MEMO

Moray Firth - Offshore Met Mast

Project execution - summary

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Status P Preliminary Only R Inter Discipline Check B Issued for Client Comment/Approval A Approved for Design, Approved for Enquiry, Approved for Use, Information C Approved for Construction, Approved for Purchase X As-built V Void/Cancelled S Superseded	P2

Internal check	**Comments**
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1. Background

The Moray Firth Offshore Met Mast (OMM) is a property of Moray Offshore Renewable Limited (MORL). MORL is owned 100 % by the Spanish utility company EPR Renewable (EDPR).

The OMM adopted by MORL for the provision of the OMM has a Gravity Based Structure (GBS) for the foundation and substructure. This GBS is formed by a concrete caisson which acts as the base of the foundation and floating element during transport and a steel mono pile (MP), which acts as substructure for the platform where the steel lattice tower with all measurement instrumentation is installed.

The OMM was damaged due to a collision with a barge in 2014.The consequence is:

- Inclined foundation approx. 2 degrees from vertical
- Paint damages to the foundation; MP
- Structural damages to the gravity based structure

OMM general arrangement

Pint damages to the MP

Missing two top sections of the OMM

MORL has contracted Ramboll as a designer and SubC Partner (SUBC) as a contractor for the repair works. The work is regulated by the CDM Regulation 2015, where MORL act as Client, Principal Designer and Principal Contractor.

2. Conceptual repair solution

To secure the structural integrity of the GBS a steel bucket will be placed around the MP on top of the GBS. The steel bucket will be placed as two halves and locked together with a combined structural and grouted connection. The interface between steel bucket and GBS will be grouted as well as the

connection between steel bucket and MP. The steel bucket will be filled with reinforced concrete blocks acting as ballast.

The two mast top sections have been repaired and will be re-installation during the repair campaign as well as the MP will paint repaired above splash zone.

3. The repair campaign

3.1 Phases and activities

The repair campaign consists of following phases and activities:

1. Project preparation
    - Project design, management, planning and engineering
    - HAZID/HAZOP
    - Method statements
    - Risk assessments
    - Procedures
    - Bridging documents
    - Overall lifting plans
    - Project manual
    - QA/QC
    - HSE Management
    - Pre-mobilisation
    - Assembly / pre-testing of steel-bucket at quay side Esbjerg, Denmark

2. Mobilisation
    - Loading and sea fastening of steel buckets, ballast, dive equipment, ROV equipment, grout/grouting equipment, lifting gear, support structures, boat landing ladder and two mast top sections.
    - Induction of personnel, testing of setup and drills.
    - Supply of all offshore personnel.
    - Supply of Technical Manager, Supervisor, Welders and harbour labours.
    - Torque tools for met mast and boat landing ladder assembly
    - Vessel approval (MWS)

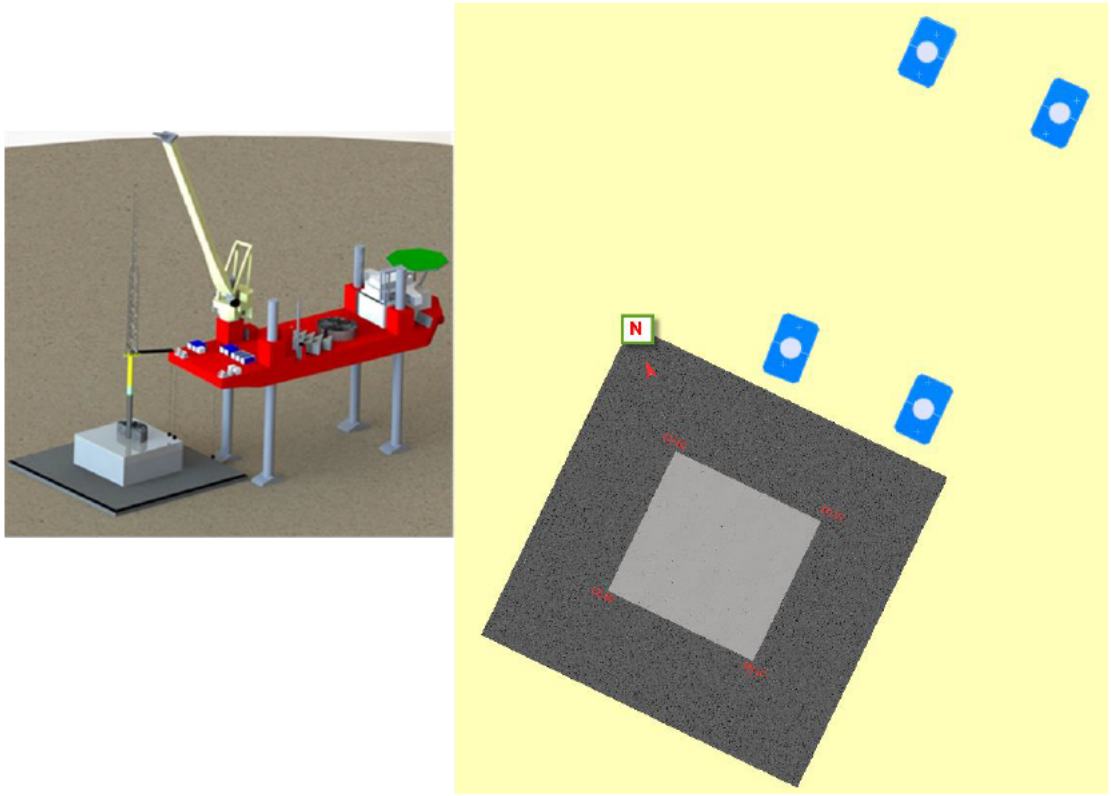
3. Offshore operation
    - Subsea operation includes:
        - Removal four lowest anodes
        - Removal of two steps
        - Water jetting of gravity foundation at bucket

        - Survey of top of gravity foundation and shim steel bucket
        - Installation of steel bucket
        - Grouting
        - Installation of ballast
        - As built (video, grout documentation)
    - Mast and topside operation includes
        - Installation mast sections (module 1 and 2)
        - NDT of existing flange connections on site (module 3 to 7) – 6 elevations of 3 flanges each.
        - Installation of boat landing ladder
        - Paint touch-up above sea level
        - All operational personnel
        - All mobilised equipment

4. Demobilisation
    - Un-loading and packing of equipment
    - Removal of support structures and sea fastening
    - Cleaning and paint touch-up
    - Supply of all offshore personnel.
    - Supply of Technical Manager, Supervisor, Welders and harbour labours

3.2 Offshore setup summary

The offshore work will be executed from a jack-up vessel similar to appendix A.
Subsea activities will primary be supported by ROV and secondary with divers, see appendix B and C.
The vessel will jack up as close as possible to the OMM
The installation of steel bucket, ballast blocks and mast top sections will be done using the jack-up vessel crane.



