A numerical study of a catamaran installation vessel for installing offshore wind turbines

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Outline

1. Introduction
2. The catamaran installation concept
3. Numerical simulation
4. Conclusion

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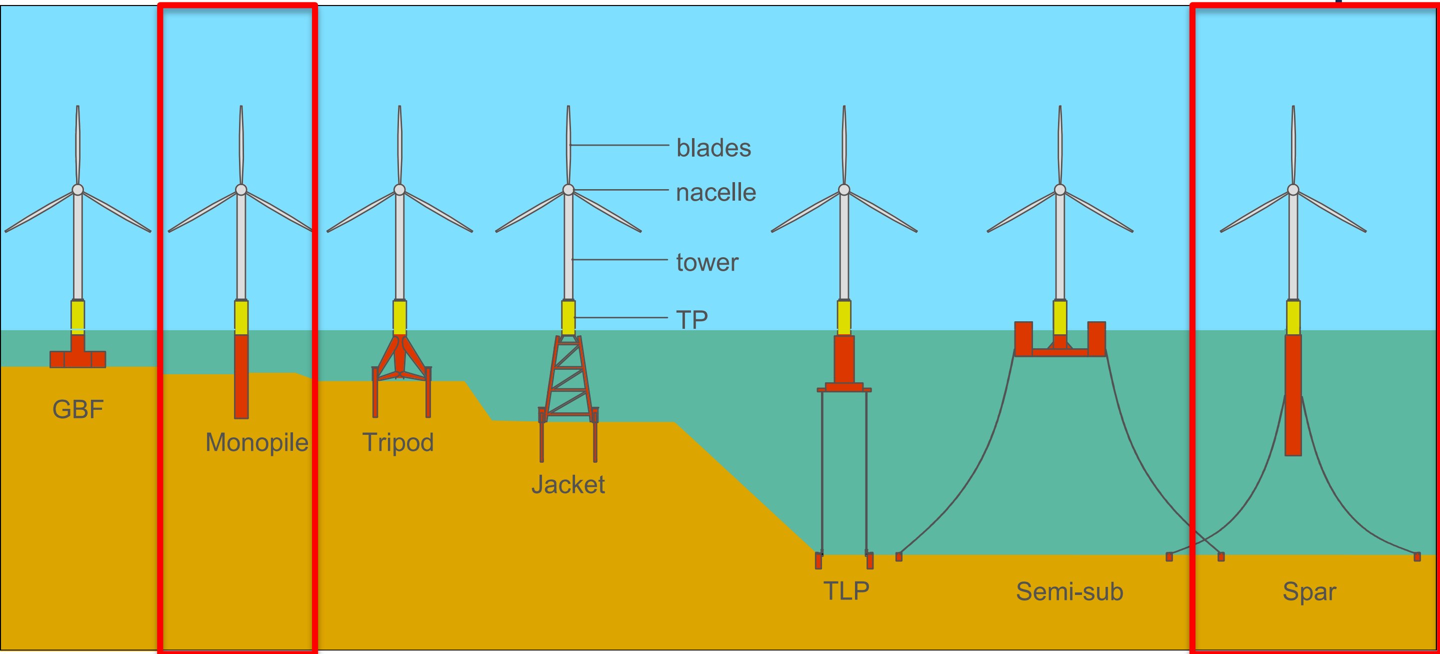
Background

