Huisman

Worldwide Lifting, Drilling and Subsea Solutions




Wind Turbine Shuttle

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Introduction

High demand for installation of wind turbines requires new “right tools”, thus high performance construction vessels

Major requirements:

- Transport and installation within shortest possible time
- As less as possible construction works offshore
- All year operation
- High workability, thus very limited downtime
- Safety

Solution:

Transport and installation of the whole wind turbine in one piece

New type high performance vessel

Introduction

Jack-up vessels:

- Weather limitations for jack-up operations
- Weather limitations for transit
- Normally low transit speeds
- Time consuming jack-up operations (lowering and retrieving legs)
- Limited maximum water depth

Crane vessels (monohull):

- Very limited weather window for crane operations due to vessel motions
- Weather limitations for transit

Solution:

SWATH type construction vessel

Concept

Requirements:

- High transit speed
- Limited vessel motions
- Compensation system for remaining motions
- Transport fully assembled wind turbines and foundations
- Short installation time

Concept

Solution: Wind Turbine Shuttle:

- Transport and installation of two fully assembled wind turbines
- Transport and installation of two complete wind turbines foundations
- All year operation in The North Sea
- High yearly performance with very limited downtime
- DP3

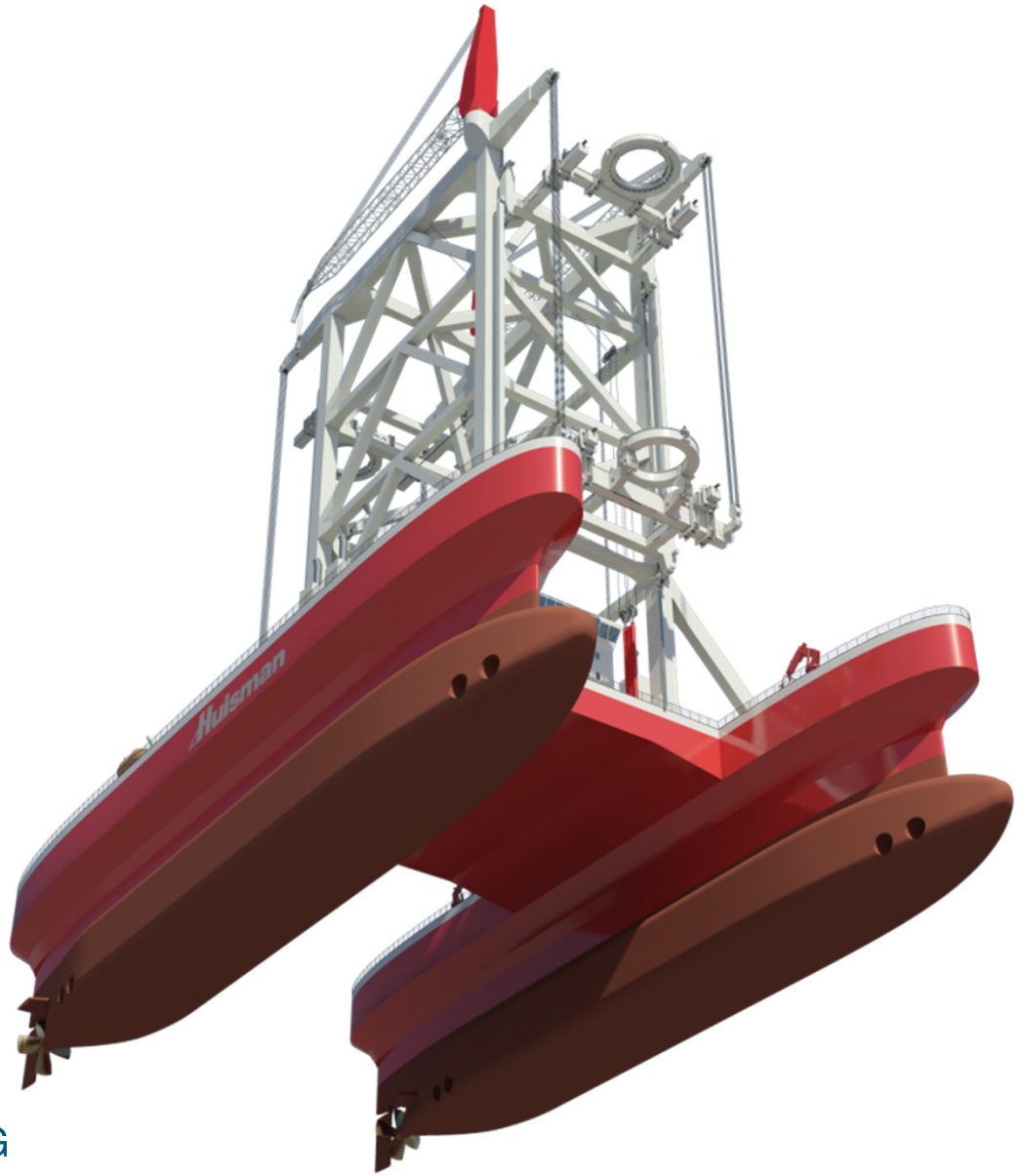
Concept

Main particulars:

Length overall:	134.3 [m]
Length of struts:	120.4 [m]
Breadth overall:	70.8 [m]
Depth from base to main deck:	28.8 [m]
Transit and installation draft:	16.0 [m]
Harbor draft:	9.5 [m]
Air gap (draft of 16 m):	7.4 [m]
Water displacement (draft of 16m):	37000 [t]

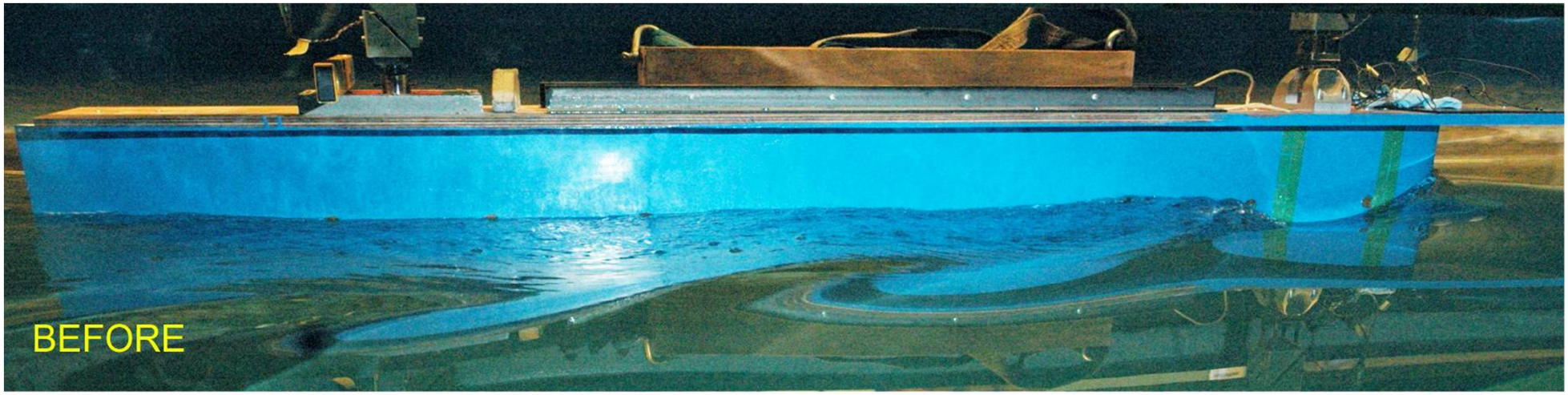
Main specifications:

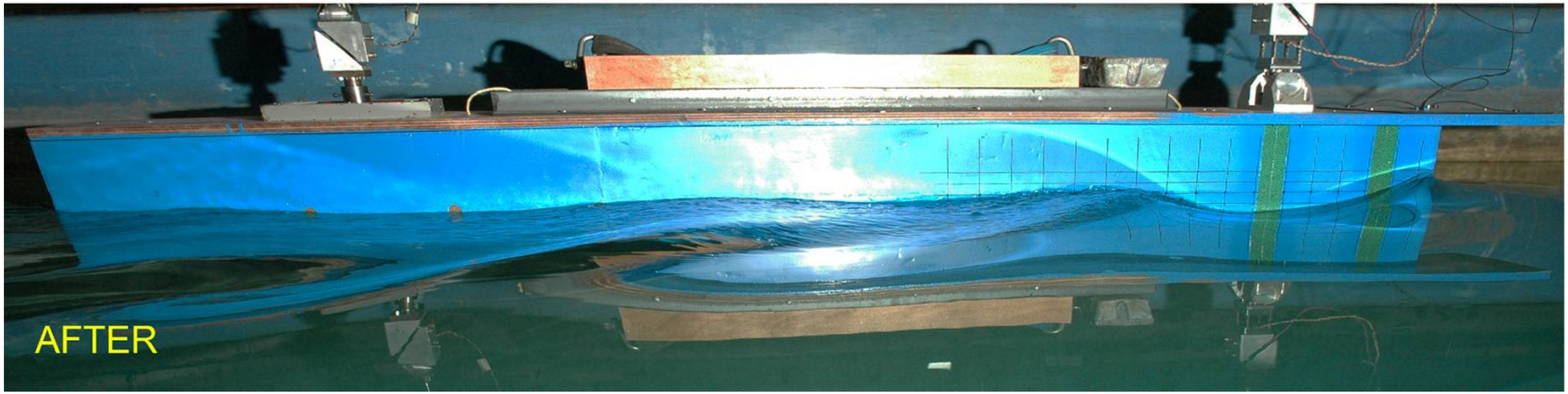
Dynamic positioning class:	DP3
Payload wind turbines:	2 x 1000 [t]
Payload foundations:	2 x 2000 [t]
Transit speed:	14 [knots]
Limiting sea state during installation (significant wave height):	3.5 [m]
Accommodation:	100 [persons]
Fuel:	MDO or/and LNG



Resistance

Resistance: bow shape optimization

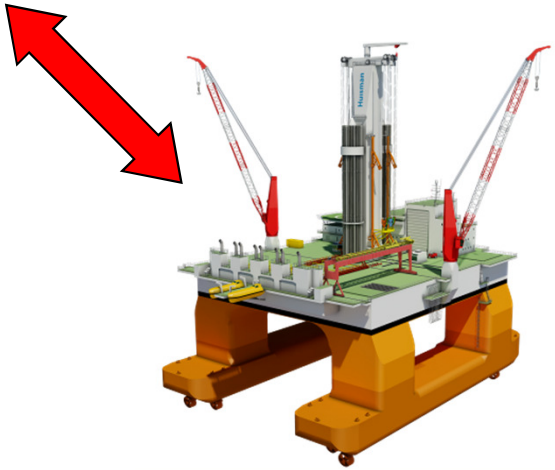


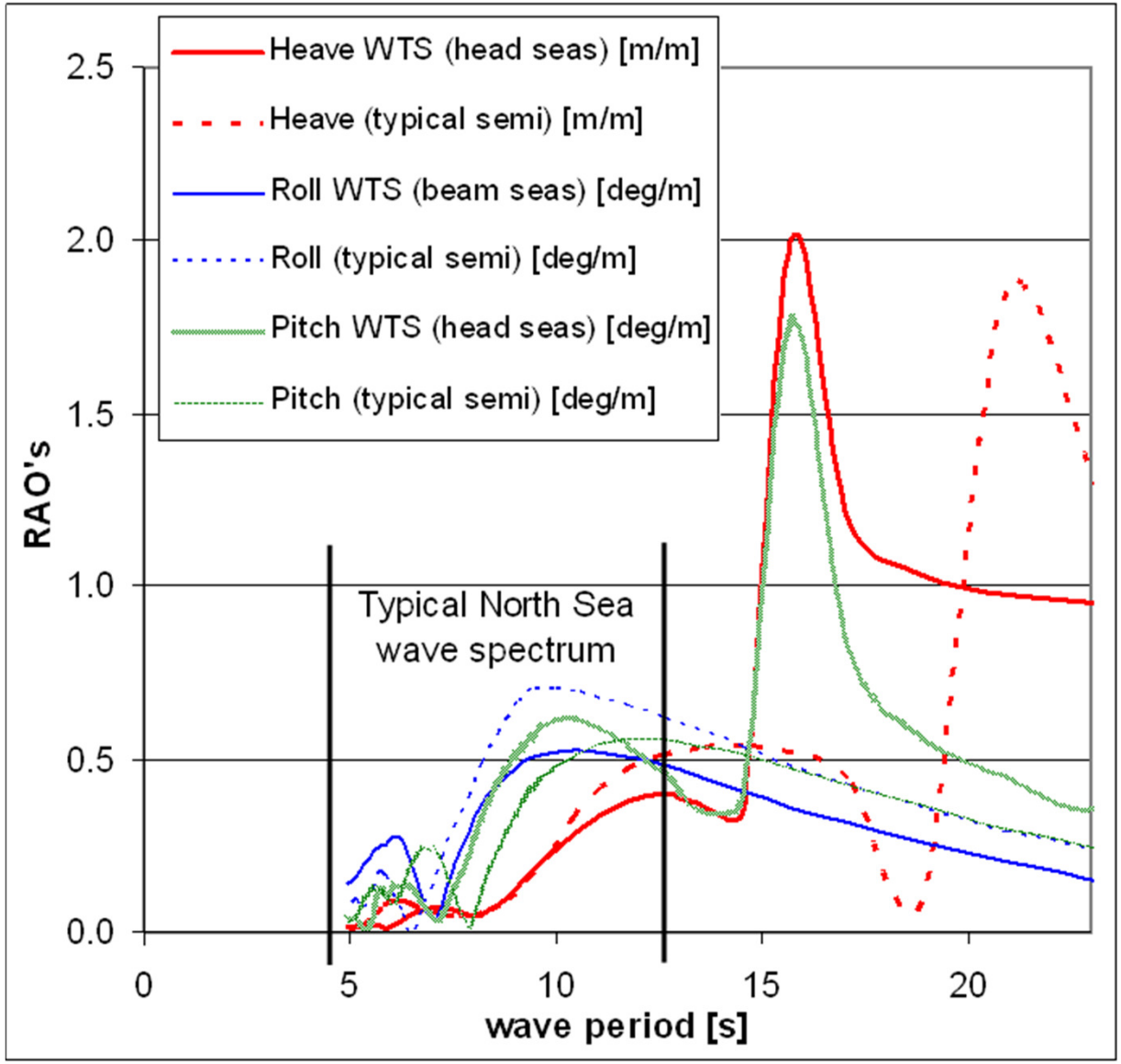


Seakeeping (numerical)

Seakeeping:

- RAO's: comparison with a drilling semi





Seakeeping (model tests)

Model tests:

Station keeping in irregular waves H_{sig}=3.5m

Significant difference was observed for pitch and roll motions between the numerical predictions and the model test measurements (up to 50%-100%)

The cause:

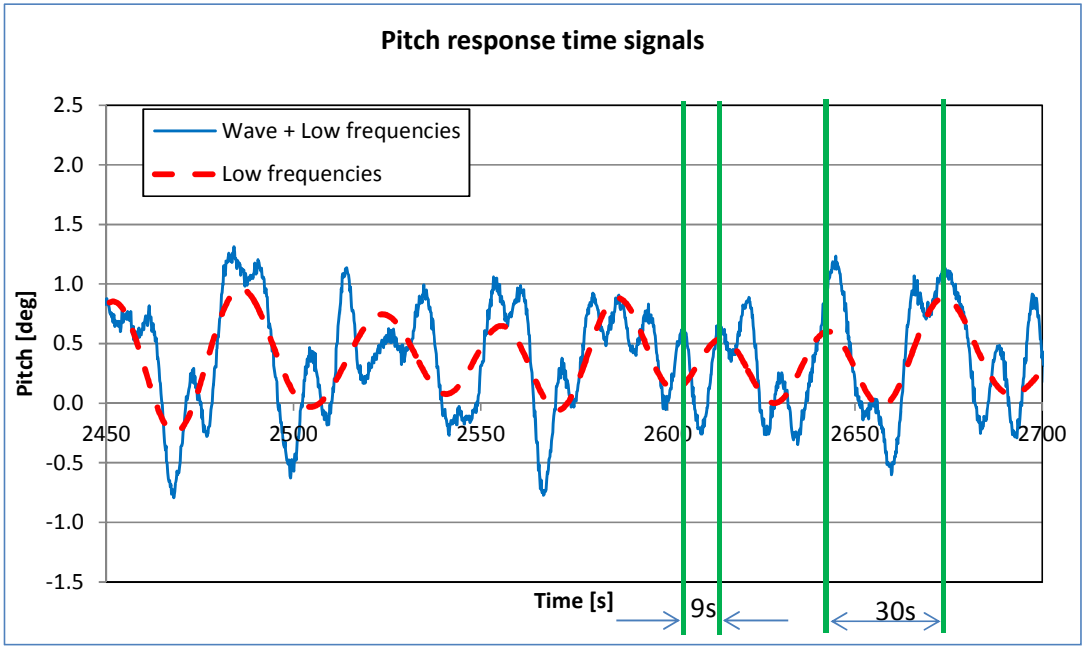
Low frequency motions

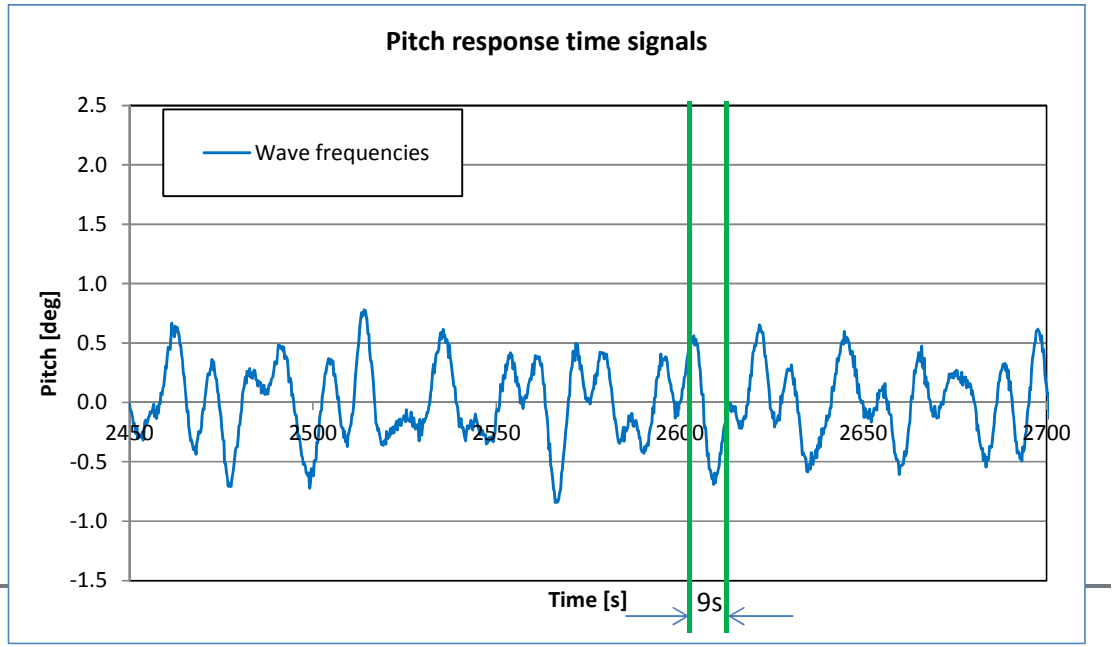
Seakeeping

Low frequency motions:

Low frequency motions occur at natural roll / pitch periods of the vessel (periods of approx. 30-40s)

The hull is very “smooth” since it is highly optimized for speed in transit. There is a lack of damping when vessel is stationary.

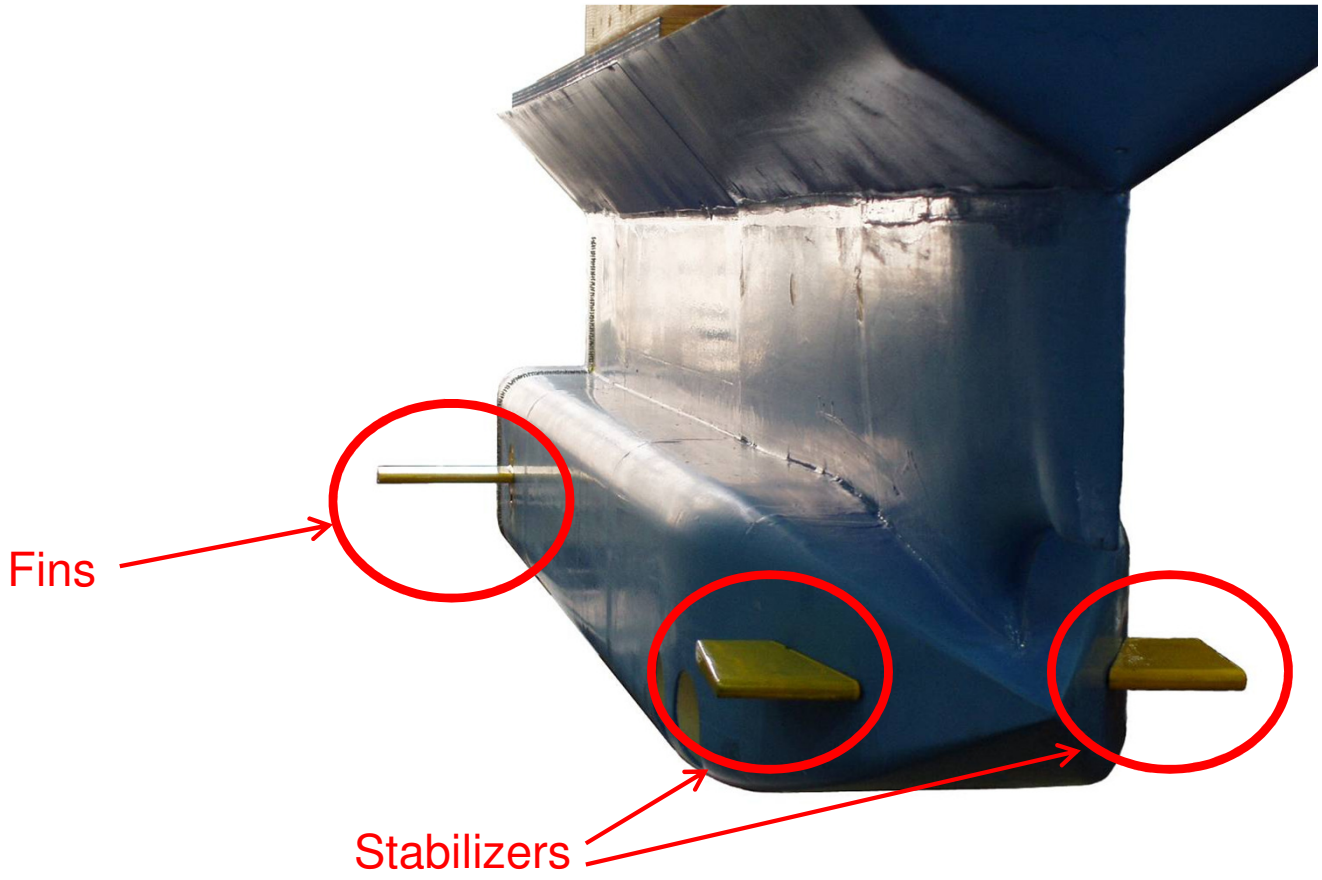




Seakeeping

Low frequency motions - Solutions:

1. Stabilizers and fins for passive damping
2. Active vessel motion compensation system.



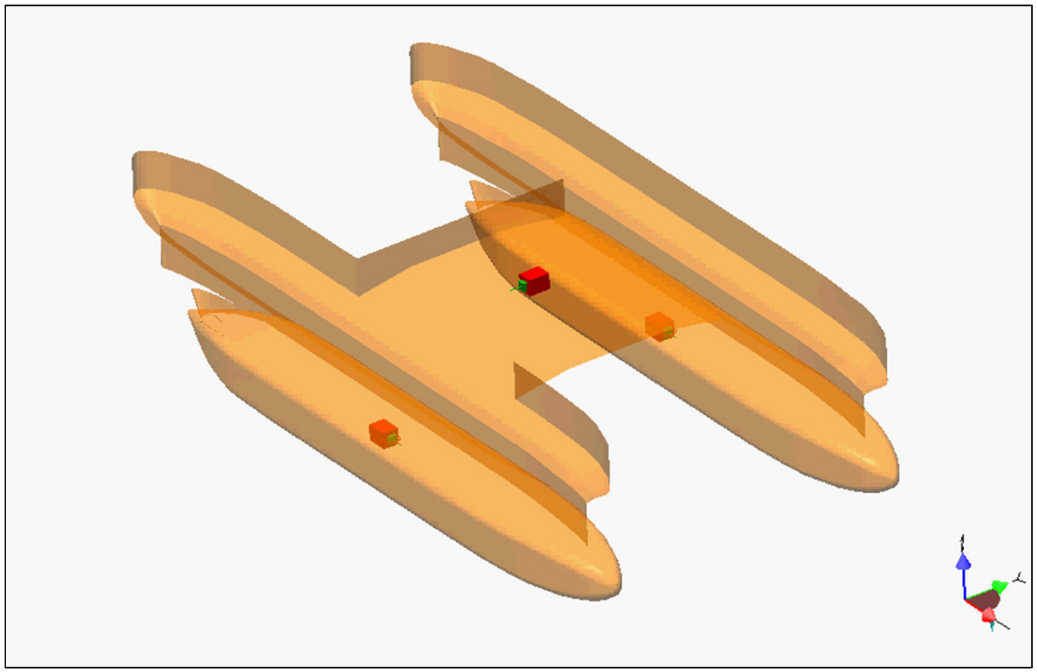
Vessel motion compensation system

System with a moving mass:

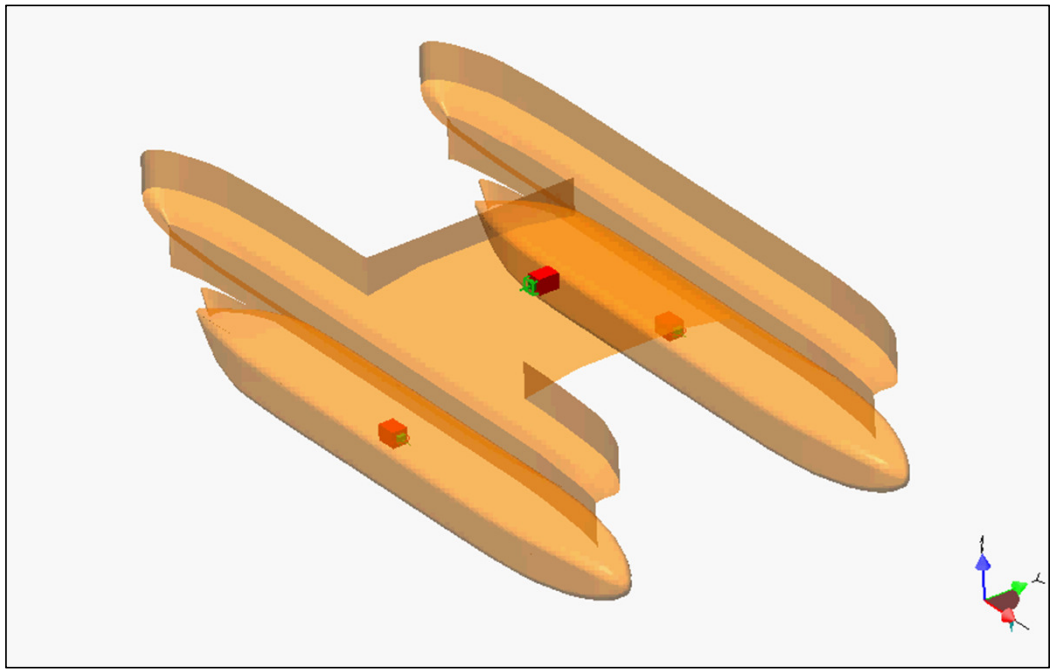
Relatively small masses (each mass is about 50-70t) and low power are required since only the low frequency motions are compensated, thus, not the wave frequency motions.

One mass for roll compensation and two masses for pitch compensation:

Roll compensation



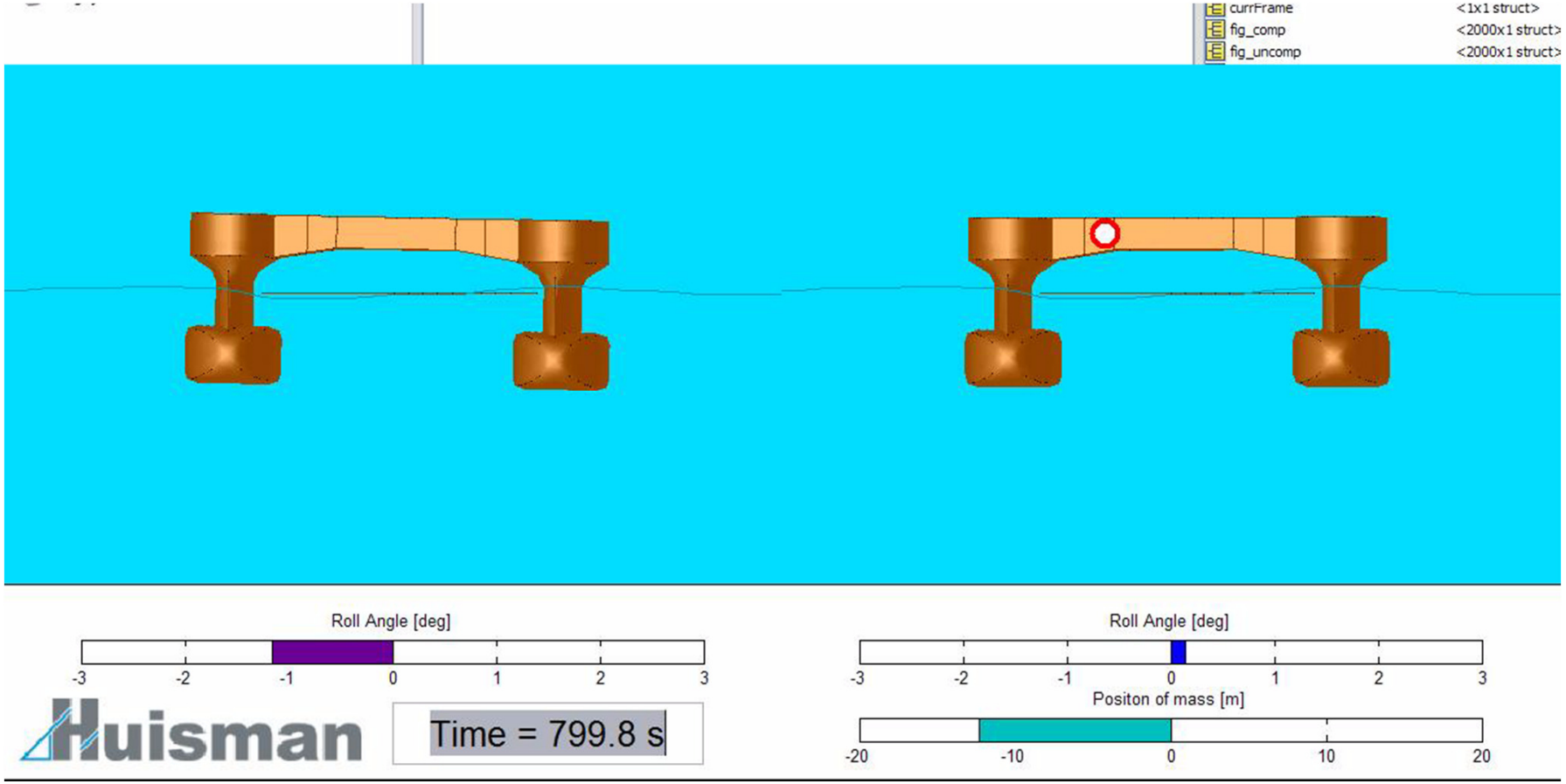
Pitch compensation



Vessel motion compensation system

System with a moving mass:

Roll compensation



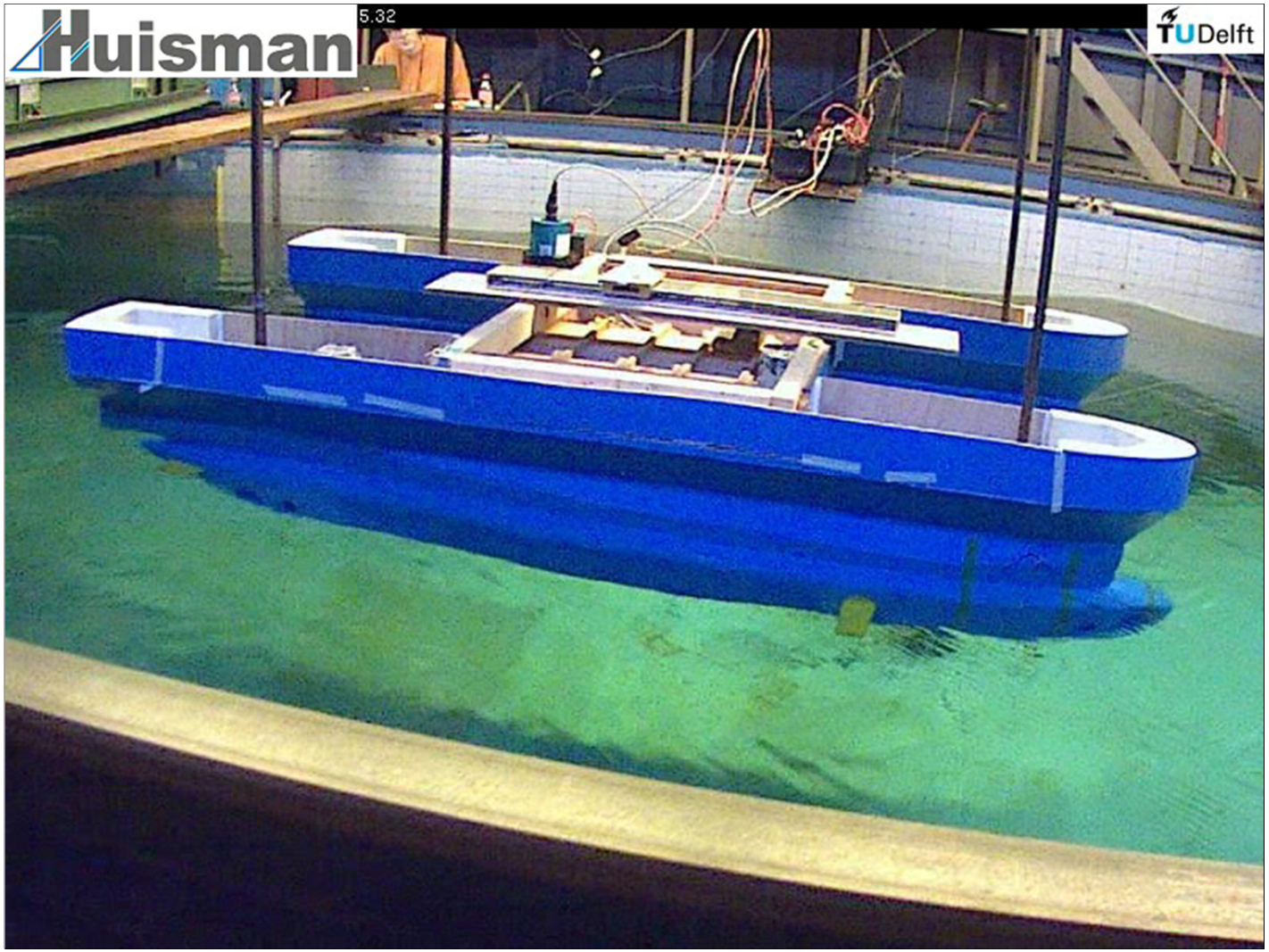
Vessel motion compensation system

System with a moving mass:

Model test set-up:

Vessel motion compensation system

System with a moving mass:

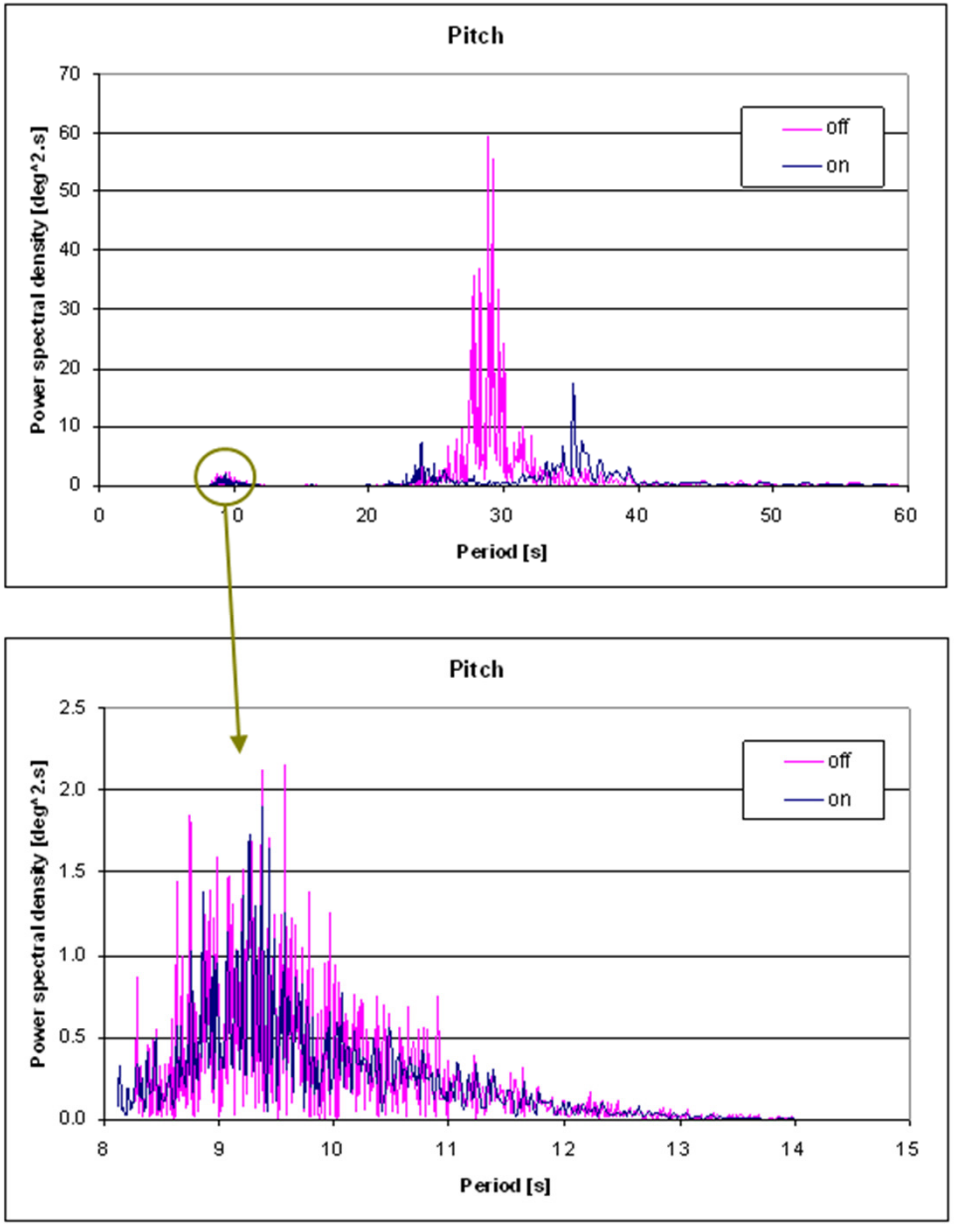


Vessel motion compensation system

System with a moving mass:

Test results:

- The low frequency motions are virtually illuminated
- Total reduction of roll and pitch is 30%-40% (including response at wave frequencies)

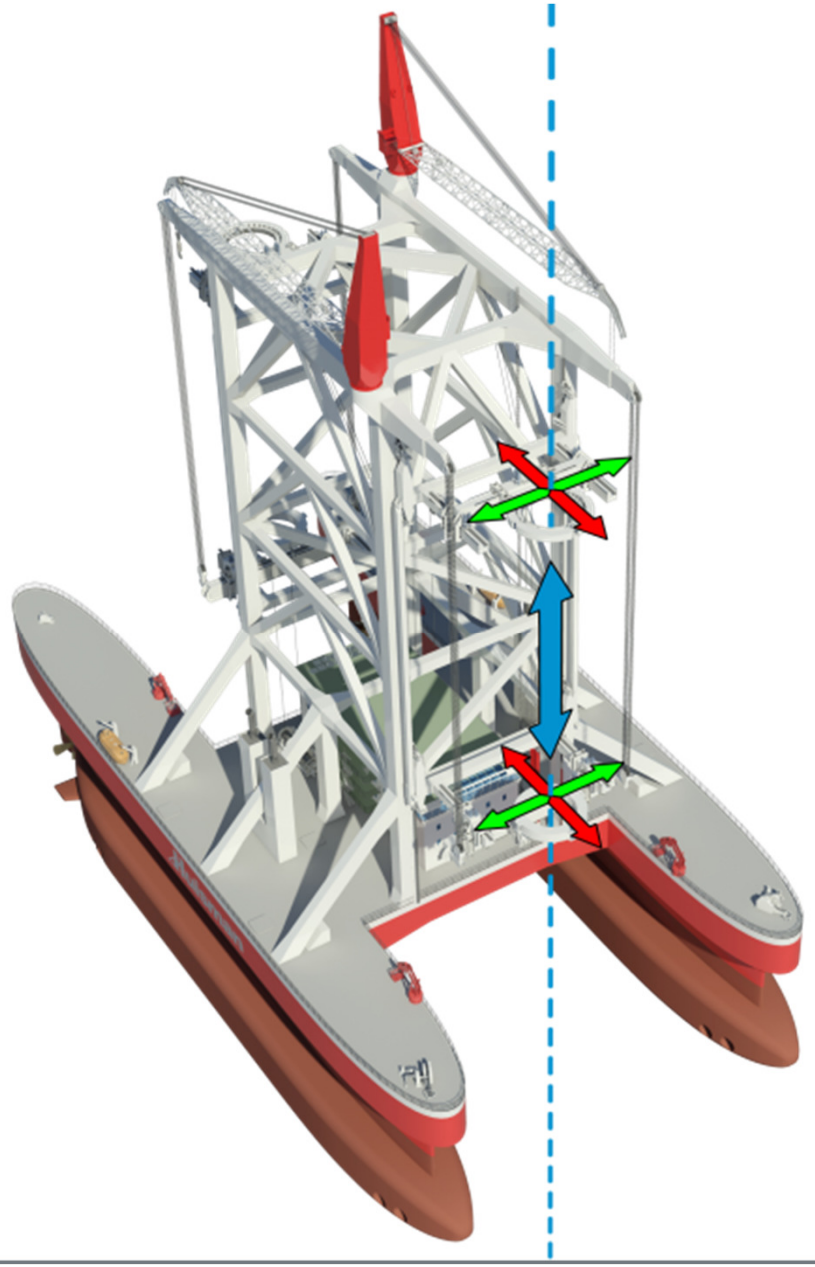


Hoisting motion compensation system

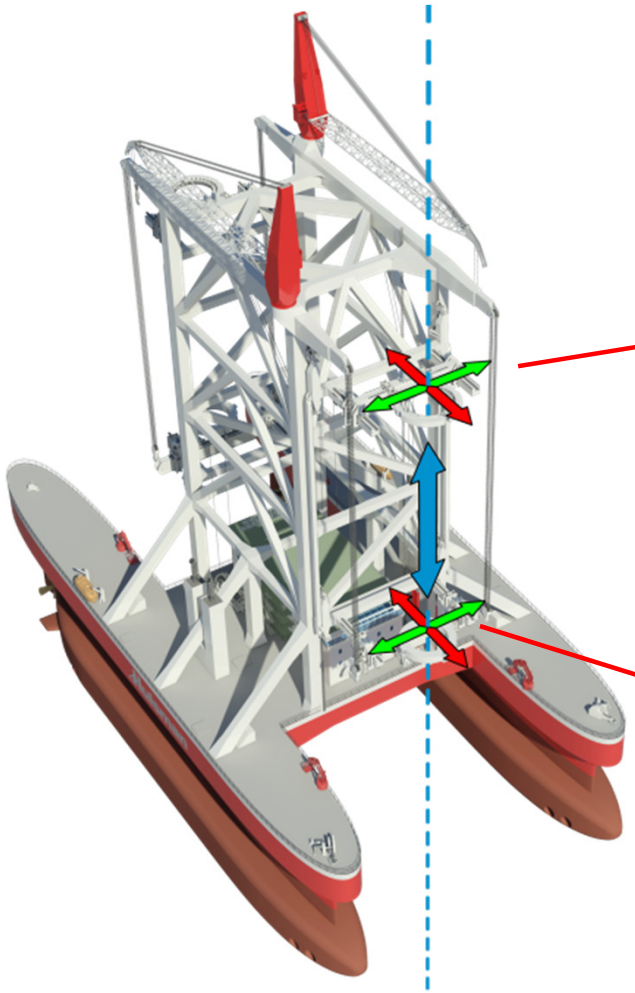
Although, the motions of the vessel are highly minimized, still some motions will remain.

Hoisting system motion compensation will take care of remaining motions:

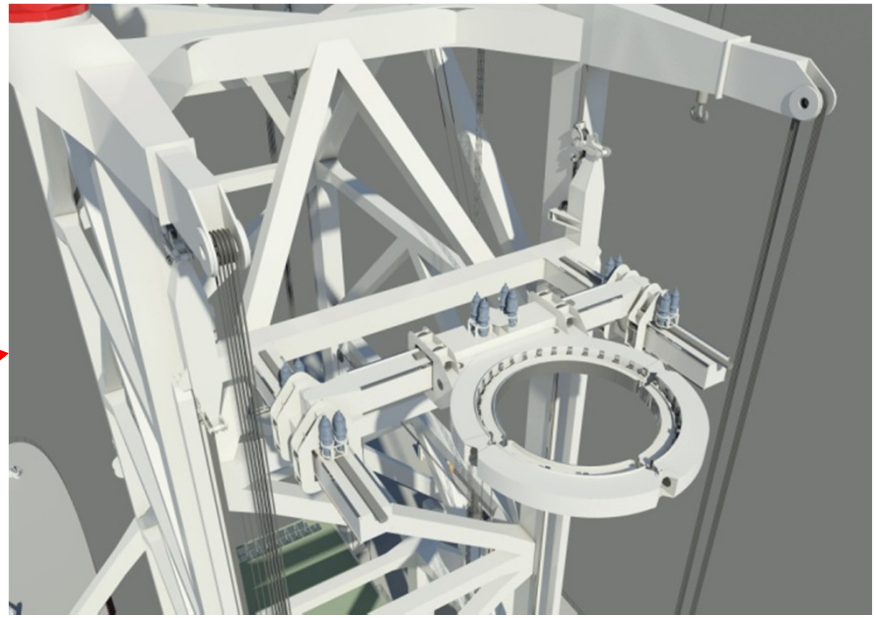
- 6 degrees of freedom
- active horizontal compensation
- passive heave compensation