Figur 1 Offshore setup

3.3 Environmental impact summary

Below will be left in-place after the repair work is completed offshore:

a) Steel bucket: 400 tonnes normal structural carbon steel
b) Ballast: 1600 tonnes (12 pcs) of reinforced concrete block
c) Grout: 66 m3 Ducorit ®, ref appendix D
d) Corrosion protection: 18 tonnes aluminium anodes
e) Paint touch up above splash zone
f) Foot print on seabed from jack-up spud cans 424m^2

4. Time schedule (preliminary)

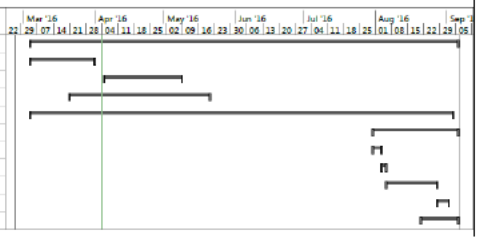
The actual offshore operation is planned to take place during August 2016, see below.
Offshore works to commence the 6th of August 2016 and finalized 28th of August 2016

File: 20-10 - Master Time Schedule - rev c - PRELIMINARY.mpp
Date: Mon 04-04-16

Moray Firth OMM repair campaign
PRELIMINARY Master Time Schedule
Activities are estimated and weather downtime not included

SUBC PARTNER

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	% Complete	Resource Names
1		Moray Firth OMM repair - PRELIMINARY	185,75 days	Fri 04-03-16	Tue 06-09-16		11%	
2		Agreements	28 days	Fri 04-03-16	Fri 01-04-16		0%	
5		Engineering In-place (ref Ramboll)	34 days	Tue 05-04-16	Mon 09-05-16		0%	
8		Authority approval (Marine Scotland)	61 days	Mon 21-03-16	Sat 21-05-16		2%	
13		Preparation	184 days	Fri 04-03-16	Sun 04-09-16		13%	
58		Operation	36,75 days	Sun 31-07-16	Tue 06-09-16		0%	
59		Mobilisation	3,5 days	Sun 31-07-16	Wed 03-08-16		0%	
70		Transit to site	2,5 days	Wed 03-08-16	Sat 06-08-16		0%	
73		Offshore repair	21,75 days	Sat 06-08-16	Sun 28-08-16		0%	
105		Transit to Esbjerg	4,75 days	Sun 28-08-16	Thu 01-09-16		0%	
113		Final documentation	15,75 days	Sun 21-08-16	Tue 06-09-16		0%	



5. Appendix A: Jack-up vessel summary

Classification and Rules

Vessel type: Gusto MSC NG-9000C-HPE
Class: DNV +1A1, CLEAN DESIGN NAUT-OSV(A)
OPP-F DYNPOS-AUTR EO HELDK
Delivery: 2012 / 2013
Yard: Lamprell PLC, Dubai
Flag: Republic of Malta

Principal Dimensions

Hull length o.a. [m]: 132
Hull breadth mid [m]: 39
Hull depth [m]: 9
Min draft (light) [m]: 4.25 (+0.8 to spud can tip)
Draft at max variable payload (m): 5.6 at elevated 19.200t (+0.8 to spud can tip)

Cargo Capacity

Max variable load (t): 7600
Deck area [m^2]: 3200
Uniform deck loading [t/m^2]: 5 - 10
WTG capacity (typical): 8x3.6 MW / 4x8.0MW
Foundation capacity: 3-4 monopiles

Propulsion, Manoeuvring and Positioning

Aft propulsion: 3 x 3800 kW Voith Schneider propellers
Fwd manoeuvring: 3 x 1750kW Wärtsilä Lips tunnel thrusters
Max speed (knots): 12
Positioning: DP2

Operational Limitations

All year survival water depth range[1]: 7.5-55m
Operation water depth range[1]: 5.5-60m
Transit fully loaded: up to wave 3.5m Hs
Jacking: up to wave 1.8m Hs

Main Crane

Type and location: Gusto GLC-800-ED-S around aft port leg
Main hook:
Long mode: 640t at 30m outreach,
(max height 120m at min radius)
Short mode: 800t at 26m outreach,
(max height 102m at min radius)
Auxiliary hook: 50t (certified for man-riding)
Mean wind limit (m/s): 16

Deck Cranes

2 cranes of type 20t SWL, 27m max radius
Certified for man-riding
1 crane of type 6t SWL, 24m max radius

Power generation

4 diesel electric Wärtsilä generators:
1 x 12v32 5760kW, 1 x 6L32 2880kW, 2 x 9L32 4230kW
Harbor (emergency) generator. CAT 3512B 1400kW
Output range: 60 Hz, 230-690V
50Hz on-deck power supply

Jacking System

Type: MSC continuous hydraulic double-acting system
Effective jacking capacity per leg (t): 5300
Pre-loading capacity per leg [t]: 9560
Holding capacity per leg [t]: 9000
Jack-up lifting / lowering speed [m/min]: 0.4 / 0.5
Leg handling speed [m/min]: 0.6

Legs and Spudcans

Number & type: 4 cylindrical
Diameter [m]: 4.5
Length [m]: 92.4
Max leg length below ship baseline [m]: 70.5
Spudcan area [m^2]: 106

Safety Systems

Fire and safety systems: Compliant with DNV Offshore Standards, IMO MODU Code and SOLAS/SPS Code, North Sea Standard
Fire & Gas detection: Shipwide integrated system
Fire extinguishing: Fire ring main, Ultra Fog water mist system
Life saving: 2x100% complement fully enclosed lifeboats and inflatable rafts
MOB: high speed rescue boat + CrewFinder system

Access

Helicopter deck D22m, 12.8t (CAP437)
Hydraulic gangway to foundation or quay
Man-riding cranes
Hydraulic boat landing for CTV

Accommodation and Facilities

Total complement: 80 persons in 56 cabins
Cabins equipped with en suite bathroom, Sat TV/video
Client offices and workshop, fitness room, laundry, TV room, etc.

Leg retrieval system (jetting)

Capacity: 50m3/h @ 30bar per pump
Capacity: 150m3/h @ 10bar per pump

Fuel consumption

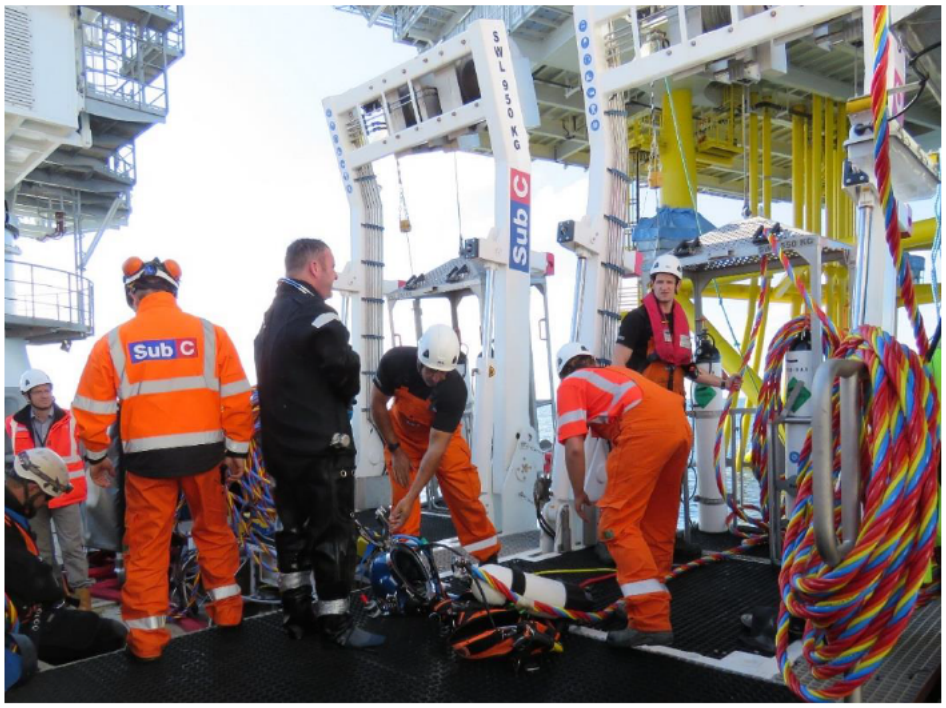
Transit speed of 10 knots [t/24h]: 45
Elevated, standby [t/24h]: 5-6
Elevated, crane work [t/24h]: 6-8

6. Appendix B: ROV spread summary

ROV setup

- A Launch and Recovery System with integrated A-frame, HPU and winch.
- A TMS for launching and recovering the ROV. The TMS is fitted on the Launch and Recovery System during transport.
- A containerized control room with integrated workshop and storage room for smaller consumables.