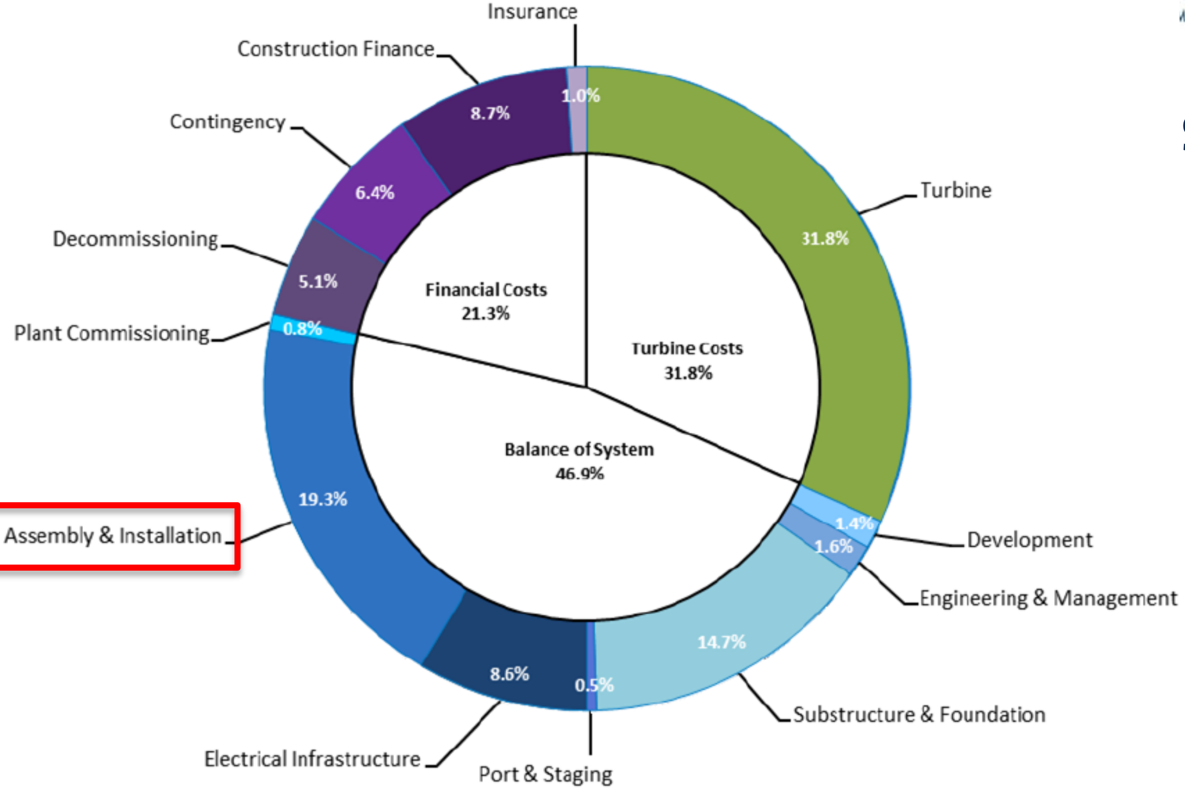
Bottom-fixed Floating



Water depth:

<20m<40m 50-70m >50-100m

Capital expenditure of offshore wind



C. Mone et al. (2015) 2015 Cost of Wind Energy Review, NREL

Installation methods - foundation

Tripod installation using a jack-up vessel
(http://worldmartimenews.com)

Jacket installation using a floating vessel
(https://www.boskalis.com)

Monopile installation
(www.seawayheavylifting.com.cy)

Installation methods - rotor blade

Bunny ear
Vatenfall

Full rotor
Dong Energy

Single-blade installation
Fred Olsen Wind Carrier

Installation methods - full assembly

Saipem 7000
Statoil AS

Novel installation vessel
Ullstein AS

Purpose of numerical simulation

- Design and testing of novel installation methods
- Response-based prediction of limiting operational conditions
- Online decision support for offshore installations