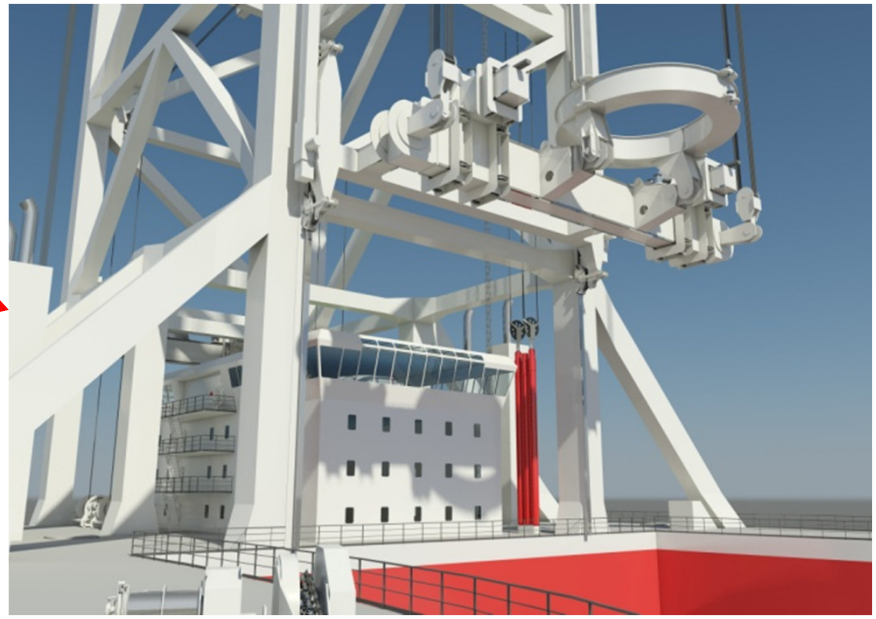
Hoisting motion compensation system



Upper clamp



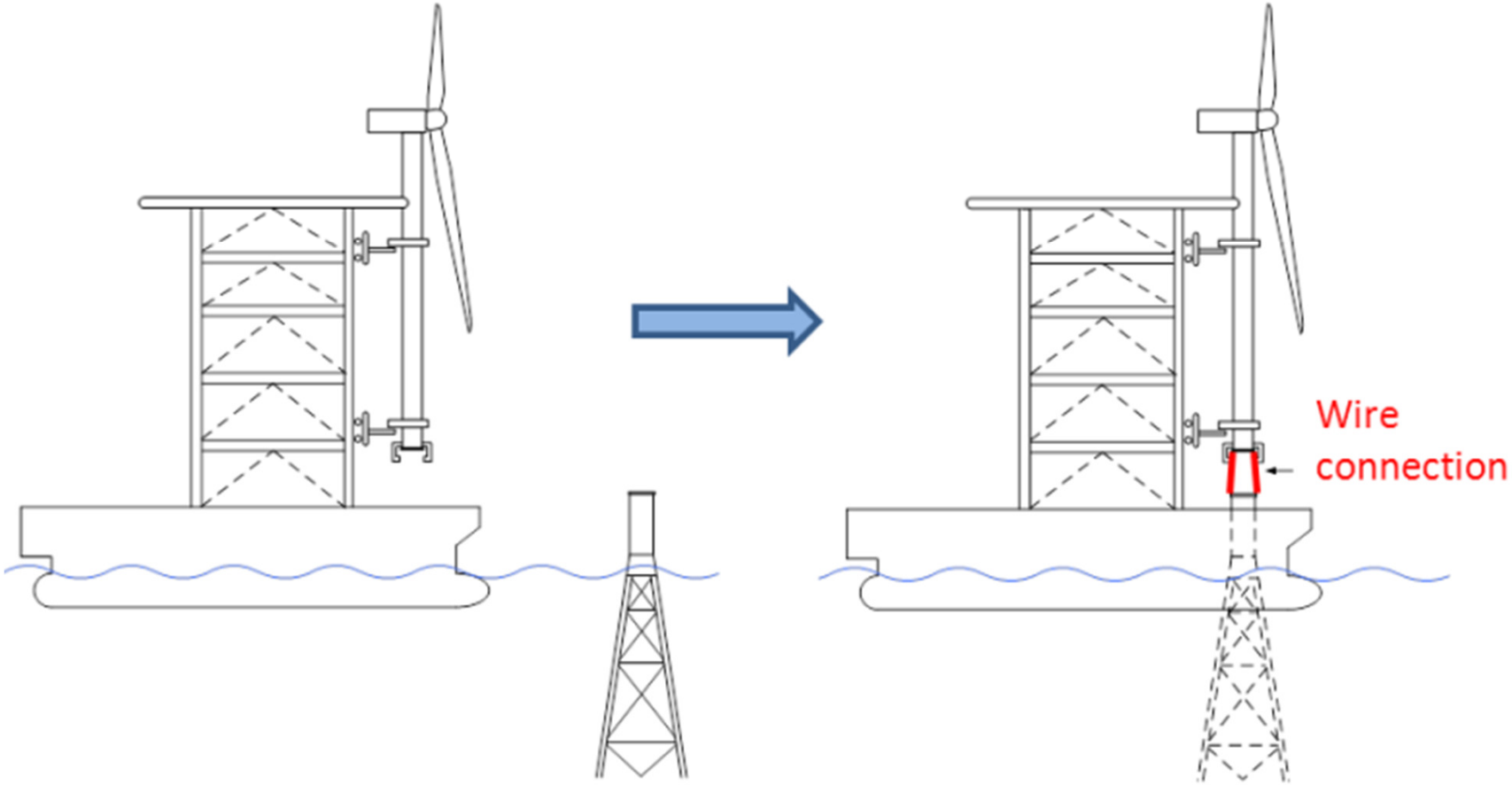
Lower clamp



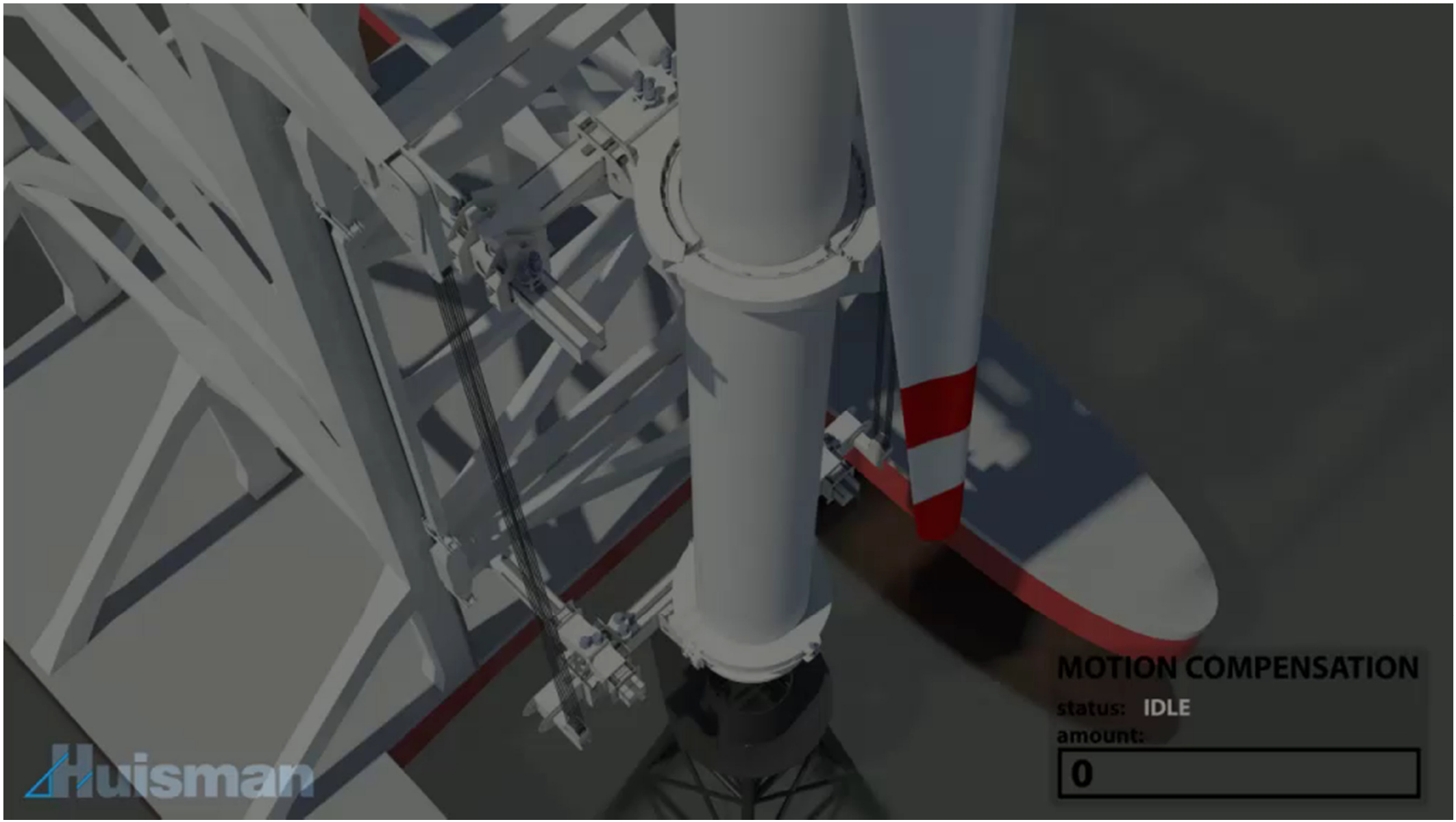
Landing the wind turbine

Connecting wires are applied between the wind turbine and the foundation. First in constant tension mode, then length control mode is engaged in combination with passive heave compensation

No impact at landing



Landing the wind turbine



Workability

The vessel and all systems are designed for installing of wind turbines in H_{sig}=3.5m and zero-crossing wave periods Tz up to 8s.

This gives annual workability of:

- In harshest areas of The North Sea: 80%
- Beatrice wind farm: up to 98%
- Dogger Bank: up to 90-95%

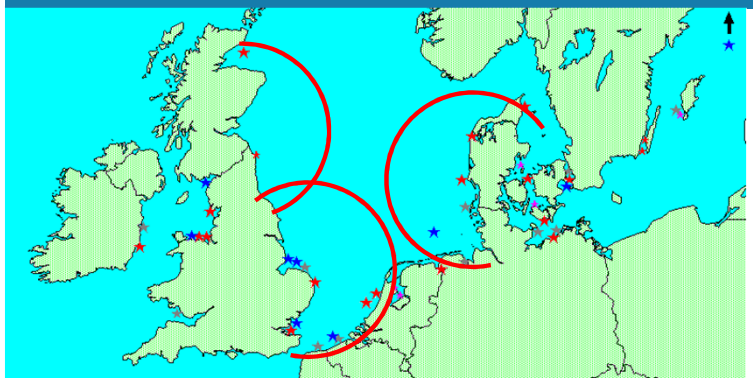
Hsig [m]			Tz [s]								
		from		4	5	6	7	8	9	10	11
		to	4	5	6	7	8	9	10	11	12
		mean	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
from	to	mean	4.5	5.8	7.1	8.3	9.6	10.9	12.2	13.5	14.8
16	17	16.5									
15	16	15.5									
14	15	14.5									
13	14	13.5									
12	13	12.5									
11	12	11.5									
10	11	10.5									
9	10	9.5				1	1				
8	9	8.5				1	1	1			
7	8	7.5			1	2	2	1	1		
6	7	6.5			2	4	4	2	1		
5	6	5.5		1	4	9	7	4	1		
4	5	4.5		2	11	19	14	6	2	1	
3	4	3.5		6	27	39	26	10	3	1	
2	3	2.5	1	17	63	73	40	13	3	1	
1	2	1.5	3	49	121	99	40	10	2		
	1	0.5	19	86	94	41	10	2			

The North Sea: 80%

Hsig [m]			Tz [s]																	
		from	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5
		to	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11
		mean	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75	10.25	10.75
from	to	mean	4.2	4.8	5.5	6.1	6.7	7.4	8.0	8.7	9.3	10.0	10.6	11.2	11.9	12.5	13.2	13.8