7. Appendix C: Dive spread summary



Dive setup

- According to UK HSE legislation.
- Surface supplied Nitrox 32%
- Decompression chamber
- Dive control unit
- Dual LARS
- 1x Dive Supervisor
- 1x DMT
- 6x Divers

8. Appendix D: Ducorit ® grout

Ducorit

- ultra high performance grout

The ultra high performance grout, Ducorit® is used for structural grouted connections in wind turbine foundations and oil & gas installations - both offshore and onshore.

Quality checked by MPA BAU HANNOVER

PRODUCTS

The core of the Ducorit® products is the unique Densit® Binder. The different properties of Ducorit® S1, Ducorit® S2, Ducorit® S5, Ducorit® $S5_R$ and Ducorit® D4 are obtained by adding aggregates such as quartz sand or bauxite.

Ducorit® products are characterised by extreme strength and stiffness, making them a strong structural component and not just a filling material. Using Ducorit® does not require special precautions with respect to environmental or personal hazards.

PUMPABILITY

Ducorit® products are pumpable up to several hundred metres through hoses between 2'' and 5''. Due to viscosity and high inner cohesion of the mixed material, there is no risk of washing out cement particles, separation or mixture with water when cast below sea level.

EARLY STRENGTH DEVELOPMENT

Ducorit® develop a significant early strength. After 24 hours of curing at 20°C (68°F), the strength reaches approximately 25% of the long term value. The early strength is even more pronounced with regard to the material stiffness.

FATIGUE

Due to ultra high strength and durability of Ducorit® products, the fatigue strength is outstanding compared to normal concrete. As fatigue strength depends upon the static strength of concrete, the fatigue strength of Ducorit® can be up to more than five times the strength of normal concrete.

Mechanical Properties

	Ducorit® D4	Ducorit® S5	Ducorit® $S5_R$	Ducorit® S2	Ducorit® S1
Compressive strength f_c [1] [MPa/psi]	200 / 28,000	130 / 18,850	130 / 18,850	120 / 17,500	110 / 16,000
Static modulus of elasticity E_c [GPa/ksi]	70 / 10,000	55 / 8,000	55 / 8,000	47,800 / 6,900	35 / 5,000
Dynamic modulus of elasticity E_d [GPa/ksi]	88 / 12,800	60 / 8,700	60 / 8,700	48,100 / 6.975	37 / 5,400
Tension strength f_t [MPa/psi]	10 / 1,500	7 / 1,000	7 / 1,000	6 / 870	5 / 725
Flexural strength f_{ct} * [MPa/psi]	23.5 / 3,400	14 / 2,800	14 / 2,800	11 / 1,450	13.5 / 2,000
Density ρ [kg/m³]	2740	2440	2440	2350	2250
Poisson's ratio ν	0.19	0.19	0.19	0.19	0.19
Fracture energy G_f * [MJ/m]	12	5.8	5.8	-	4.0
Consistence Class[2]	a2	a2	a2	a1	-
Compressive Strength class (EN 206-1)	>C100/115	C100/115	C100/115	C100/115	-
Compressive Strength class (24h) [2]	Class A	Class B	Class A	Class A	Class A
Shrinkage[1] $\varepsilon_{cs(28)}$	SKVB I (0,413 ‰)	SKVB 0 (0,558 ‰)	SKVB 0 (-)	SKVB 0 (0.578 ‰)	-
Shrinkage[1] $\varepsilon_{cs(\infty)}$	SKVB I (0,421 ‰)	SKVB 0 (0,567‰)	SKVB 0 (-)	SKVB 0 (0.579 ‰)	-

*(minimum 28 days curing at 20°C). * with 1.9% by volume of steel fibres*

1) DAfStb-Richtlinie Herstellung und Verwendung von zementgebundenem Vergussbeton und vergussmörtel (Juni 2006)

2) Note that the stipulated values are mean values, based on 75x75 mm cubes

Densit

A member of the FLS Group

Evaluation of environmental impact of Ducorit® in marine systems

Ducorit® is a pure mineralogic product except of a small dosage of an organic component known as a superplasticizer. The dosage of this component is less than 1% in Ducorit®.
The mineralogic components are cement, microsilica and aggregates (quartz or bauxite).

When introduced to the marine system the product will when not confined disperse into the main components.

- The aggregates will precipitate contributing to no harm to the environment.
- Cement will react with water forming hydroxides, that rapidly will react with CO_2 forming carbonates, thus returning the cement to its former state before production. Eventually these components will dissolve in the marine system, contributing to no harm to the environment.
- Microsilica will probably at first precipitate, and as cement eventually dissolve contributing to no harm to the environment.
- The superplasticizer will at first dissolve. Being biodegradable the superplasticizer is eventually broken down to CO_2 and water.