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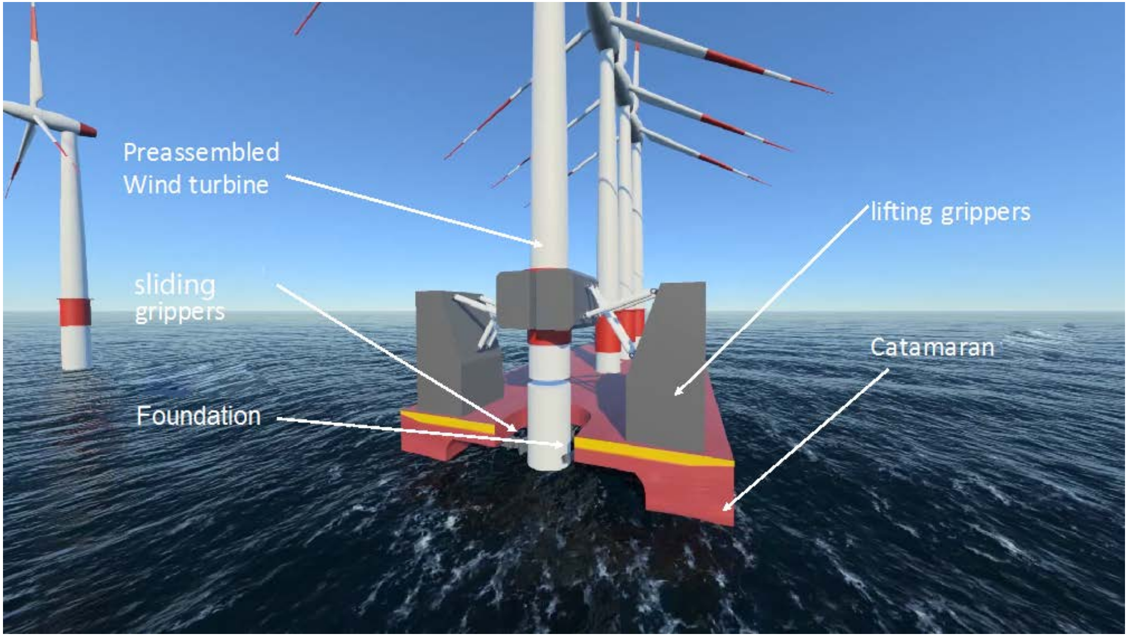
The catamaran installation concept



L.I. Hatledal et al. (2017)

Challenges of the concept

- Hydrodynamics

  hydrodynamic coupling, sloshing, viscous effect

- Structural dynamics

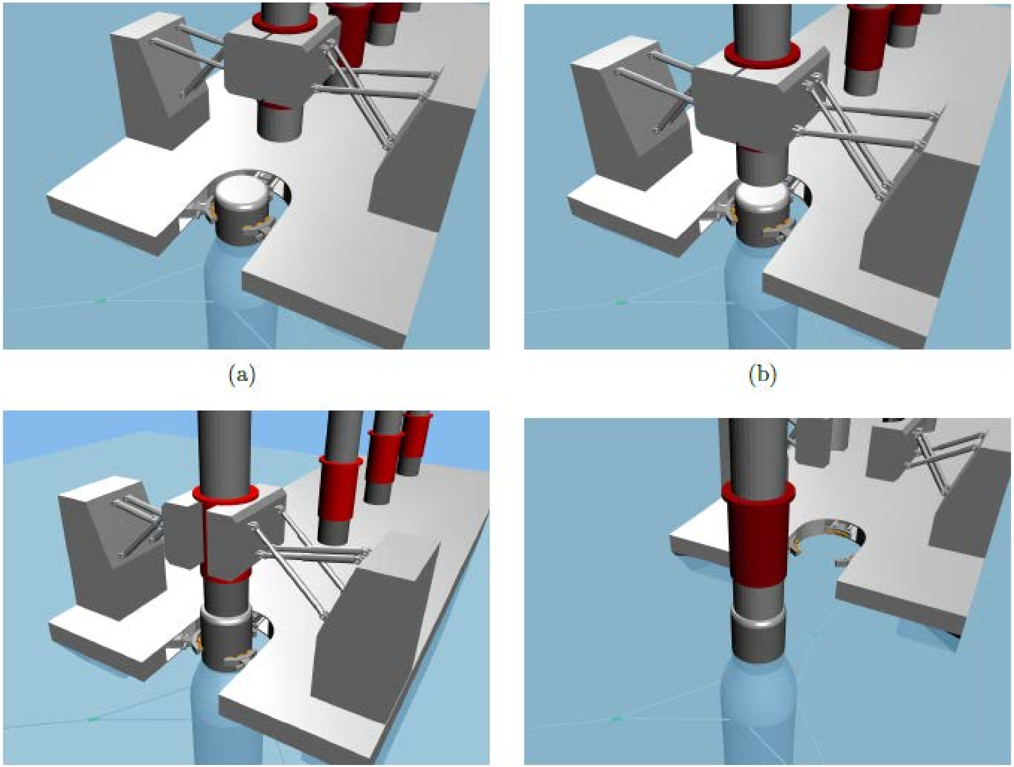
  coupled motion modes, mechanical coupling

