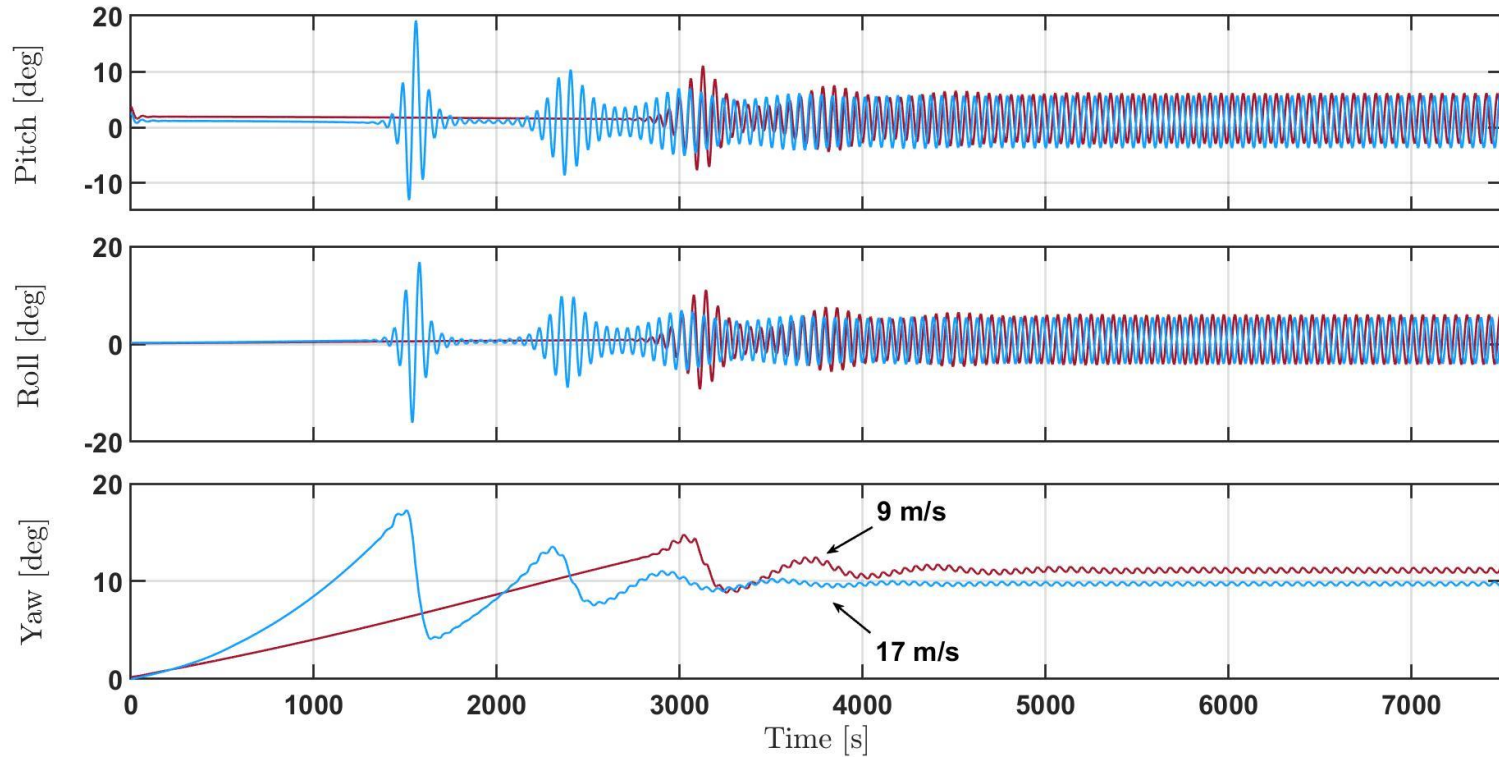
## Stabilization





# Adapted spar sailing turbine

## Stabilization



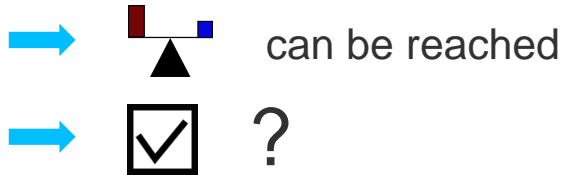
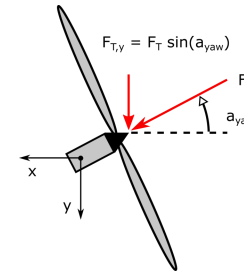
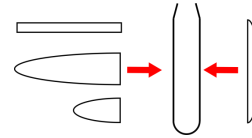
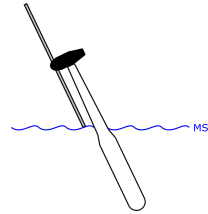
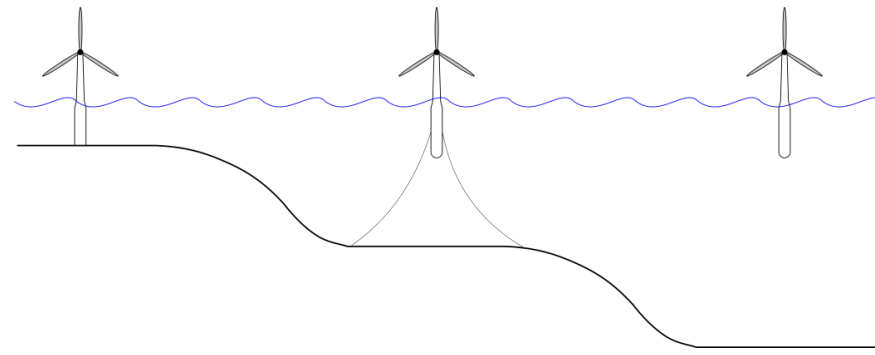
# Summary

Many opportunities for sailing wind turbines

Spar sailing turbine is unstable