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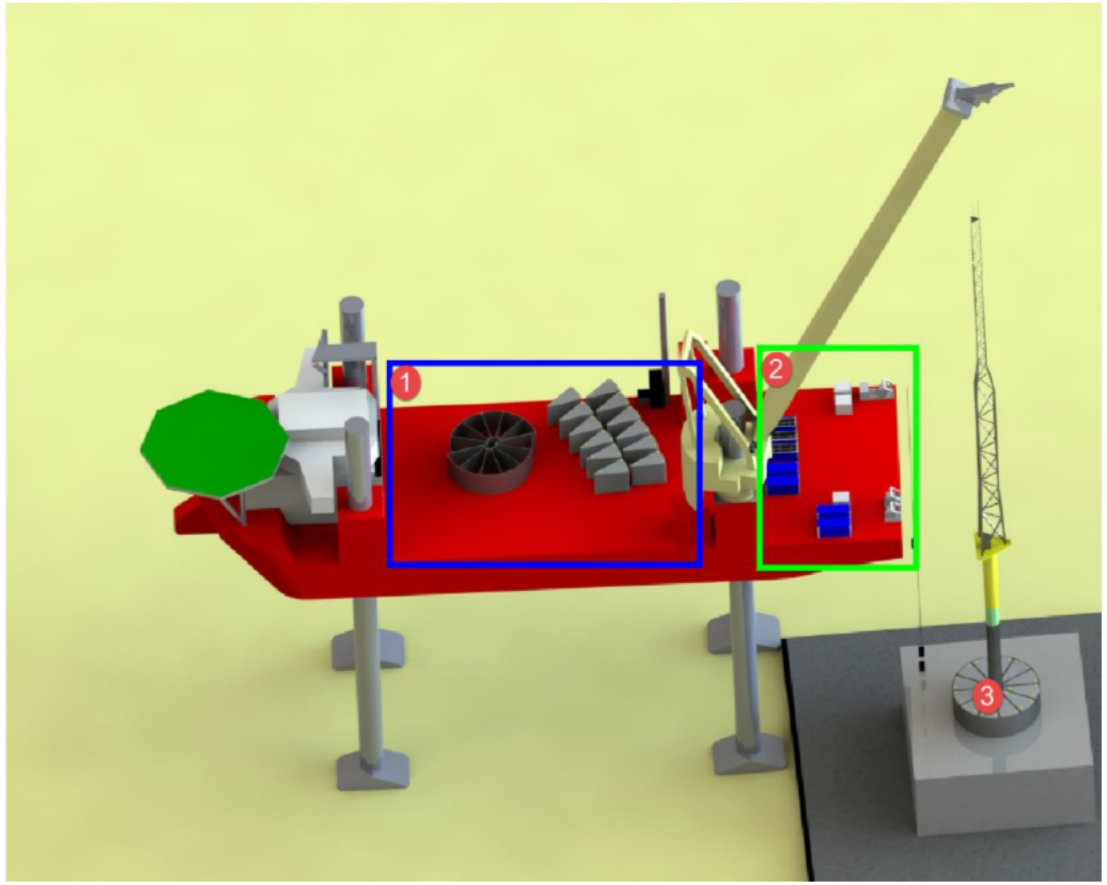
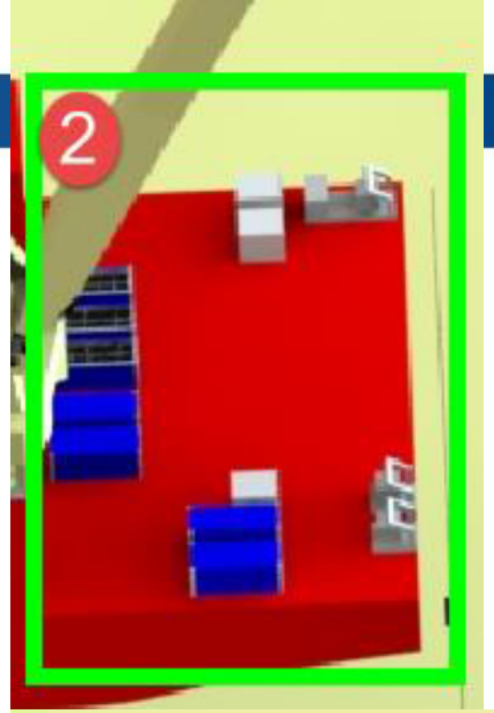
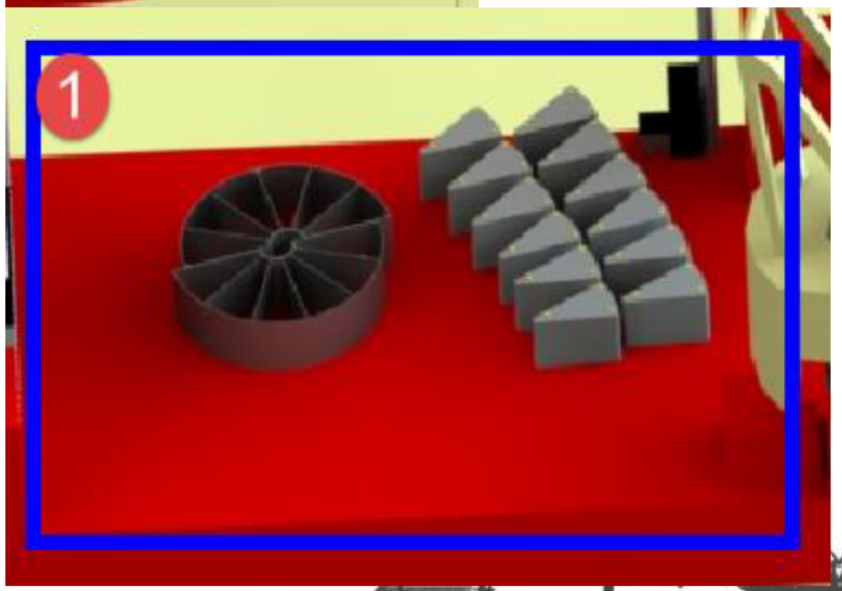
Manager, Business development

9. Appendix E: Conceptual method statement

EPDR Moray OMM Repair







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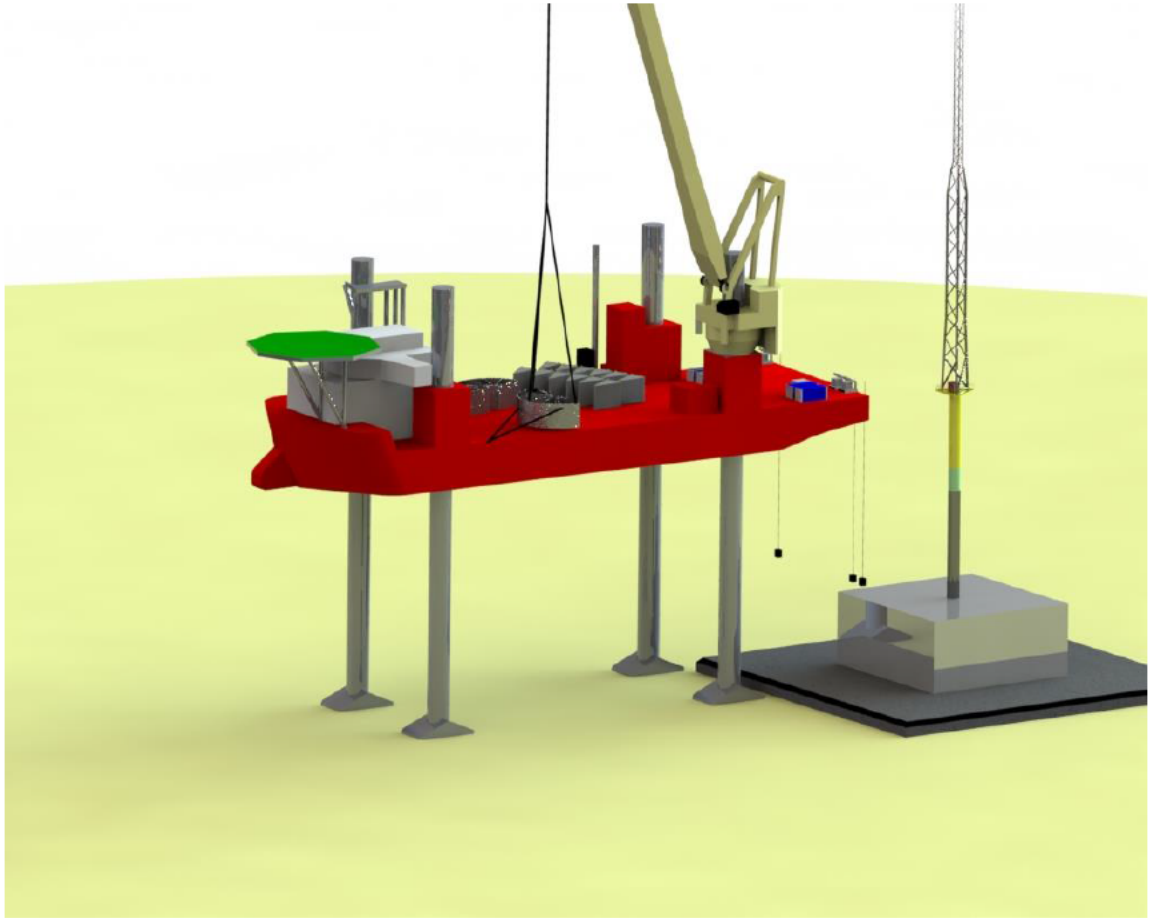