- Automatic control

  station keeping of the vessel, active ballast system

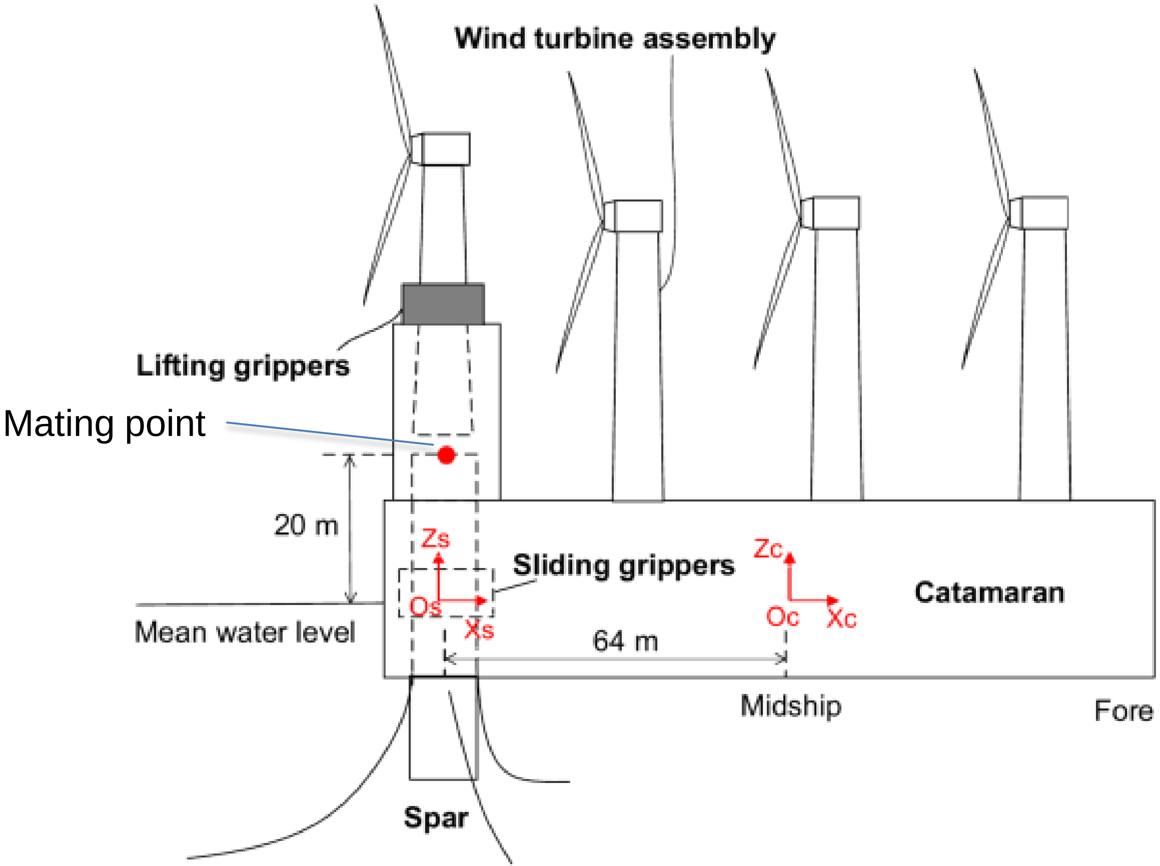
  motion tolerance and control, landing force control

Installation procedure



(a) (b) (c) (d)

Monitoring the relative motions



Properties of the catamaran

Catamaran with four wind turbines

Length overall (m)	L_{OA}	144
Breath moulded (m)	B	60
Spacing between monohulls at waterline (m)	L_{hull}	38
Draft (m)	T_c	8.0
Displacement mass (tonnes)	D	18502.9
Vertical center of gravity above baseline (m)	KGc	28.6
Transverse metacentric height (m)	GMt	66.4

Properties of the spar

Diameter at top (m)	L_{bd}	9.5
Diameter at waterline (m)	M_{bd}	14
Draft (m)	T_s	70
Displacement mass (tonnes)	D	11045
Vertical center of gravity above baseline (m)	KGs	30
Vertical fairlead position below waterline (m)	Z_f	15
Body origin in global coordinate system	(X_s,Y_s,Z_s)	(0,0,0)
Total length of mooring line (m)	L_{moor}	680
Diameter of upper chain segments (mm)	D_{up}	132
Diameter of lower chain segments (mm)	D_{low}	147