Drag elements lead to more stability

Instabilities may be avoided by turbine controller





University of Stuttgart

**Thank you!**



**Leonard Willeke**

e-mail [st150067@stud.uni-stuttgart.de](mailto:st150067@stud.uni-stuttgart.de)

phone +49 (0) 711 685-68XXX

fax +49 (0) 711 685-68293

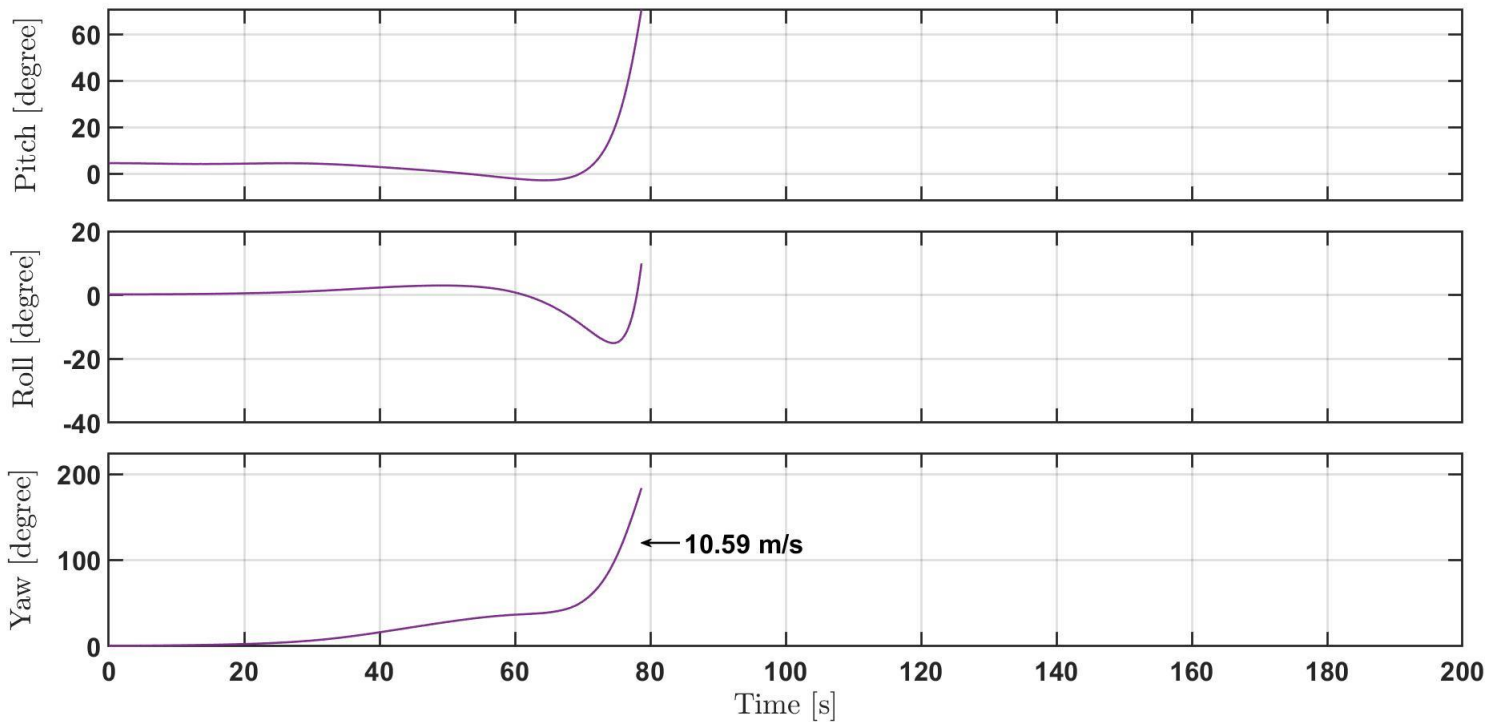
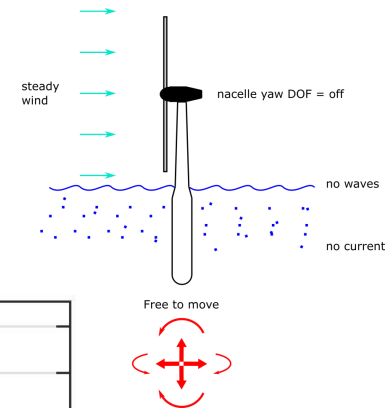
University of Stuttgart