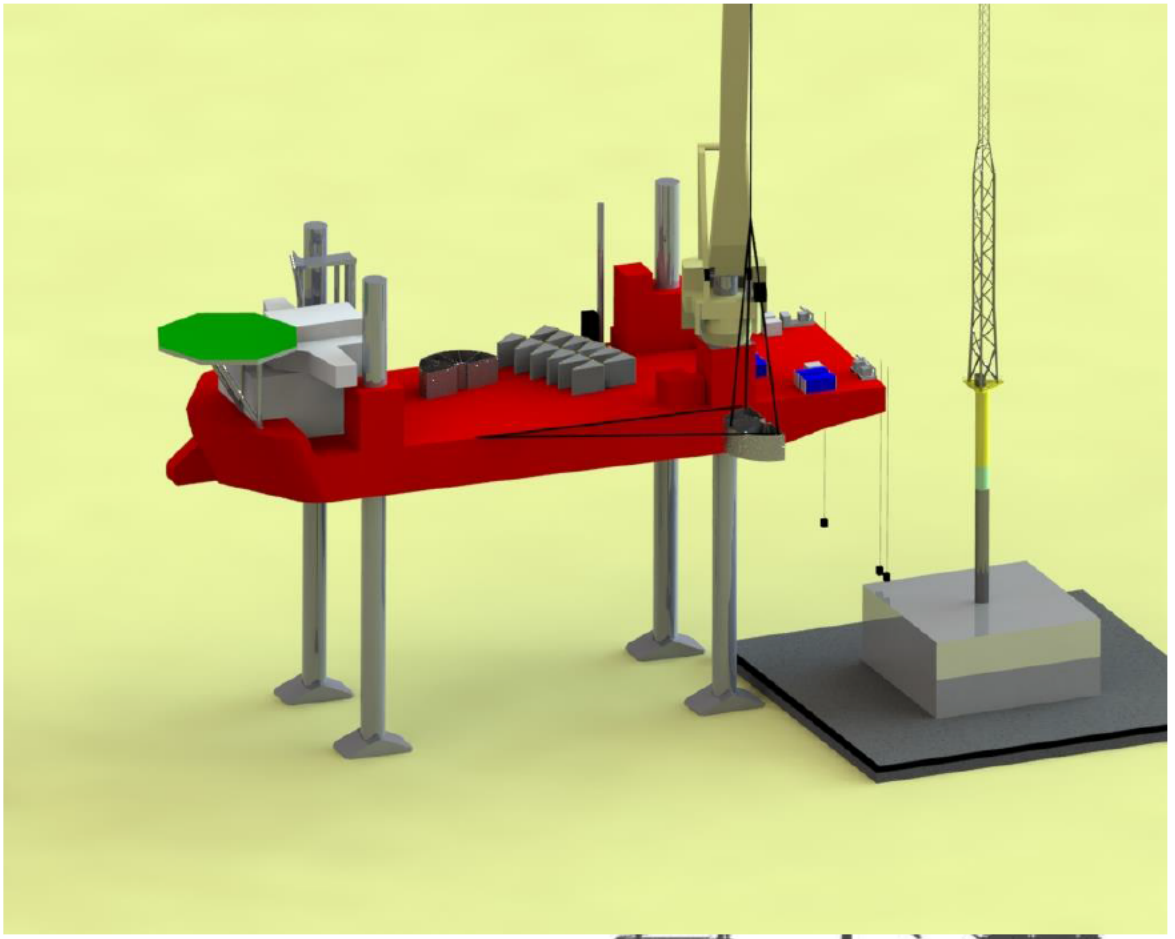

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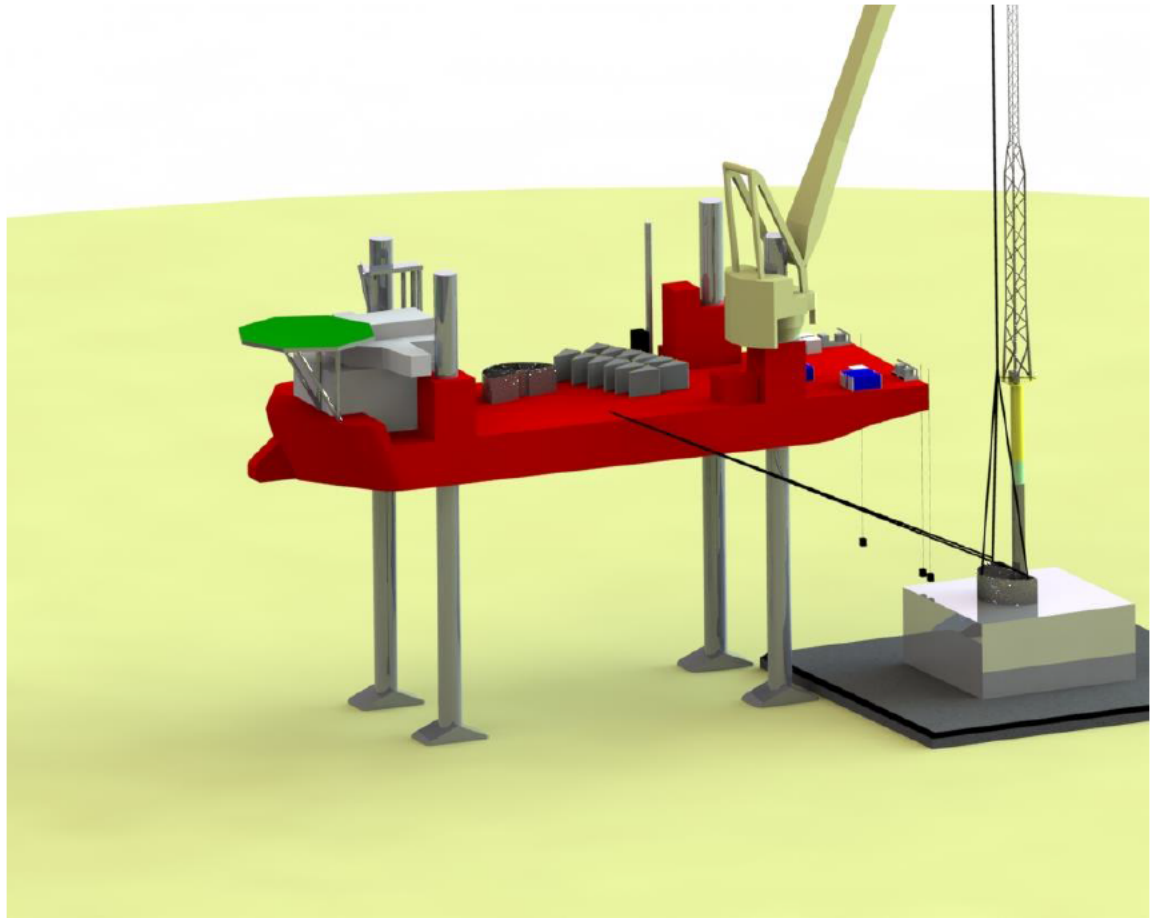