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   Time-domain simulation

   Frequency-domain simulation

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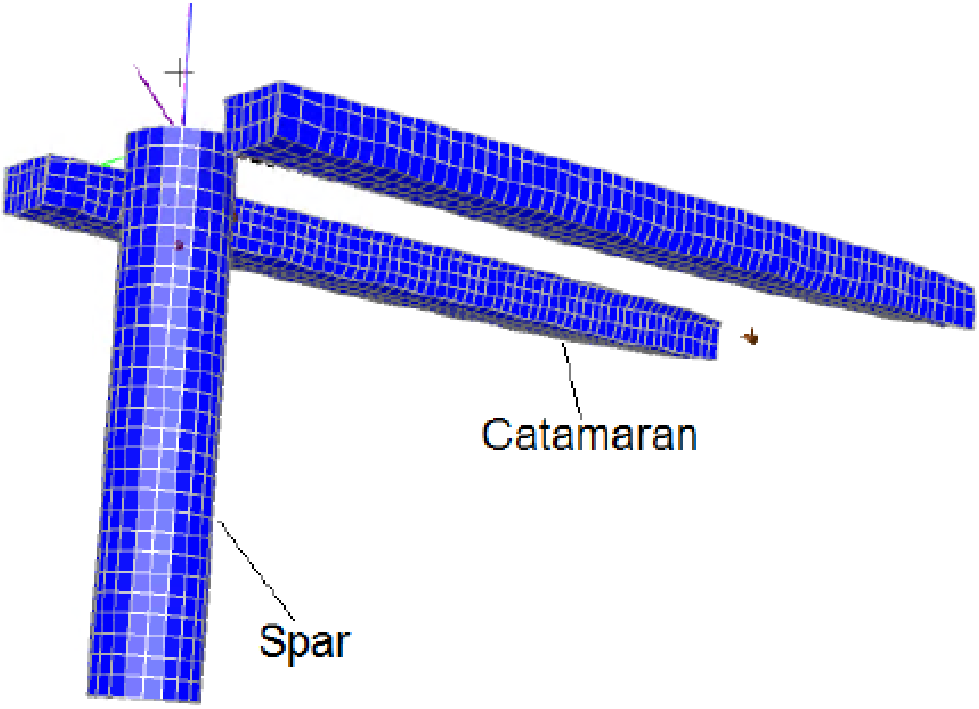
Time-domain simulation

WADAM: Hydrodynamic analysis of the two-body system

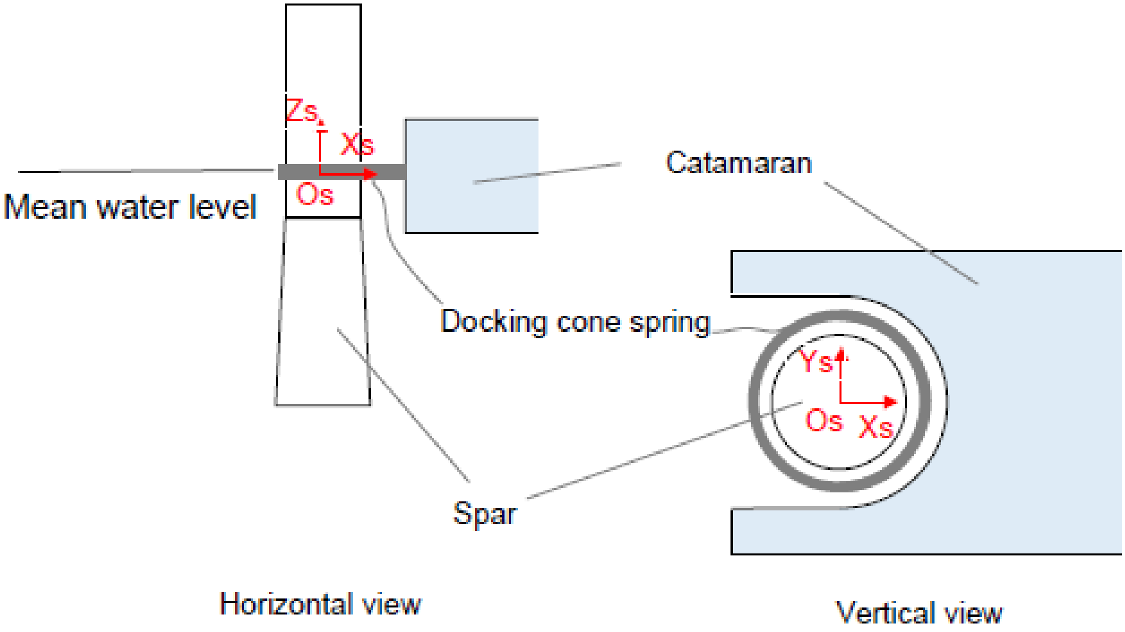
HAWC2: Calculation of the wind forces on the turbine assemblies