8	9	8.25																
7.5	8	7.75																
7	8	7.25																
6.5	7	6.75																
6	7	6.25																
5.5	6	5.75												2				
5	6	5.25											11	8				
4.5	5	4.75									4	17	34	3				
4	5	4.25								5	52	74	14	2	1			
3.5	4	3.75							11	44	134	56	17	1		2		
3	4	3.25						4	126	207	111	20	5	2		1		
2.5	3	2.75				4	31	241	491	203	55	11	9	1		1		
2	3	2.25			7	36	527	973	335	97	39	23	8	2		1		
1.5	2	1.75	30	30	50	480	1350	1720	700	330	210	120	60	35	20	10	5	3
1	2	1.25	469	312	2350	2568	945	490	250	163	76	51	20	14	6	5		
0.5	1	0.75	501	3381	2514	1220	774	458	246	134	83	60	33	21	12	9		
	1	0.25	1022	993	653	395	252	164	92	61	35	31	23	11	16	4		

Beatrice Wind Farm: up to 98%

Efficiency

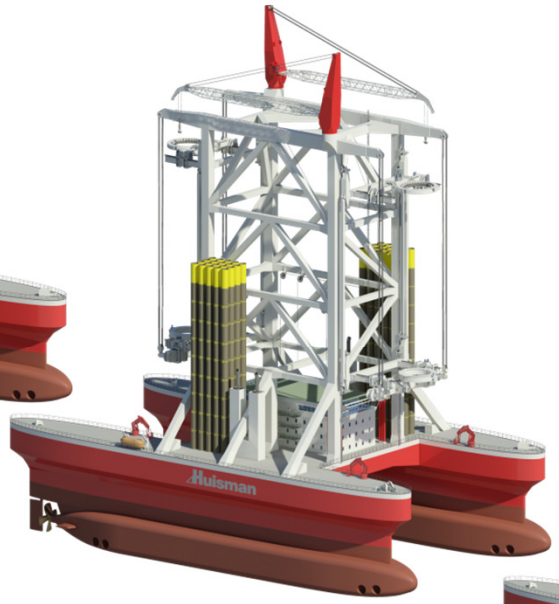


Distance shore base to wind farm	50	100	150	[miles]	
Load two wind turbines	2	2	2	[hrs]	
Sail to wind farm	4	8	12	[hrs]	
Install two wind turbines	4	4	4	[hrs]	
Sail back to harbour	4	8	12	[hrs]	
Contingency	6	6	6	[hrs]	+
Total for two wind turbines	20	28	36	[hrs]	
Load two foundations	2	2	2	[hrs]	
Sail to wind farm	4	8	12	[hrs]	
Install two foundations	2	2	2	[hrs]	
Sail back to harbour	4	8	12	[hrs]	
Contingency	4	4	4	[hrs]	+
Total for two foundations	16	24	32	[hrs]	
Total for two wind turbines & foundations	36	52	68	[hrs]	
Number of wind turbines & foundations per year based on; workability of 80% for installation of wind turbines and a workability of 90% for installation of foundations, excl. piling	409	284	217	[-]	

Number of wind turbines + foundations the WTS can install in one year

Other applications

Installing mono piles



Pile driving

Decommissioning
of top sides

Catamaran Type WTS
for shallow water

Wind Turbine Shuttle

Questions?