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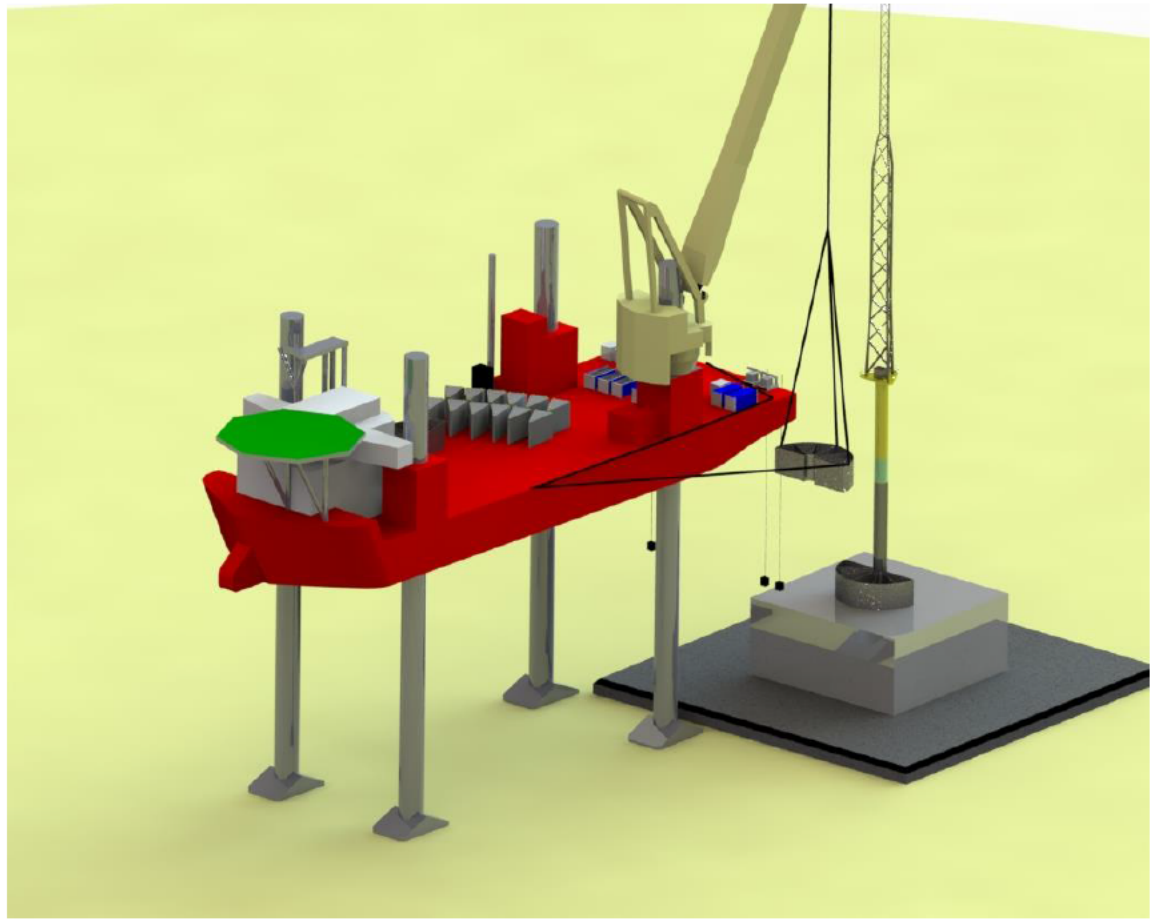