SIMO: Time-domain coupled analysis
Catamaran with dynamic positioning system; spar with mooring lines;
sliding grippers between catamaran and spar

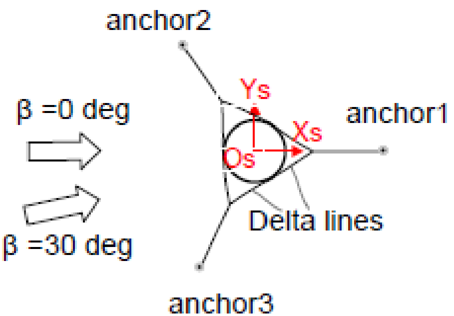
Modelling of the hydrodynamics



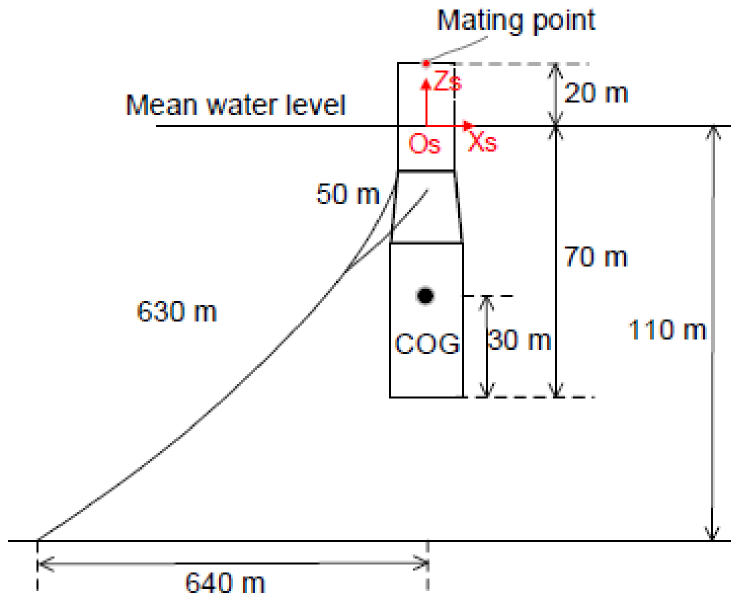
Modelling of the sliding grippers



Modelling of the mooring system



Vertical view



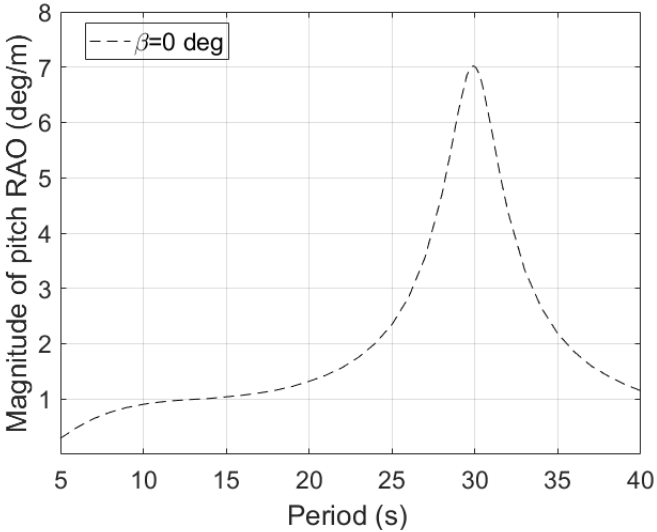
Horizontal view

Frequency-domain approach

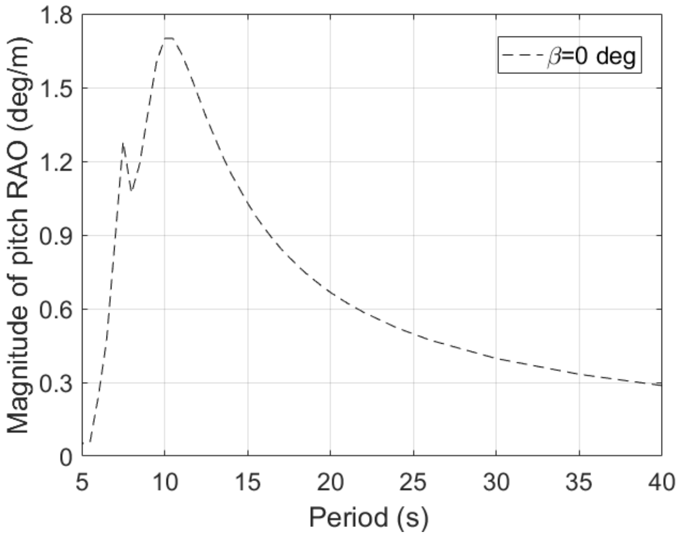
1. Hydrodynamic analysis of the two-body system