Stuttgart Wind Energy (SWE)

Allmandring 5B, 70569 Stuttgart

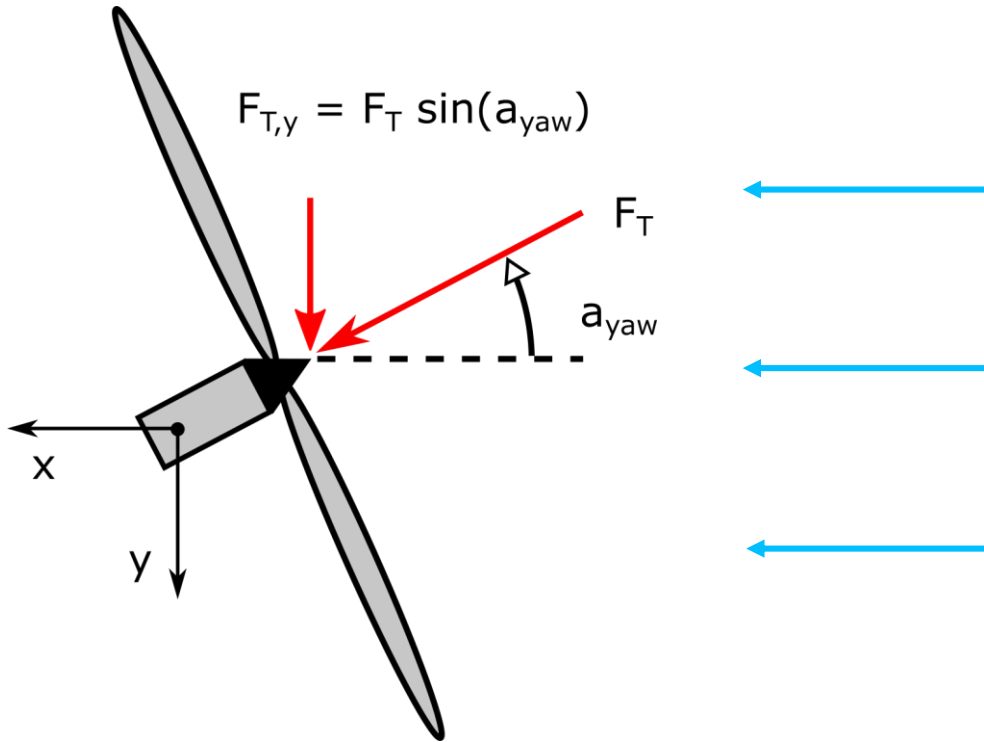
# Appendix

## Results of the sailing spar platform without drag elements



# Appendix

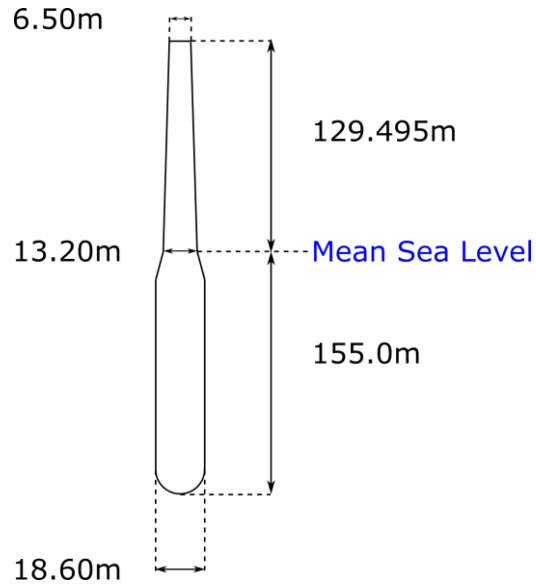
## Thrust force distribution



# Appendix

## Models of spar and turbine

### WindCrete spar



### IEA Wind 15 MW reference turbine