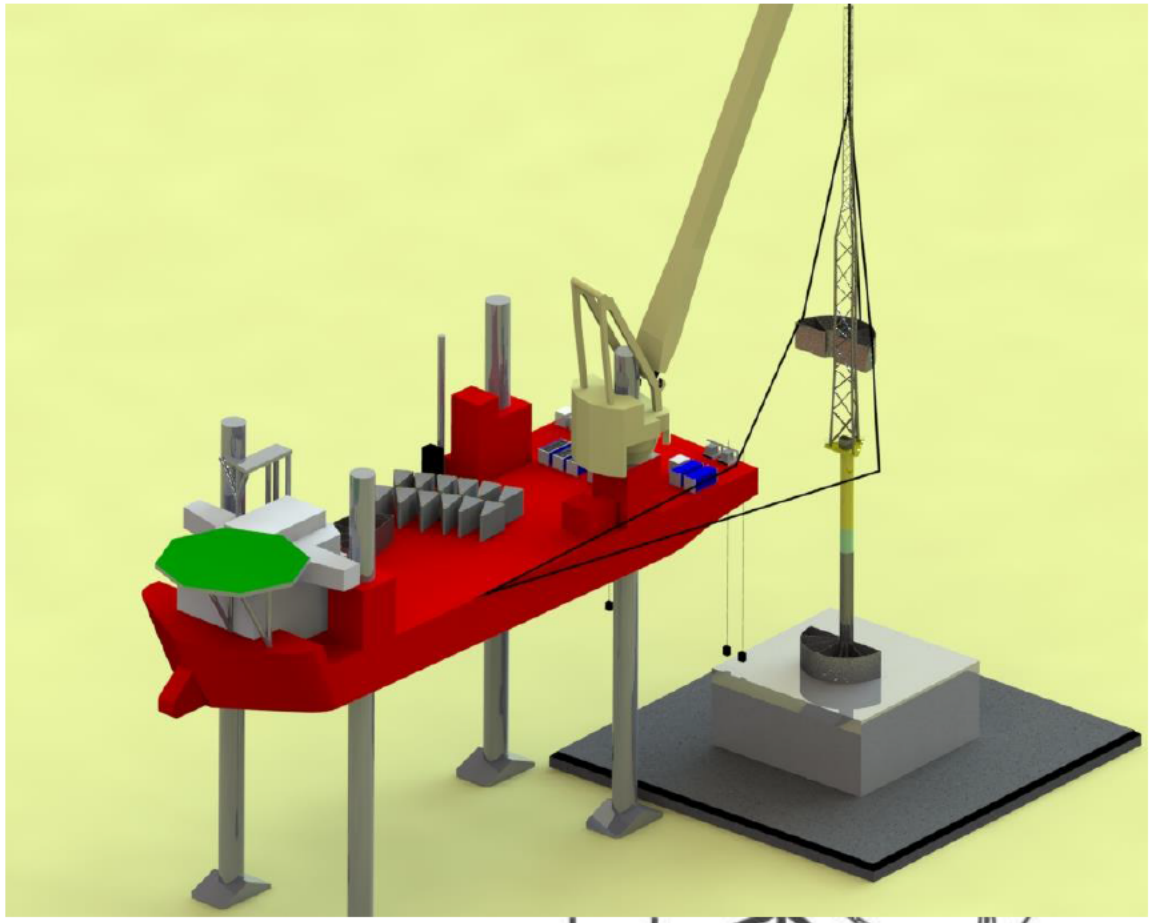

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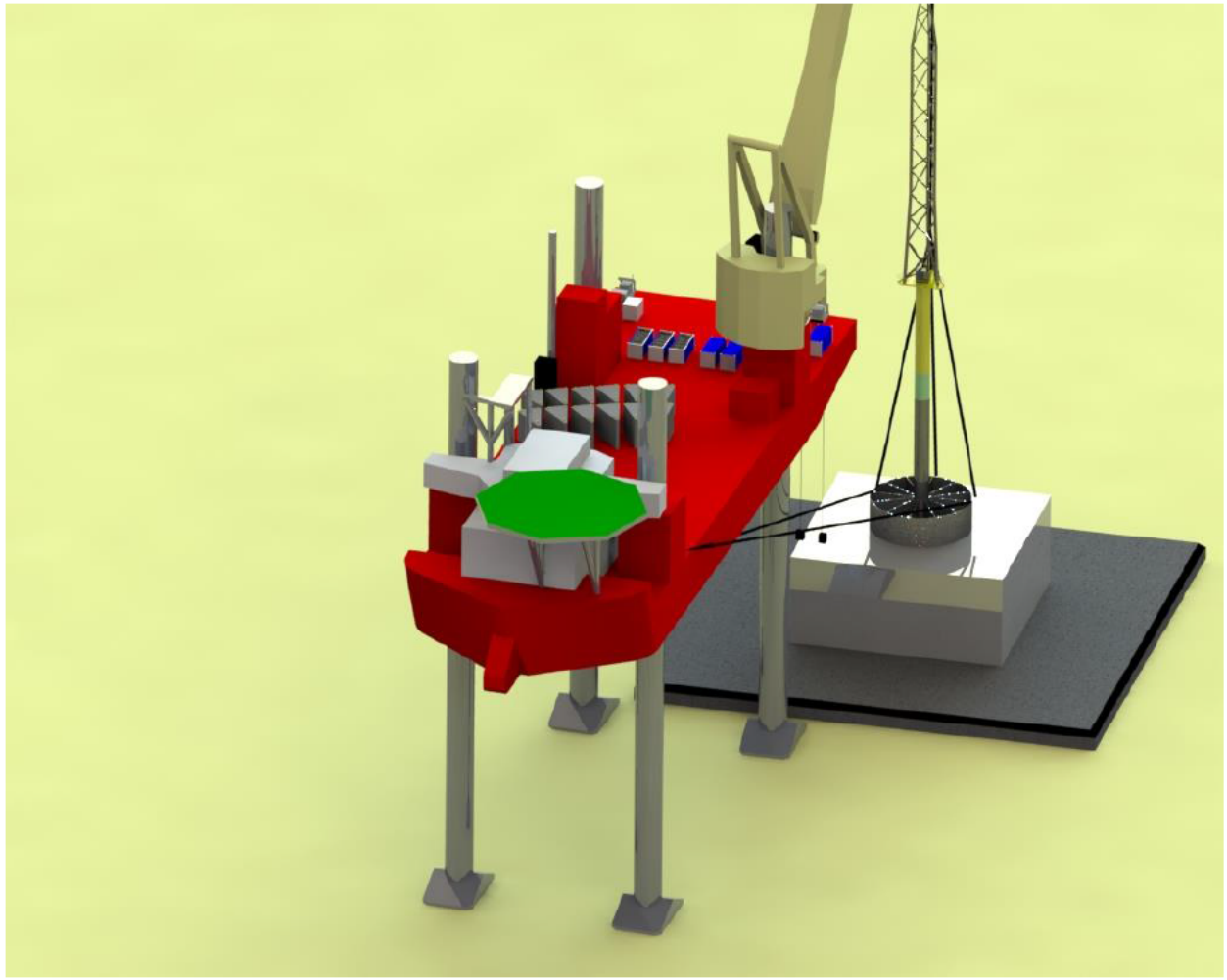