2. Short-term motion prediction of the mating point by using Response Amplitude Operators

Magnitude of the pitch RAOs



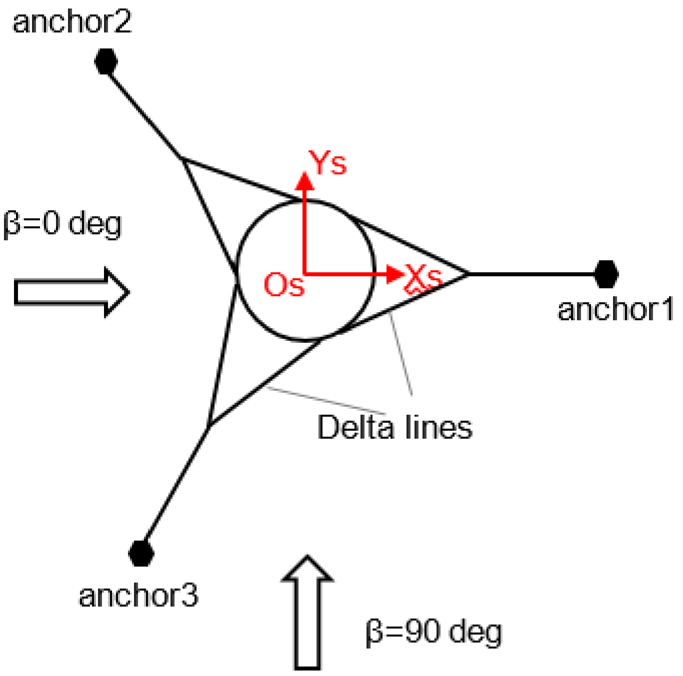
Spar



Catamaran

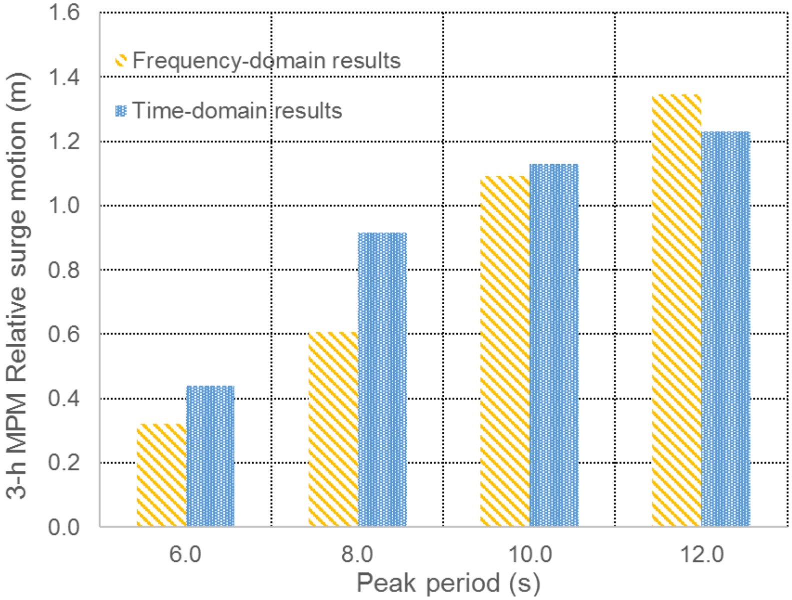
NTNU

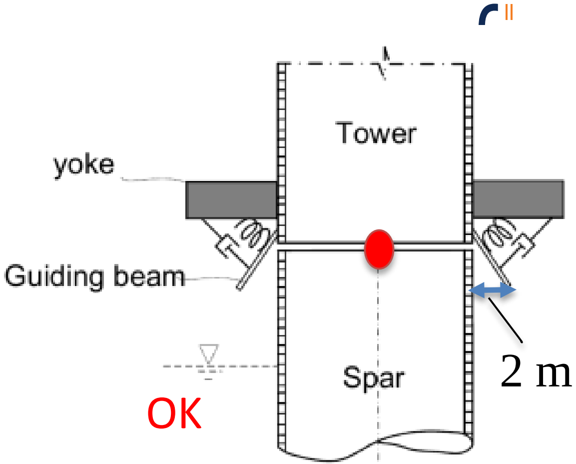
Environmental conditions



Hs=2.0 m Tp=6, 8,...,12 s β=0, 90 deg

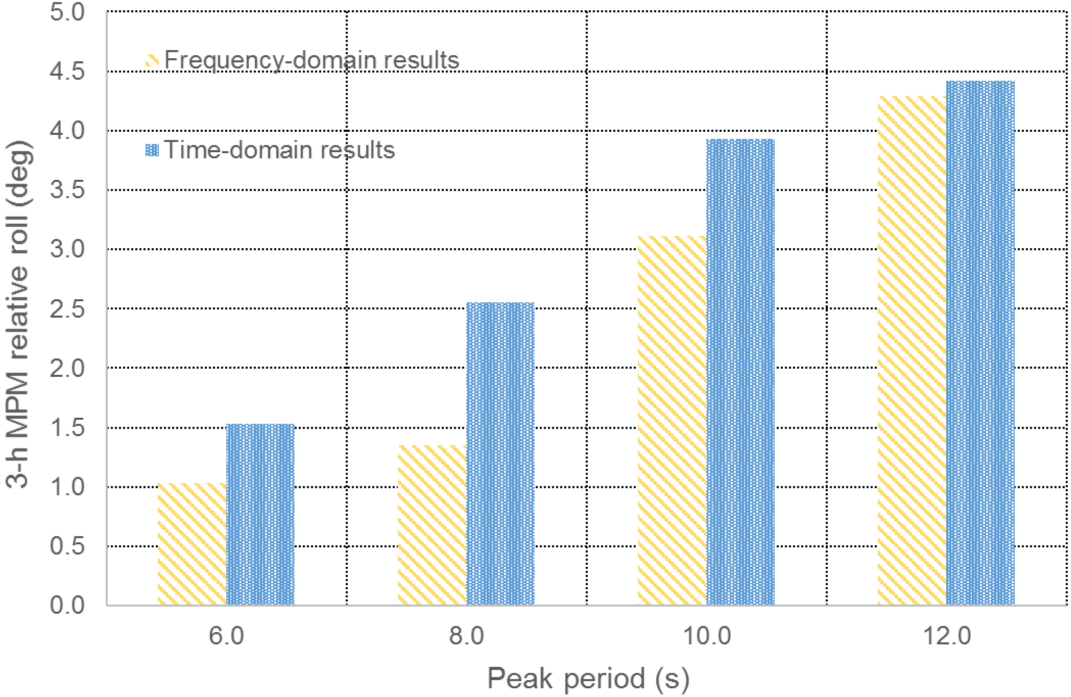
Results - relative surge motion





Hs=2.0 m, β=0 deg

Results - relative roll motion



Hs=2.0 m, β=90 deg

Conclusion

- A numerical modelling approach of the catamaran installation concept is introduced.

- Future work is needed for implementing the active heave compensator, dimensioning of the catamaran, active ballast system, etc.

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