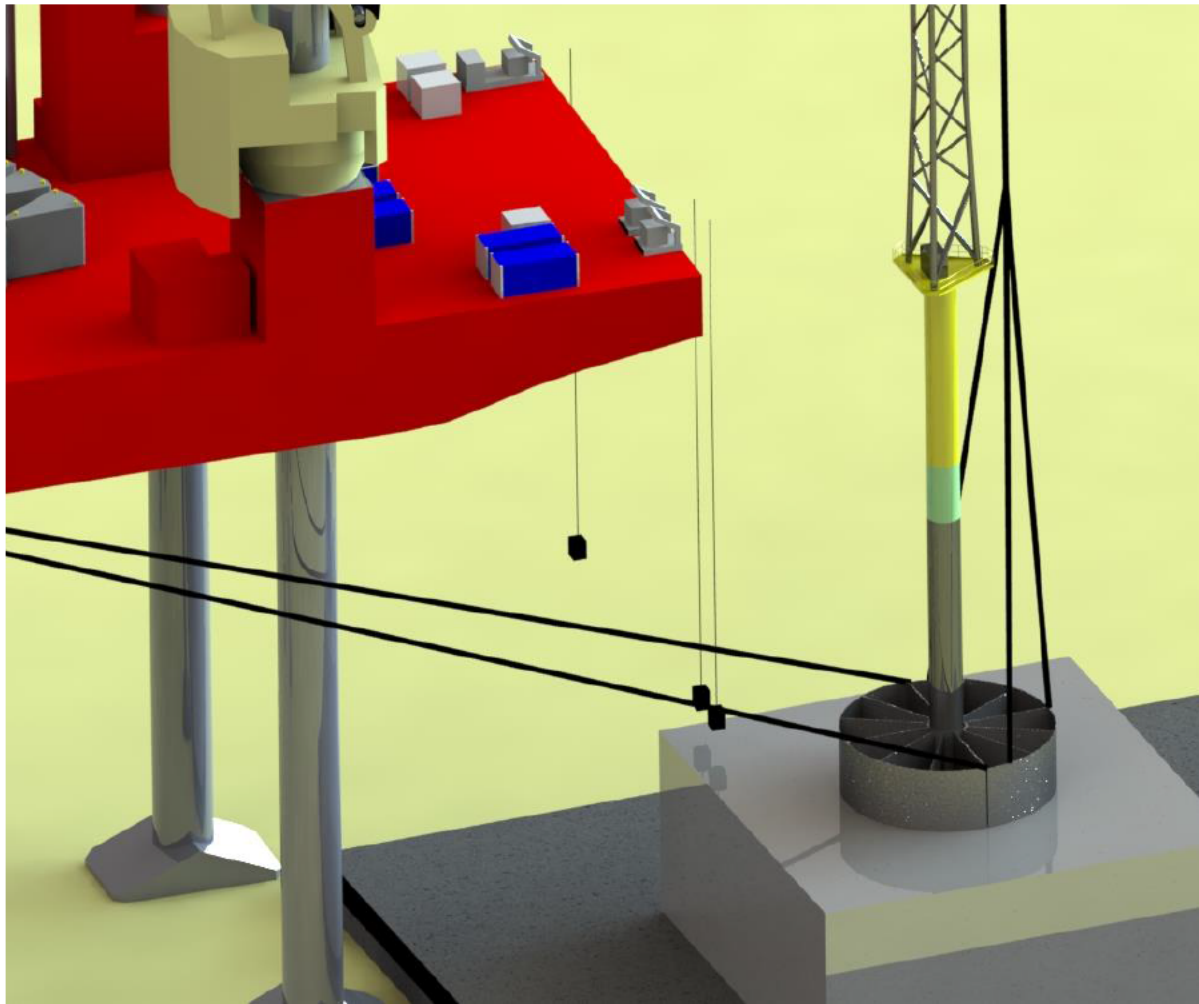
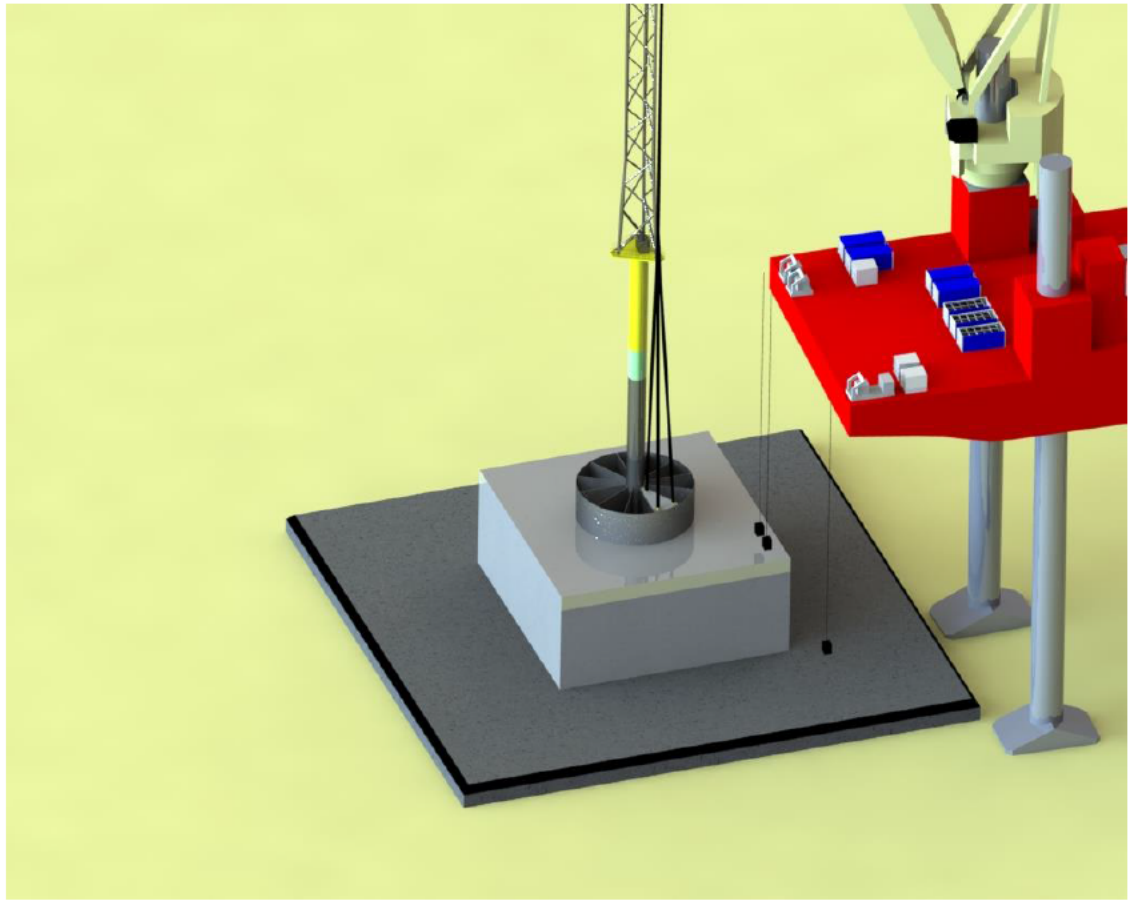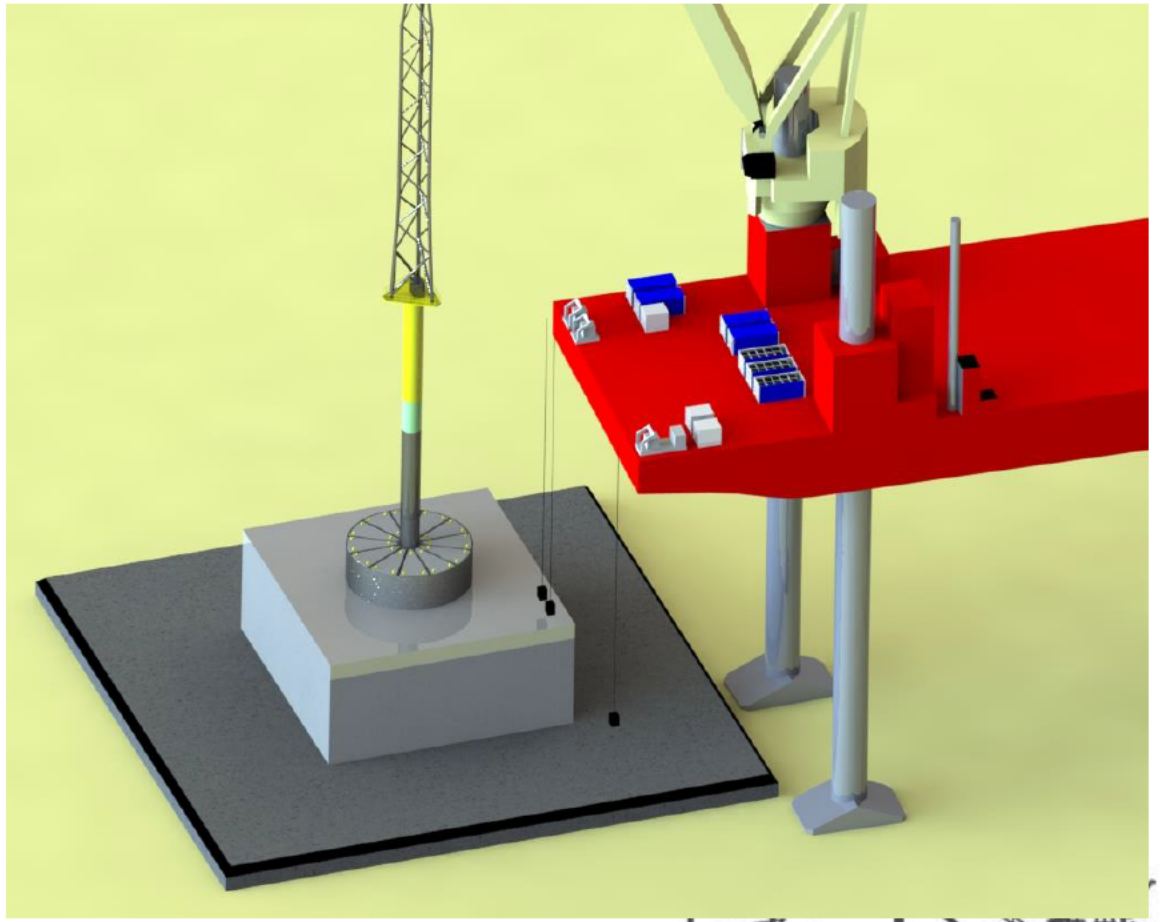
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